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Original Research Article

Impact of Videoconferencing Technology as an Educational Tool for Saudi Dental Healthcare Personnel

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Abstract

The healthcare literature contains several examples and uses of interactive videoconferencing as a consultation tool for remote clinics, or for the education of students in distant locations. However, no systematic review was conducted to evaluate the influence of videoconferencing technology as an educational tool for Dental Healthcare Personnel (DHCP). Thus, this systematic review was conducted to investigate the impact of employing videoconferencing on the learning outcomes of DHCP or dental students, as well as to explore the future prospect of implementing this tool in Saudi Arabian context. The search strategy included 11 electronic databases including MEDLINE, CINAHL full text, ScienceDirect and PubMed plus manual and grey literature searches of any relevant study in English language up to January 2018 after assessing the eligibility of the full-text article based on certain inclusion and exclusion criteria. Out of 671 studies, 17 were eligible to be included in the review. The majority of the selected literature (11 studies) was of moderate quality, while four studies were considered as being high quality and the last two were located in the poor quality category. Most of the included studies were mixed qualitative studies (12 studies) and the remaining were quantitative studies (5 studies). This review shows a positive learning impact of videoconferencing on DHCP. As, no financial or infrastructure issues are encountered, this technology seems promising with the potential in Saudi Arabian dental education, providing that leaders of Ministry of Health (MOH) and Dental Schools of Saudi Arabia can be convinced to use it.

Keywords: Videoconferencing technology, dental healthcare personnel, DHCP, distance learning, dental education, educational tool.

INTRODUCTION

The origins of videoconferencing can be traced back to 1963 when the first analogue system was developed for commercial purposes, although it would be another twenty years before the first digital videoconferencing system would be available [1]. For the following decade, videoconferencing was prohibitively expensive and complex to set up; as Reynolds *et al.* point out, early versions of digital systems were similar to a studio set- up, consisting of a large screen and sizeable floor-standing cameras [2]. The cost of digital videoconferencing systems has since reduced significantly, and systems have become much more reliable and simple to use [2]. The development of faster and more reliable digital communication networks has also facilitated videoconferencing system use, with higher quality transmissions and lower associated costs [3]. According to Taylor *et al.*, there are two different means of videoconferencing: point- to-point, and multi-point. Point-to-point conferencing refers to the simplest set-up whereby one participant or group is connected to another. The components required to allow this type of videoconference, such as the camera and microphone, are often integrated into common computing devices including laptops and tablets. It is also possible to set up a system with dedicated, room-based computer hardware. For multi-point videoconferencing, three or more points (or locations) are connected, and all participants or groups can see and hear one another as well as any shared content [4].

The healthcare literature contains several examples and uses of interactive videoconferencing [5–

7]. The literature most frequently describes videoconferencing technology being used in the following ways: 1) to provide continuing education and support to practicing professionals and health care providers, 2) to provide direct patient care to patients and 3) to educate students and graduate residents. Since videoconferencing utilises similar characteristics as real-time conferencing, (i.e., face-to-face communication) featured in synchronous verbal exchanges with the ability to see a collaborative partner live [8,9] it also has a potential for facilitating online collaborative learning arrangements successfully. From an educational perspective, according to Mason *et al*. there are four main areas where videoconferencing has been of benefit: meetings, teaching, management for virtual graduations, and interviews, either for jobs or as examination opportunities for oral components in research degrees [3]. Videoconferencing technology can be used to provide healthcare providers with information that will better educate them in the proper care and treatment of patients [10]. Distance learning has been used to help reduce this professional isolation and aid in the professional development of rural specialists [11]. Rural healthcare providers participating in interactive videoconferences have rated them positively and found them helpful in overcoming the large distances separating physicians [12]. Interactive videoconferencing increases the availability of continuing education for rural providers. It allows providers, who likely would not otherwise participate, to benefit from participation in such educational programmes, while avoiding the costs in money and time associated with travel to such educational meetings [13].

While the use of technology is unlikely to completely remove all issues relating to faculty shortages, new developments in technology may be beneficial in reducing some of these problems and could potentially provide solutions as well [14]. Moreover, Schroth *et al*. state that distance from postgraduate centres and domestic commitments are the key factors inhibiting healthcare staff from undertaking continuing professional development (CPD) regularly [15]. Therefore, distance education – and specifically interactive videoconferencing – is one such technology with the potential to provide students and residents with excellent educational opportunities while simultaneously lessening the burden on faculty members[16]. It has the potential to increase access to instructors that are not locally available. Using interactive videoconferencing, students can have exposure to and interaction with experts in the field from whom students would otherwise not have the opportunity to learn. When students are able to learn from a more experienced expert in a particular field, the students potentially have a better and more diverse learning experience [17]. In addition, the local faculty has a decreased teaching burden in terms of class preparation. Distance education also allows multiple groups to participate from distant locations, providing an opportunity to educate more people with fewer instructors. This has the potential for greater educational cost-effectiveness, with many people in distant locations benefiting from the instruction of a distant instructor [18, 19].

Due to the author's work with the Ministry of Health (MOH) in Saudi Arabia for over 10 years, along with the researcher's knowledge verified by checking numerous pieces of relevant literature, no studies appear to have been carried out in Saudi Arabia which assess dental professionals' attitudes towards the benefits and challenges of teledentistry in general or videoconferencing in particular. Also, no studies have been carried out to assess dental health professionals' willingness to use this technology in education, particularly for dental purposes. Therefore, this review aim to investigate the impact of employing videoconferencing on the learning outcomes of Dental Healthcare Personnel (DHCP) or dental students; to explore the required technologies for the implementation of successful videoconferencing as a dental education tool; and to discuss the future prospect of implementing videoconferencing as a dental education instrument in my practice in Saudi Arabia.

MATERIALS AND METHODS

To enable the selection of appropriate studies through appropriate inclusion criteria [20], a review question was formulated based on PICO framework as shown in figure 1.

P –**Population** – Dental healthcare personnel (DHCP).

I – **Intervention** –Using videoconferencing as an education tool.

C– **Comparison** –Traditional methods of dental education or any other educational methods.

O – **Outcomes** – Enhance learning quality of the target audience from different perspectives such as cost, students'/teachers' convenience, time, attraction, interaction and so on.

Fig-1: PICO approach for quantitative review question (Wallace *et al.*, 2009)

A search was undertaken using four approaches in order to identify all of the primary studies within the range of the review question. Firstly, 11 electronic databases were searched for any relevant articles. These databases are MEDLINE, PubMed, ESBCO, (CINAHL), Wiley Online Library, Saudi digital library, ProQuest, SienceDirect /Elsevier, Cochrane Database of Systematic Reviews, and the Ovid and Education database ERIC. The following search strings, with appropriate alterations for the different databases, were used: "Teledentistry", "Telemedicine and dental education", "Telemedicine and dentistry", "Dental videoconferencing", "Dental education", "Dental synchronous Education" and "Dental Distant Learning". Keywords were used both singularly and in combination in order to conduct a thorough search of the databases and retrieve the most relevant studies. Secondly, bibliographies were hand searched in order to identify the maximum number of relevant studies, and the following journals were hand searched: the Dental Education Journal, Telemed and the Telecare Journal, and the Telemedicine and e-Health Journal. Thirdly, a citation track was also carried out, either manually by searching in the reference section of the selected articles to explore new articles or via Scopus (from Elsevier) by searching by author name for related articles. Finally, unpublished studies and grey literature that meet the inclusion and exclusion criteria were searched as well to reduce the possibility of publication bias and widening the search results. Unpublished, potentially relevant work can be located in a number of ways. The most important of these involves contacting researchers with one or more publication on the topic for forthcoming data, or further details of existing data [21]. Thus, two authors who are experts in this field and had published a great deal of research on videoconferencing in dental education have been corresponded. Moreover, the author searched on Google scholar and different databases such as opengrey.eu, which is a European database compiled by different national libraries in various European countries, who submit any grey literature they receive, and the WorldCat database for dissertations and theses. Government agencies, conference proceedings and other scientific associations were investigated to retrieve any related articles.

Table 1 shows the inclusion and exclusion criteria that were used to determine which studies should be included in this review. In order to reduce the reviewer bias, 10% of the total number of the identified articles was given to one of author peers who is interested in the same area to examine the validity of the inclusion and exclusion criteria as a calibration rule.

Table-1: Inclusion and exclusion criteria

Number	Inclusion criteria	Exclusion criteria
1	All of the publications were required to be published in English.	Studies that have been written in languages other than English.
2	The publication date had to be from the earliest date published to January 2018.	Studies with no abstracts when retrieved from the electronic database.
3	Studies that were conducted on DHCP only.	When the population of the studies is not exclusive to DHCP or students in the Dental field.
4	Studies focusing exclusively on videoconferencing in dental education not in any other medical field or by using other teledentistry approaches such as online learning.	Studies that focus on other applications of Videoconferencing rather than dental education.
5	Studies that compared Videoconferencing to standard dental education methods or anything else.	Studies that used any other methods of Teledentistry as an education tool rather than videoconferencing, such as online dental education, web-based self-Instruction, applications and gaming that were used either online or offline.
6	Studies published in peer-reviewed journals, dissertations, unpublished materials or any grey literature.	Dental practitioners' or patients' opinions, attitudes towards telehealth/videoconferencing studies, editorials letters, literature reviews, commentary Reports, legal issues, and books.

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines checklists were applied after all of the articles had been identified [figure 2]. Furthermore, it was decided which studies should be included and excluded, by examining the eligibility of the articles and extracting the relevant information. After that, all of the selected primary studies were assessed for the quality of their study design.

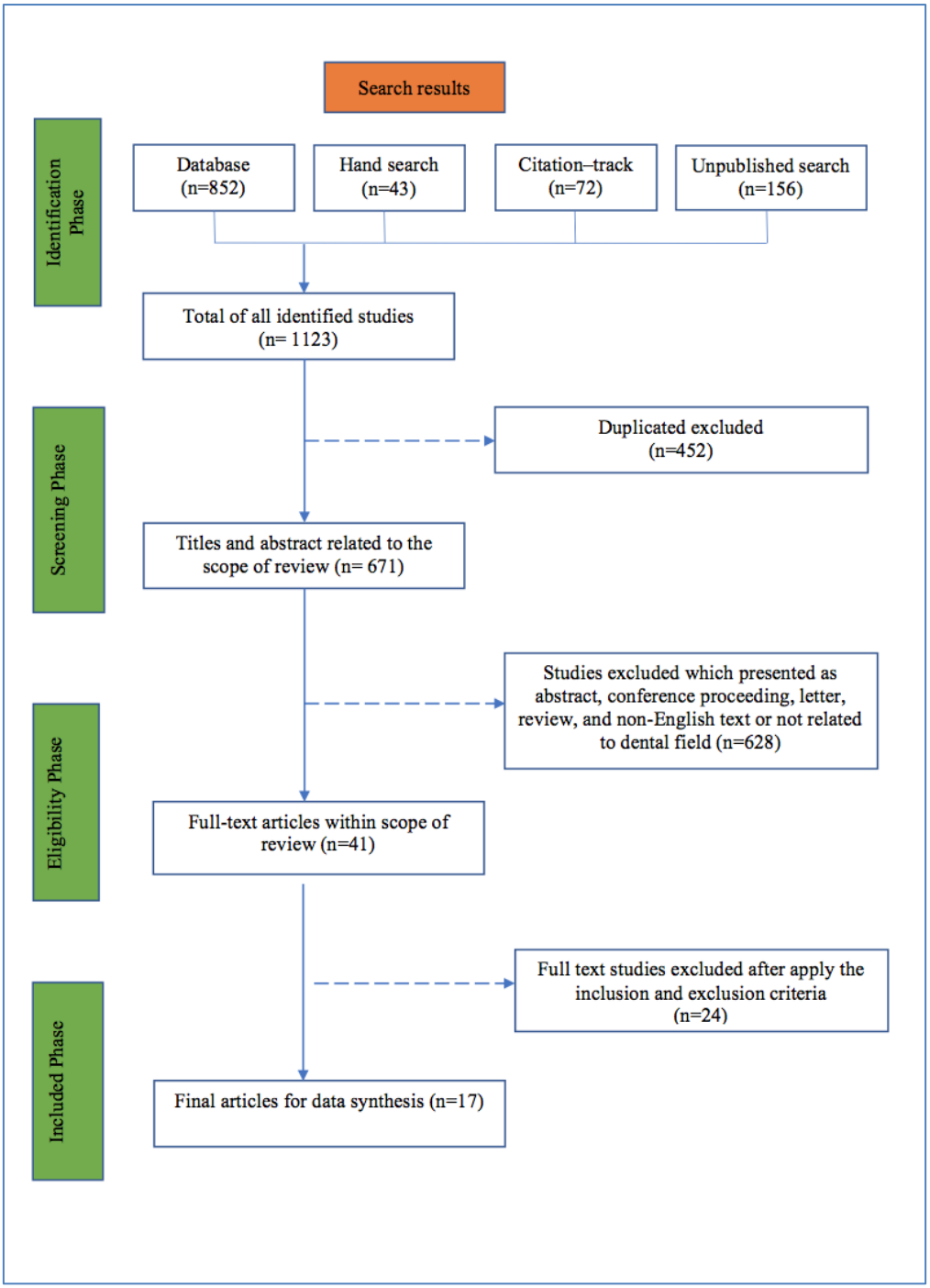

Fig-2: Systematic Reviews and Meta-Analyses (PRISMA) guidelines checklists

DATA EXTRACTION AND ANALYSIS

Health Care Practice R&D Unit (HCPRDU) from the University of Salford; was used in this review to examine the methodological quality of individual studies. Based on this checklist tool, a scoring system from 15 criteria was developed by the author to rate the quality of each primary study. Two points for each single criterion were given if the study met it, whereas null points were given if the study failed to meet the specific criterion. If the given information was not clear or could not be securely judged, then it deserved one point only. Based on these scores, the total was calculated and each study was categorised into one of three groups based on their quality: high quality from 30 to 24, moderate from 23 to 14 and poor quality below 14 points. The analysis was made clear by grouping these data together for analysis within two thematic categories. The first one was investigating the impact of videoconferencing on DHCP's learning from different perspectives such as cost, students'/teachers' convenience, time, knowledge gain, interaction and so on. The second category was the technologies required for the implementation of successful videoconferencing

as a dental education tool in Saudi Arabia were explored.

RESULTS

All four search approaches, which comprised the database search, hand searching, citation tracking and the search for unpublished material, yielded 671 studies, after removal of the duplicated studies. The titles and abstracts of all 671 of these studies were reviewed and based on this assessment all of the studies were potentially relevant. Reviews, letters, and comment studies, as well as non-English texts and studies not related to the dental field were excluded. This step resulted in 41 remaining studies, which were then evaluated against the inclusion and exclusion criteria that were described in the methodological chapter. If a decision over a text's relevance could not be reached based on the title and abstract alone, the researcher read the full text and then assessed this against the same inclusion and exclusion criteria. During this process, 24 studies were excluded as they did not meet the criteria in the following ways: the participants in 6 studies were nurses and other healthcare providers rather than DHCPs; 2 studies used videoconferencing for non-education purposes; 11 studies used a different approach to teledentistry rather than videoconferencing tools, such as online learning, video monitoring and learning applications. Five studies did not meet the criteria for other reasons. These two screening rounds, reviewing first the title and abstract and then the full text, resulted in a final number of 17 eligible studies for mapping and quality appraisal [12,22–37]. The included studies are shown in table 2. The majority of studies were conducted in the United States (n= 12) and in general dentistry (n=6) [table 3].

The majority of the literature (11 studies) were of moderate quality [22,24,25,27,28,30,33–37], while four studies were considered as being high quality [12,23,26,32] and the last two were located in the poor quality category [29, 31]. Most of the included studies were mixed qualitative studies (12 studies) and the remaining were quantitative studies (5 studies).

DATA SYNTHESIS

As a result of heterogeneity and inconsistency among the 17 identified studies, Meta-analysis cannot be conducted. In this situation, narrative synthesis is used instead of meta- analysis which is the case for this review. The data extracted from the studies was synthesised in this review by dividing the data into two categories: the impact of videoconferencing on the DHCPs and the Technology requirements for successful videoconferencing education in dental field.

Table-2: Eligible studies (total 17) with key findings

Study	Aim	Study design	Care setting/sample size	Data collection methods	Key findings
Eaton et al., 2001	To evaluate how effective continuing professional development (CPD) is among small groups of dentists and four dental schools at different sites using videoconference links.	Mixed method design (quantitative and qualitative); survey	257 dentists participated in 40 postgraduate videoconference teaching sessions which took place in 1998/1999.	Questionnaire based on Likert scale and open-ended questions were used to evaluate three areas: presentational style, technical aspects and educational value	The majority of the participants (90%) felt that videoconferencing was helpful in delivering educational material. It was noted that participants found the most beneficial aspects of videoconferencing to be no need for travel, the accessibility of excellent lecturers, and the opportunity for discussion and interaction with experts. Participants also rated technical aspects quite highly as well, in particular sound quality (54-76%). Once the technology has had a chance to improve sufficiently, it has the potential to provide CPD for dental professionals in the workplace or at home, depending on their requirements.
Odell et al., 2001	To evaluate how feasible videoconferencing is for postgraduate education; to assess its practicability and teacher satisfaction; to evaluate the necessary equipment.	Mixed method design (quantitative and qualitative); survey	27 teachers from 4 dental school at London deliver 40 lectures and discussion sessions to more than 250 dentists at distant sites.	Questionnaire based on Likert scale and open-ended questions were used beside video recording of both presenter and audience	The time needed to prepare for videoconferencing was roughly the same as for a face-to-face lecture. 20 lecturers were given the opportunity to use videoconferencing instead of lectures; the videotapes showed the lecturers to be confident with the new medium and adapted to it with little effort. The most common faults exposed were those commonly seen in novices, namely too much movement and not enough looking at the camera. Overall, lecturers viewed the medium positively, although an increase in sound quality would enable a more rapid uptake of videoconferencing in postgraduate dental education.
Bednar et al., 2007	To assess levels of acceptability by both faculty and orthodontic residents and efficacy in the context of learning gains using a range of instruction modes using a videoconferencing tool.	Quantitative study; pre- and post-test design	Orthodontics residents from three universities in the USA (namely Ohio State University, the University of North Carolina, and the University of Louisville) were involved in the current research, and participants took part in clinical conferences, basic concepts seminars, and clinical seminars by means of high-speed internet connection.	7-point Likert scale questionnaire	The orthodontists viewed the educational experiences as positive. Participation on real-time videoconference seminars was preferable to both real-time observation and later observation of recorded material. The authors concluded that this acceptance of videoconference seminars was influenced by the personality and enthusiasm of the instructor and their teaching style, which enhanced the experience.

Klein et al., 2011	To evaluate the effectiveness and acceptance of the use of videoconference and interactive seminars for the purpose of in-office continuing education.	Mixed method design (quantitative and qualitative); survey	23 orthodontists in private practice were divided into five smaller groups based on their experience, ability to use computers, different software of videoconferencing and location. They participated in watching recorded interactive seminars (60 minutes) in which faculty members and residents shared ideas, questions, and opinions about a selected topic. A follow-up discussion for continued education without having to leave one's office or home was carried out. For all seminars, preparation required reading seven to 10 assigned articles in the orthodontic literature which were sent out in advance.	Questionnaire based on Likert scale and open-ended questions as feedback	The use of recorded seminars followed by live interaction through videoconferencing is not distractive, and it can be an effective and highly useful means of providing at-home or in-office continuing education. This could potentially save private orthodontists both time and travel costs. There was 72% agreement that they could learn the material as well as in a traditional class. 22 of the 23 participants agreed that this was an enjoyable and effective learning experience. All groups also commented that the quality of the recorded seminars could and should be improved, with emphasis on audio and video quality. Overall, all participants agreed that they would recommend this method of learning to others.
Klein et al., 2012	(1) Gauge programmatic interest in using blended distance learning, (2) evaluate interest from faculty and residents, (3) ascertain the perceived usefulness of the seminars, and (4) gather feedback pertaining to future use.	Mixed method design (quantitative and qualitative); survey	63 orthodontic residents from programmes in the USA were invited to participate in 25 interactive seminars. Participants in this blended learning project were expected to: read all assigned articles before viewing a recorded seminar; watch a 1 to 1.5-hour recording of an actual interactive seminar on a website; and participate in a 30-minute follow-up discussion immediately after watching the recorded seminar, either with a faculty member at the participating institution, or via a videoconference with the leader of the web-based seminar.	Questionnaire based on Likert scale and open-ended questions as feedback	Just over half (n=33, 52%) of the 63 US graduate orthodontic programmes fully participated in this project with a total of 256 residents and 42 faculty members. 80% of the residents and 83% of the faculty completed the surveys that provided feedback on their experiences. Perceptions from both residents and faculty were generally positive. However, faculty rated the experience on average as more enjoyable and effective than did the residents. Overall, although feedback was received concerning the need for improvements to the technology such as faster pace, better editing, more frequent slides shown throughout the recording, and better sound quality, the majority of participants were in agreement that they would use this technique for distance learning again.
Martin et al., 2012	To make comparison between three communication modalities: video and audio over internet protocol [AV]; AV plus a 3D virtual artefact [AV3D]; and traditional face-to-face [FTF].	Mixed method design (quantitative and qualitative)	14 Fourth-year undergraduate dental students at university of Sheffield in the UK spilt into two groups to present a clinical case scenario to their supervisor. All learners participated in all three communication modalities (face-to-face, audio and video communication as remote discussion or audio, video and 3D communication).	The experiments were assessed qualitatively (video) and quantitatively (questionnaire)	The video evidence revealed that the participants were considerably more relaxed using AV and AV3d rather than FTF. Higher levels of eye contact were recorded during AV and AV3D than FTF. From the evaluation questionnaires, it is clear that both staff and students felt that more learning could be achieved using the FTF method, followed by AV, then finally AV3D. Overall, an internet-based remote meeting was seen as more relaxed, but with lower levels of learning compared to the FTF method.
Miller et al., 2011	To test the effectiveness and level of acceptance in the use of previously recorded interactive seminars and various kinds of live follow-up discussions.	Mixed method design (quantitative and qualitative); survey	Orthodontic residents from 12 universities participated in evaluating four methods: local follow-up discussion, videoconference, teleconference (audio only), and no discussion. After distant residents accessed the seminars, they were able to watch them at their convenience.	Pre-test and post-test questionnaire based on 7-point Likert scale and open-ended questions as feedback	The action of being live and interactive from a remote location seems to be as acceptable and as effective as local live interaction. Following an interactive seminar recording, participants rated local follow-up discussion as being very similar to videoconferencing, although teleconferencing and no discussion were rated much lower. Overall, it appears that using interactive seminar recordings along with follow-up discussion is as effective as interaction in a live seminar.
Ignatius et al., 2006	To ascertain how information and communication technologies can be utilised in the context of dental education in order to reduce travel and increase the interactivity between teachers and students.	Quantitative design; survey	A total of 26 dental residents from different specialties in eight different cities in Finland participated in this study. IP-based videoconferencing was used to transmit lectures from the university to a number of training locations. Students were able to raise questions and could present images of their clinical cases throughout the lectures. The videoconference also included discussions about treatment plans.	Post-test questionnaire to assess picture and sound quality separately, as well as to provide a rating for videoconference as an educational tool.	The response rate was 65%. Results revealed that, in terms of using videoconferencing as an educational tool, the rating was excellent in 15%, good in 62%, neutral in 15% and poor in 8%. The quality of images was rated as good (29%), neutral by ten (48%) and poor by five (24%), with no excellent rate. On the other hand, the quality of the sound was rated as excellent by 7%, good by 57%, neutral by 29% and poor by 8%. Moreover, the overall potential cost saving per student was estimated to be at least €43,600. In conclusion, the study suggests that videoconferencing is an appropriate tool for use in long distance learning in dentistry.

Miller et al., 2007	Assess how well pre-recorded seminars and follow-up discussion are in distance learning, with a particular focus on orthodontic training programmes and continuing education.	Mixed method design (quantitative and qualitative); survey	85 orthodontists from three dental schools and a number of Iranian orthodontists were asked to prepare for and then watch three pre-recorded seminars about basic dentistry, before taking part in a live discussion immediately following the seminar. Evaluation was made on three types of communication at the discussion seminar: audio interaction via telephone; chat room interaction via Net Meeting software; and live video interaction using high-speed internet connection.	Questionnaire based on 7-point Likert scale after each session and open-ended questions	Results revealed that videoconferencing received the highest ratings, telephone interaction came in the second place, and finally internet chat came in third place. Moreover, all the residents reported that they would be happy to repeat the distance learning experience again. In conclusion, based on the evidence seen in the pre-recorded seminars and follow-up discussions, distance learning is an effective means of instruction which can assist orthodontic residents in gaining access to educational tools, information, and expert lecturers.
Johnson et al., 2006	To evaluate the effectiveness of continue dental education (CDE) through two-way interactive audio and video communication.	Mixed method design (quantitative and qualitative); survey	80 participants from 10 remote sites attended a CDE course through Iowa communication network (ICN).	A questionnaire at the end of the course. 13 questions answered by agree or disagree and feedback as well	Participants overwhelmingly felt that there was sufficient interaction and asking question with the instructors, who for some was more than 100 miles away (93.2%). Based on participants feedback, 76.2% of the ICN course participants felt that they saved between $100 and $250 by attending this course. Overall, the participants were very pleased with the quality of the electronic presentations (89.4%).
Reynolds et al., 2002	The utilisation of webcasting and videoconferencing for dental training. Also, to compare videoconferencing and webcasting in different teaching scenarios in the dental education context.	Mixed method design (quantitative and qualitative);	220 participants from the dental school at King's College, London participated in videoconferencing (n=8) and three phased online learning sessions (n=35) Most of the students were undergraduate dental surgeons.	Qualitative analysis was utilised involving questionnaires with a 5-point Likert scale, interviews, and observations. Educational, presentational, and technical issues were evaluated.	Participants rated the video media very highly, and thus it was considered to be the most appropriate method of CPD delivery (rated very good and good more than 80% of the time). The seminar presenter and the teaching material also scored highly in all areas (good to very good, 4–5 on the Likert scale). Videoconferencing was viewed as being more suited to 'special occasions' like large or important lectures, while webcasting was deemed more suitable for one-to-one situations. From a technical perspective, webcasting does not involve any extra work for the presenter, there is more reliable audio, and the time needed to set up is much less than for videoconferencing.

Gruppen et al., 1996	To evaluate of the efficacy of interactive videoconferencing in maxillofacial surgery residency and continuing education.	Mixed method design (quantitative and qualitative); survey	Two topics for videoconferencing broadcast across 55 sites throughout the USA and Canada in two separate sessions, to be viewed from over 2000 oral surgeons. The format of both broadcasts consisted of a surgical case study of an actual patient. This portion included recorded commentary from several members of surgical team. After the 60-minute taped portion, audiences were given the opportunity to telephone a panel of national experts with questions related to the topic which took 90 minutes.	Pre-test and post-test questionnaire and open-ended questions as feedback after each session	The results provide evidence that an educational videoconferencing broadcast can have a substantial impact on the knowledge and attitudes of oral and maxillofacial surgery residents, faculty and practitioners. All groups showed a statistically significant increase in knowledge and confidence attributed to the broadcasts. However, there were a few negative observations focused largely on several technical problems encountered during the broadcast at specific sites.
Reynolds, 2001	A dental practice on the Isle of Wight was provided with a videoconference link which enabled students to observe 'real-life' treatments and diagnoses via intra-oral cameras.	Mixed method design (quantitative and qualitative); survey	Nearly 600 undergraduate dental students participated over four years in the videoconferencing project. Besides the diagnosis facility, the project consists of weekly seminars and five major lectures on various topics each year. Students have access to remote staff.	A questionnaire based on Likert scale and open-ended questions as feedback	Assessment of the project showed that the vast majority of students – 98% – found the sessions to be good or very good, and most students felt they would benefit from further sessions. While some local staff found the associated equipment to be complex, they appreciated the enhanced experience it gave the students. Likewise, the students valued the use of technology in this manner.
Kunin et al., 2013	To assess whether the educational needs of the students were met by the new asynchronous format, as opposed to the traditional FTF and synchronous formats.	Mixed method design (quantitative and qualitative); survey	Total of 219 first year dental residents in the General Practice Residency participated in five endodontic lectures through face-to-face (n=30), synchronous /videoconferencing (n=139), and asynchronous/online (n= 219) learning formats.	Pre-test and post-test questionnaire and open-ended questions as feedback	There was a 77% response rate. Students reported a preference for FTF and asynchronous formats over the synchronous format for efficacy, clarity of presentations, and quality of interactions between presenter and students. This curricular model was impacted heavily by technology, and the results indicate that the asynchronous format is a useful method for teaching postgraduate courses.

Iwaki et al., 2012	To assess how effective live broadcast lectures are, with the same content presented twice but with a different structure each time.	Mixed method design (quantitative and qualitative); survey	A one-hour live broadcast on complete denture prosthodontics was presented to two sets of fourth-year students: 63 students in 2009, and 67 students in 2010. In addition, 13 faculty members in 2009 and 14 in 2010 were in attendance.	Post-test questionnaire and open-ended questions as feedback	There was a 100% response rate. The study results indicate that live broadcast lectures can potentially assist students in experiencing clinical settings, and could help in complete denture prosthodontics education. Several students felt negatively towards some technical factors such as sound and light. Nevertheless, the overall experience of live broadcast followed by lecture was found to be very useful.
Mattheos et al., 2003	To evaluate the application of internet-based videoconferencing on an interactive examination.	Quantitative design; cross sectional	39 undergraduate second-year students were divided into five groups for assessment purposes of the final exam in periodontology, either three groups for assessment via videoconferencing (n=24) or two groups for standard classroom assessment (n=15). The standard classroom examination was held at Malmo University, Sweden and the assessor in the videoconferencing assessment was in Bern, Switzerland.	Questionnaire and students score at both assessment modalities	The technology used in this study was found to be reliable. The technique used for the interactive exam was viewed positively, although attitudes towards the videoconferencing were significantly less positive ($p < 0.01$). No statistically significant differences were found between the performance of each group. Students in the conventional group reported that interaction was the main strength of the exam, however the videoconference group did not report the same appreciation. Overall, while students might prefer classroom-based assessment, internet-based videoconferencing is able to facilitate a highly structured assessment very successfully.
Cook and Stevens, 2000	To assess the cost of the videoconferencing in postgraduate dental education.	Quantitative design; cross sectional	Between January 1997 and July 1998, 15 videoconferencing teaching sessions were held between centres in Bristol, Taunton, London and Winchester. Equipment costs were calculated and included in the videoconferencing system. Staff costs were calculated at £93 per hour for consultation /senior lecturer, £33 for dental GP based on NHS staff costs. Travel costs were on car travel at 25p per mile.	A questionnaire after each session and estimated cost calculation for three scenarios	The majority of participants felt that any disadvantages were outweighed by the saving in time and travel. In all the three scenarios, our calculations demonstrate that significant savings principally on the cost travelling time.

Table-3: Studies conducted in several countries

No	Country	No of studies	Studies references
1	USA	8	Bednar et al., 2007 ; Klein et al., 2011 ; Klein et al., 2012 ; Miller et al., 2011 ; Miller et al., 2007, Johnson et al., 2000 ; Gruppen et al., 1996 and Kunin et al., 2013.
2	UK	6	Eaton et al., 2001; Odell et al., 2001; Martin et al., 2012; Reynolds et al., 2002; Cook and Stevens, 2000 and Reynolds, 2001.
3	Finland	1	Ignatius et al., 2006.
4	Japan	1	Iwaki et al., 2012.
5	Videoconferencing held between Sweden and Switzerland	1	Mattheos et al., 2003.

Impact of Videoconferencing on DHCP's learning

The influence of this modality of learning on DHCP could be measured from different perspectives such as cost benefits, students'/teachers' convenience, interaction, time efficiency, and knowledge gain.

Cost benefits

Cook and Stevens constructed three scenarios for calculating the cost of videoconferencing in comparison with traditional lectures when the trainees travel to attend training sessions. They stated that in all the three scenarios, the calculations from 15 videoconferencing sessions demonstrate a significant saving, principally in costs associated with travelling time. For example, in the second scenario, an expert was available via a distant link to two remote sites simultaneously, thus saving the cost and time of the two journeys otherwise required. The cost of this expert to visit the two sites separately for a total of ten trainees who are far away (100 miles) from the presenter's site was £1,588 whereas the cost of 1.5-hour three site tutorials through videoconferencing using an ISDN line was £820, meaning that the difference between the two modalities was £768 [29]. In the same way, Ignatius *et al.* conducting 100 videoconferencing sessions from the University of Turku in Finland to over eight different cities at varying distances (range 50–350 km). The total annual expenses for face-to-face lectures per student are €21,800, broken down as follows. Firstly, assuming that the students used the cheapest form of transport available to them, their travel costs would be €12,800 euros per year. Secondly, the time spent traveling represents time that is lost for working, which is estimated to be worth €250 euros per day, or €18,000 a

year. However, as roughly half of the lectures took place in the evenings this figure can be halved to €9,000 euros per student annually. Balancing this, the cost of the videoconferencing equipment had to be taken into account. The cost of the equipment was approximately €6000, accounting for the fact that 5 trainees could use one display monitor at a time, while the cost of maintaining the equipment and the cost of connecting to the Internet were around €1000 per year per site. The total cost saving of using videoconferencing for training was therefore calculated to be at least €20,400 per student annually. It was thus concluded that long-distance learning in dentistry could be well served by videoconferencing [36]. Based on the participants' feedback in Johnson *et al.*'s study, 76.2% of the participants felt that they saved between $100 and $250 per session by attending their course through videoconferencing compared with face-to-face education sessions [37]. All stated that most participants were interested in engaging in videoconferencing training sessions again due to the cost benefits and the advantage of access to first-rate lecturers from home or the office without the need to travel [12,22,24,25].

Convenience

90% of the participants expressed positive opinions about the ability and efficiency of receiving educational material through videoconferencing. The greatest benefits of this mode of learning, according to the participants, were having the opportunity to communicate with experts in their field, being taught by first-rate lecturers, and eliminating the need to travel [22]. Odell *et al*. used video recording as a qualitative method in addition to a questionnaire with 27 teachers who participated in 40 videoconferencing sessions as part of distance learning in the UK. The video recorded sessions showed that the lecturers appeared confident and seemed to have adapted to this new mode of teaching with very little trouble. Moreover, 20 teachers out of 27 considered videoconferencing as an alternative to giving lectures in person and they found it free of stress, despite it being the first time that any of them had delivered lectures through videoconferencing [30]. The same situation occurred with 14 students in Martin *et al.*'s study [33]. They reported that the video recordings showed that the students were significantly more relaxed and empathetic during the discussion with their supervisor when using audio-video communication than when using face-to-face communication. Reynolds evaluated the effectiveness of videoconferencing links for the delivery of education courses for nearly 600 undergraduate students of a dental school who participated in the project for over 4 years. The project results indicated that videoconferencing was regarded by the participants as an effective way of learning, as 98% said that the sessions were good or very good and more than 95% would like to repeat the experience [25]. Iwaki *et al.* broadcasted a live clinical case for one hour to fourth-year undergraduates and they reported that 90% of the participants felt that this method was better than observing the procedure in clinics, since all of the students could see the same case in an effective manner [27]. In the same way, Klein *et al.* used recorded interactive seminars for 23 orthodontists who were in private clinics. The participants watched recorded interactive seminars (60 minutes) in which faculty members and residents shared ideas, questions, and opinions about selected topics. Then there were follow-up discussions that the participants could take part in without having to leave their office or home. As a result, several participants specifically commented that they liked being able to watch the videos at their convenience and being able to stop, start, rewind, and fast-forward as they pleased, then participate in distance interactions from their office and home [12]. They agreed that this was an enjoyable and effective way to learn. In fact, this is in agreement with the findings of Cook and Stevens, who reported that the financial savings are not the only potential benefit of using this technology [29]. An equally persuasive reason for its use may be its capacity to facilitate increased educational opportunities by reducing the impact of geographical isolation and improving access to expert tuition.

Student-teachers and/or student-student interaction

Reynolds *et al.* stated that 'Interactivity' is crucial between teachers and students [23]. Therefore, training by watching recorded lectures, and then participating in discussions through videoconferencing, allows the learners to concentrate and to learn at their own pace, so it is an effective method that orthodontists can use either at home or in the office [12]. Johnson *et al.* conducted videoconferencing between 10 remote sites for 80 general dentists as a continuing education course and they stated that the dentists agreed overwhelmingly (93.2%) that even though the instructors were many miles away, they still had plenty of opportunities to interact with them and ask questions, which reflected positively on their knowledge [37]. Miller *et al.* evaluated how acceptable and effective it was to learn with previously recorded interactive lectures, followed by different kinds of discussions. They found little difference between live interaction when the participants are next to each other, and live interaction from a distance. The participants in the study commented that engaging in follow-up discussions was the same, whether they were in the same room as the lecturers or conducted as distance learning with a far-away faculty [34]. In the same way, Bednar *et al*. stated that the orthodontic residents had positive opinions of educational experiences that were mediated through videoconferencing [31]. They rated most highly the experience of live participation in seminars via video conferencing, rather than watching a pre-recorded lecture, as they felt that this was more interactive and helped them to learn more effectively [31]. Miller *et al.* compared three types of interaction as post- seminar discussion: audio interaction through a

telephone; interacting in a chat room with Net Meeting software; and live video interaction using high-speed Internet. The results revealed that videoconferencing received the highest ratings, telephone interaction came in second place and finally Internet chat came in third place [35]. On the other hand, Kunin *et al.* reported in their study that residents rated face-to-face instruction significantly highest in terms of effectiveness, clarity of presentation and quality of student- instructor and student-student interaction, compared to asynchronous formats (online) and the synchronous format (videoconferencing) [26]. Mattheos *et al.* compared assessment via videoconferencing with standard classroom examination and he found that the students in the conventional group viewed interaction as one of the main advantages of examination, but interaction was not as highly rated by the videoconference group [28]. Conversely, Reynolds *et al.* stated that the 'Interactivity' was appreciated most in online webcasting where the chat box gave time to reflect before responding, compared to webcasting without a chat box or videoconferencing [23]. However, Bednar *et al.* confirmed that the acceptability of distant interactive seminars was influenced by the instructor's personality and teaching style and how that can facilitate the interaction [31]. This is in agreement with the findings of Klein *et al.*, who stated that the negative reactions and low levels of interaction were primarily related to the topic or the fact that the presenter was not clear [12].

Time

Odell *et al.* reported from the teachers' view that it took the same amount of time to prepare for videoconferencing as face-to-face lectures. For 90% of the sessions, preparation ranged from ten to sixty minutes. Teachers reported that the medium had not caused significant additional workload. Moreover, when the teachers were asked to rate videoconferencing with the option of travelling to deliver the same seminar, just 6 out of 27 said that they would rather have travelled. Others said it was 'different' rather than an alternative and at least two felt it could not replace being present in person [30]. It can also be seen that time could be saved not only when preparing the teaching material, but also in avoiding having to travel to different locations to deliver or attend educational courses [12]. Eaton *et al.* conducted a study to evaluate the effectiveness of continuing professional development (CPD) when it was delivered to dentists via videoconferencing. This was the first study to use videoconferencing to overcome the constraints of time rather than travel, as the distance of 12 miles between the postgraduate centres and the nearest London teaching hospital would take one hour at non-peak times. An overwhelming majority (90%) of the participants were happy that they no longer needed to travel to London to take part in education sessions and would like to participate in future videoconferencing opportunities [22].

Knowledge gain

Gruppen *et al.* evaluated the efficacy of interactive videoconferencing in Maxillofacial Surgery Residency and Continuing Education by broadcasting two topics with videoconferencing at 55 sites throughout USA and Canada [24]. This took place in two separate sessions, which were viewed by over 2,000 oral surgeons. They use pre- and post-test to assess the difference in comprehension; the same knowledge assessment items were administered before and after the broadcast. The results provide evidence that an educational videoconferencing broadcast can have a substantial impact on the knowledge and attitudes of oral and Maxillofacial surgery residents and practitioners. All of the groups showed a statistically significant increase in knowledge (almost 18%) after the Naso-Orbital Ethmoidal course (NOE) and 24% after the Severely Atrophic Maxilla course (SAM). The confidence attributed to the broadcasts also increased from 2.9 before the broadcast to 3.8 after it. Both programmes gained high ratings for the education material's quality and the fact that it was easy to understand the surgical procedures [24]. On the other hand, Martin *et al.* compared three different ways in which an educator and learners can communicate: face-to-face (FTF), audio and video (AV) and three-dimensional audio and video (AVD3). The students filled in an evaluation questionnaire, the results of which showed that they preferred FTF interactions as they felt that this provided more opportunity for providing and obtaining information. AV was ranked second and then AV3D. Face-to-face interactions were also rated highest by the educators for the same reason, the receiving and delivering of information [33]. From the knowledge impact perspective, Reynolds *et al.* argued that videoconferencing should be preserved for 'special occasions', for example important seminal lectures, and that webcasting (online) learning was preferable in a one-to-one setting [23]. Klein *et al.* claimed that video interaction was more effective at helping students to understand the educational material, and was better than simply reading the material. They also reported that videoconferencing delivered a better learning experience, compared to learning without it. However, there was 72% agreement that they could also learn the material in a traditional class and that it was an effective method of providing continuing education [12].

Technology requirements for successful videoconferencing education in dental field

Table 4 highlights the systems used in each study to conduct education via videoconferencing links. It can be seen from the data above that an Internet connection, camera, and sound equipment such as a microphone are the principal materials that are required to establish a videoconference call. There was no agreement between the studies regarding the standard equipment needed to conduct videoconferencing, but the Internet connection speed seems to be a vital

element for success. However, some studies did not include any information regarding the materials they used to handle their distant courses [24–26,28]. Based on the participants' responses, many studies show that the negative part of this modality is related to technical aspects, especially the sound component and the Internet connection [12, 22, 23, 27, 32, 36, 37]. However, improvements in technology would allow a rapid expansion of dental education by videoconferencing.

Table-4: systems used in each study to conduct education via videoconferencing

Study	systems for videoconferencing	Associated technical problems
Eaton et al., 2001 & Odell et al., 2001	PC incorporated with videoconferencing card release 1.1, commercial ISDN2 (128 kbs) lines, colour videocamera, and a Toshiba TLP 411E data projector with integral rostrum (document) camera. Sound was captured using either AKG C680 BL output via the standard PC speakers or in some centres via lecture theatre sound systems. The videoconferencing systems were mobile allowing transfer between centres.	Sound provided the greatest technical difficulty, as it was often assessed as being poor. Also, there were ISDN2 line faults, which resulted in high levels of pixilation or a frozen picture (with normal sound) and overheating of the data projector.
Bednar et al., 2007	Internet 2 connection and dual-streaming equipment to enable images and data to be transmitted at the same time.	Not reported.
Klein et al., 2011	For group 1 to 4 WebEx software program for videoconferencing and Telephone-line to join conference call. Whereas, for group 5 Elluminate software with both audio and video transmitted over the Internet was used to eliminate the need for a conference call.Web Camera sent to each participant unless the participant's computer had a built–in camera. The Internet bandwidth speed not mentioned.	The post-seminar discussions did receive some criticisms that were largely related to the bandwidth. The images were not clear enough to capture body language cues. There were delays in anyone speaking, and then 2 spoke at the same time. Also, difficulty with setting up WebEx software.
Klein et al., 2012	Not reported.	the slow pace of the seminars, and video and sound quality.
Martin et al., 2012	High-speed fibre optic Internet was used (100 Mbit). Skype software program.	No technical problems were reported.
Miller et al., 2011	A complete videoconferencing system at Ohio State University (OSU) was used. Camera, microphones and many software were used such as ''on the fly'', ''Quicktime''. the Internet speed was not mentioned.	No technical problems were reported.
Ignatius et al., 2006	Lectures were transmitted from the university to the training locations using IP-based videoconferencing (384 kbit/s–1Mbit/s). The University of Turku had a multipoint bridge that allowed 12 videoconferencing sites to be connected simultaneously. The major dental units used set-top videoconferencing units (Polycom FX). In addition to standard audiovisual equipment for videoconferencing, laptop computers, document cameras, digital cameras and wireless intra-oral cameras were used.	Image quality was rated as follows by the participants: 'good' 6 respondents (29%), 'neutral' ten (48%) and 'poor' five (24%). The image quality was not considered to be excellent by anyone Sound quality was rated as follows: 'excellent' 7%, 'good' 57%, 'neutral' 29% and 'poor'8%. The overall rating of videoconferencing as a tool in specialist training was excellent in 15%, good in 62%, neutral in 15% and poor in 8%.
Miller et al., 2007	Internet 2 connection, dual-streaming video conferencing, PowerPoint, To make the recordings available to distant schools, they were digitised with Real video and uploaded to a website at the University of North Carolina (UNC) that was accessible by user name and password	No technical problems were reported
Johnson et al., 2006	Laptop computers, VCRs, slide projectors, video copy stands microphone, multiples camera, touch screen at the presenter's control station and 32-inch monitors. When the microphone is activated from the participants to ask questions the camera zoom in on them directly during the question. Internet speed not mentioned.	Some technical difficulties were experienced (one remote site could not be viewed by the originating site and another experienced difficulty with video transmission).
Reynolds et al., 2002	The videoconferencing equipment used was the PROVIDENT kit and included a full screen PC based system with zoom camera and projection facilities. Both the ISDN2 (128 Kbits/s) and LAN (364 kbits/s) connectivity were available for this investigation.	The sound quality and Camera shyness of audience were the main Problem for videoconferencing.
Gruppen et al., 1996	Not reported	Not reported
Reynolds, 2001	Not reported	Not reported

Kunin et al., 2013	Not reported	Not reported
Iwaki et al., 2012	A ready-made teleconference system (video conferencing system PCS-XG55; Sony Business Solutions Corporation), 2- a liquid-crystal display TV (AQUOS LC-13SX7A, 13 inch; Sharp Corporation); 3- an instrument rack (FOT65-10EC; Nitto Kogyo Corporation), a video camera (NV- S25; Panasonic Corporation). Internet speed not mentioned	There were some desirable improvements to be made to the sound, lighting, slide transition and camera work
Mattheos et al., 2003	Not reported	Not reported
Cook and Stevens, 2000	Videoconferencing system, ISDN line, standard PC, data projector, document camera	Not reported

DISCUSSION

To date and based on our knowledge, this current systematic review appears to be the first to evaluate videoconferencing in dentistry as a tool for dental education. However, the range of various interventions used in the reviewed studies led to difficulties in synthesising the data. The development of technology over the last 20 years can be traced through analysis of these interventions. For example, from a technical perspective, the older papers explored the use landline ISDN as an Internet connection with a simple videoconferencing system [22,23,29,30,36], whereas the latter studies used very fast bandwidth connection such as Internet 2 connection or fibre optic Internet with expensive and advanced videoconferencing systems [31,33–35]. While the ability to compare studies over time is hindered by the rapid changes in technology, it does reveal the development and trajectory of videoconferencing technology in dental education. Further difficulties in comparing the studies arise with the fact that there is no consensus on which learning outcomes to assess; this leads to uncertainty about which teaching platforms the students prefer. Moreover, a large number of studies did not randomly assign participants or use control groups [22,24,25,27,29–32,36,37], thus introducing possible bias into the research, as stated by Olson *et al.*[38].

Distance education in the dental field should be similar or equal in quality to having the instructor physically present. This statement is in accordance with a number of distance learning studies' meta-analyses which demonstrate that the quality of learning outcomes in distance learning is at least equal to more traditional methods of instruction [39,40]. However, the results of this review asserted that no one format is the ideal solution in an educational environment, a conclusion that is consistent with other studies' findings [41]. Studies with a focus on other fields of education report differing results – two studies found that students preferred face-to-face instruction over asynchronous (online) and synchronous (videoconferencing) learning [37, 42]; another reported that synchronous learning was preferred to asynchronous [43]; and other studies did not find differences between synchronous and face-to-face learning [16, 44]. Other studies found web-based learning to be preferred over face-to-face [38, 45], while another found no difference between them [46].

There seems to be a consensus between the identified studies regarding the cost benefits of videoconferencing in comparison with traditional methods of learning. The saving of travelling time and cost were the most positive answers given by the participants in terms of willingness to attend more videoconferencing sessions for the purpose of education. As Odell *et al.* point out; videoconferencing has particular benefits for dentists working from home or from rural locations. For instance, the majority of continuing education occurs outside of normal working hours and impacts on teachers in terms of finding time to teach sessions [30]; this can often involve long journeys or overnight stays to conduct sessions and lectures [2]. For this reason, videoconferencing is frequently marketed as an option which reduces travel costs for all participants, whether students or clinicians. This is particularly true for postgraduate and continuing professional development courses where participants already have a certain degree of subject knowledge, so face-to-face or paper- based lectures are not essential [22, 30, 32, 36]. While a vast array of videoconferencing systems is now available [47], the most suitable option would depend – in part – on the number of participants/connections, the physical configuration of the connected sites, the volume of traffic to be transferred, the necessary applications, and the distance between the connected sites [48]. Videoconferencing was prohibitively expensive in the past, but recent technological advances mean that costs have fallen considerably [49]. While taking all of this into account, dental schools and associated educational organisations can consider a technological education tailored to their needs.

Distance education often creates an image of students sitting at home, or in tiny classrooms in rural and remote locations, behind their computers, isolated from their peers and teachers and working independently. However, well-accepted constructivist theories of learning suggest that students learn best when engaged in a community of inquiry in which peers and teachers play equally important roles [50].

Feeling connected to peers and instructors in community of inquiry has been conceptualised in the literature as 'presence', and is shown to improve both satisfaction [51–53] and outcomes [54] in distance learning. Interacting among new people or different group members would advocate group construction of new knowledge derived by different viewpoints. According to Levine and Resnick [55]. The social interaction among students who have different points of view would direct the creation of knowledge or the discovery of insights through conceptual improvement. Moreover, Jackson asserts that forming groups without the diversity of group members' experiences, perspectives, and knowledge could undermine students' potential for learning and problem-solving effectiveness [56]. Furthermore, another favourable attitude towards the synchronous small-group discussions through videoconferencing was students' learning facilitations such as helping their thinking process and communicating and sharing ideas among group members. It was also established that social interaction between students plays a key role in the learning process, and can impact significantly on learning outcomes. Collaboration between participants has been shown to improve learners' complex and higher-order thinking when discussing problems, brainstorming potential solutions, and arriving at final solutions [57,58]. Participants in more than one study in this review liked learning in their collaborative synchronous in a small-group setting because such an environment allowed them to be able to share ideas, facilitated them towards a better understanding of the concepts, and helped them to work successfully as groups [25,27,34,35,37]. Similar to Goold *et al.*'s study [59], participants in studies by Klein *et al.* [12] and Gruppen *et al*.[24] also enjoyed collaborating with their groups, and reasoned that the process facilitated greater course content comprehension and provided useful knowledge resulting from the interactivity. While Klein *et al*.[12] reported that interacting through videoconferencing technology is not distractive, Lögdlund argued that students participating in VC courses were not interacting as part of learning, but reduced to participant observers. He criticised VC courses in that they were "organized to fulfil the requirements of practice rather than to promote learning" (p.195) [60]. Interaction sufficient to be in parity with a live classroom experience requires reinvention, or modification to the existing VC technology. Therefore, Campbell recommend to reinvent videoconferencing technology in four categories: equipment, teaching methodology, instructor technology training, and student orientation [61]. These four categories each have an effect on the fifth category – interaction. It is believed that modification in these four areas will improve interaction, which is considered key for student academic success as well as in majority innovation decisions favourable to the continued adoption of videoconferencing technology in the dental field. Rogers states that decisions to reject a previously accepted innovation can occur at any stage in the innovation decision process [62]. Further, dissonance such as that previously described can be substantially disruptive in the implementation stage of adoption.

On the contrary, most studies in this review indicated that technology problems were the biggest drawback of videoconferencing at a distance. However, such negative experiences did not greatly affect the overall positive attitudes towards their learning environment in most studies. Problems with sound was reported as the most significant shortcoming of videoconferencing in many studies [12,22,23,27,30,32,36]. Other studies on the usage of videoconferencing revealed similar results, thus emphasising the importance of the quality of the audio transmission [63-65]. Allen *et al.* correspondingly addressed issues which could hinder discussions such as muted microphones, video quality, audio quality, and audio lag [63]. The delays in the transmission of video and audio at times caused some overlaps and interruptions in the dialogue construction [64]. According to O'Conaill *et al.*, in videoconferencing, if the audio transmission was reliable, collaboration processes would be successful [65]. Therefore, technical assistance during the sessions or the provision of good training in how to operate the videoconferencing system seem important [61]. To reduce technical troubles, Odell *et al.* delivered one-day training courses prior the start date of the project and conducted two lectures via videoconferencing to ensure the readiness of the participants [30]. In the same way, Iwaki *et al*. recruited two technology experts to operate the system in both the lecture room and the clinics in order to reduce any technical problems [27]. Moreover, prior to the class meeting time it was necessary to provide clear instruction for the testing of students' audio, webcam, and headsets to ensure that all equipment was functioning properly [66].

According to Engilman *et al*., Internet speed can disrupt the sound quality and video image; this phenomenon is known as latency. An acceptable videoconference must therefore keep latency to a minimum. In order to achieve this, the authors recommend maintaining a high bandwidth (transmission speed), at least 384 kilobits per second, and ideally over 768 kbs [47]. This is in agreement with the findings of this review, whereby the technical problems are mainly associated with low bandwidth connection while no problems were reported with high-speed Internet such as the Internet 2 connection (10 gigabits per second) [31,34,35] or fibreoptic Internet (100 Mbit) [33]. One key point worth noting is that most studies were conducted over a decade ago with limited technology at that time. Therefore, this drawback should be interpreted with caution due to the difference in both videoconferencing technology and Internet bandwidth connection these days in comparison with that time.

Implications for future practice in Saudi Arabia

In early 2016, a new vision for the future of Saudi Arabia was developed; this is known as the 2030 Vision [67]. The vision, values, and mission statement of the country health services were updated accordingly by the Ministry of Health (MOH) to correspond with 2030 Vision [68, 69]. However, a lot of effort is needed to improve the health and education services to achieve the beneficiaries' satisfaction and build a prosperous future and sustainable development [68]. For example, Saudi Arabia is ranked 93rd in Global Internet Connections' Speeds with 4.9 Mbps as the average speed [70], which is above the requirement to conduct videoconferencing (768 kbs or greater) as stated by Engilman *et al*.[47]. Moreover, regarding the readiness of other infrastructure for this technology such as audio-visual systems, the MOH and Saudi Universities are capable of gaining these technologies since the MOH and Ministry of Education in Saudi Arabia receives the highest amount of the country's annual budget each year based on the data from the Ministry of Finance [71]. As stated above, it seems that the MOH and the Universities in KSA do not have any financial barriers to establishing the infrastructure required for videoconferencing. The author believes that leadership and stakeholder engagement are the main obstacles to setting up this technology in the Saudi dental industry. As Scoville and Little, any improvement might be a change, but not any change is necessarily an improvement [72]. Approximately 70-80% of errors within the healthcare sector is down to a breakdown of non-technical skills [73]. It is argued that it is vital to better understand how and why these errors happen, such as teamwork, leadership, communication, decision making and awareness of situations. As a result, leaders play a key role in the success of a project and they must effectively communicate the project's stakeholders in order to motivate all participants to complete the task successfully [74]. The MOH and universities need to invest in producing young leaders who are able to change the entire organisational culture by implementing new ideas. I believe transformational leadership is the best approach and can be utilised to implement this change. In this style, the leaders set out clear goals and motivate people with a shared vision of the future, and they communicate well with them. Al-Sawai states that with transformational leadership, you can encourage trust, autonomy, empowerment, flexibility, creativity and innovation [75]. By building these kinds of qualities you can achieve the changing sustainability. The first step in Kotter's model of change is to establish a sense of urgency [76]. This step, according to Kotter, is crucial as all stakeholders need to collaborate in a holistic fashion to transform the organisation. If stakeholders are not motivated, people will not take part and the effort will be wasted. On the other hand, if early adopters and innovators are targeted rather than those less engaged, there is a greater likelihood of mass engagement and a successful result [62,77,78]. Thus, the process of stakeholder engagement is complex and involves an understanding of the cognitive, behavioural and emotional styles of all those involved [79]. Engaging with stakeholders is no longer a choice for organisations nowadays, and the means of engagement must be chosen [80]. Engagement should be systematic, logical, and practical [81]. Thus, the expense involved in developing and maintaining stakeholders' knowledge in terms of money, time, and effort is justifiable [80].

Providing a curriculum to students scattered over a broad geographical area is a challenging logistic problem, particularly with a relatively small number of dental specialists. These factors often limit the range of educational resources available in most programmes which is typically the situation in Saudi Arabia. Therefore, videoconferencing is considered as an alternative modality of traditional education. The use of videoconferencing in delivering dental courses is still at a relatively early stage in |Saudi Arabia, although the technology has advanced sufficiently to make it a viable option for distance education providers. This will continue to expand in the future.

CONCLUSION

The results of this review asserted that no one format is the ideal solution in an educational environment. The reviewed question is answered successfully in this review. This review shows that there is a positive learning impact of videoconferencing on DHCP. Firstly, there seems to be a consensus between the identified studies regarding the cost benefits of videoconferencing in comparison with traditional methods of learning, from the perspective of saving travelling time and costs, particularly for participants who are in rural areas or very far from education centres. Secondly, videoconferencing technology seems not to be distractive and it encourages interaction between the students themselves and between the students and their teachers, which is reflected positively on the learning process outcome. Finally, there is a debate between the identified studies regarding whether videoconferencing is a more convenient media for learning and whether it allows the students to gain more knowledge than other methods of learning (online and face-to-face). Technical problems were the key drawbacks of videoconferencing. However, such negative experiences did not greatly affect the students' overall positive attitudes towards their learning environment in most studies. Overall, videoconferencing is a promising technology and it has the potential to solve many problems in dental education in Saudi Arabia, providing that the leaders at the MOH and dental Schools of Saudi universities can be convinced to use it, since no financial or infrastructure issues are encountered.

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