Wales COVID-19 Evidence Centre (WC19EC)
Rapid Review

A rapid review of the effectiveness of alternative education delivery strategies for undergraduate and postgraduate medical, dental, nursing and pharmacy education during the COVID-19 pandemic

Report Number: RR00004 (August 2021)

Rapid Review Details
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TOPLINE SUMMARY

What is a Rapid Review?
Our rapid reviews use a variation of the systematic review approach, abbreviating or omitting some components to generate the evidence to inform stakeholders promptly whilst maintaining attention to bias. They follow the methodological recommendations and minimum standards for conducting and reporting rapid reviews, including a structured protocol, systematic search, screening, data extraction, critical appraisal, and evidence synthesis to answer a specific question and identify key research gaps. They take 1- 2 months, depending on the breadth and complexity of the research topic/ question(s), extent of the evidence base, and type of analysis required for synthesis.

Background / Aim of Rapid Review
Education delivery in higher education institutions was severely affected by the COVID-19 pandemic, especially for healthcare students whose continuing education is imperative to maintain a well-educated healthcare workforce. Emergency remote teaching, without prior contingency planning, was developed and adapted promptly for the circumstances. We investigated the **effectiveness of alternative education delivery strategies during the COVID-19 pandemic** to ensure **medical, dental, nursing and pharmacy students** acquired the relevant knowledge to become effective practitioners, able to translate learning into clinical practice, and how this informs either further planned education delivery or adaptations in emergencies.

Key Findings

Extent of the evidence base
- No relevant existing reviews were identified during preliminary work, so the review focused on **23 primary studies**, all in undergraduate education and none was UK-based.
- These comprise 11 single cohort descriptive studies; 10 comparative descriptive studies of remote versus in-person learning (previous pre-COVID academic year or same academic year, 2019/20); and two RCTs comparing bespoke interactive online platforms with standard video format or textbook-based preparation.
- Studies included medical (12 descriptive studies, 2 RCTs), dental (2 studies), nursing (3 studies) and pharmacy (4 studies) education.
- There was considerable variability between studies in terms of students, type of distance learning and platforms used, and outcome measures applied; most focused on knowledge gained.
- Most studies were low or very low quality with small sample sizes.

Recency of the evidence base
- All studies were published in 2020 – 2021.

Evidence of effectiveness
- Remote teaching was valued, and learning was achieved, but the **comparative effectiveness of virtual versus in-person teaching is less clear**.
- In medicine, self-reported competency and confidence, and demonstrable suturing skills were achieved through participating in remote learning. However, **lower levels of knowledge (including**

exam results) were obtained by students who received virtual or blended learning compared to in-person teaching (low - very low confidence).
- Using **bespoke interactive platforms** in undergraduate medical training was superior to standard video (low confidence) or 'textbook' presentations (very low confidence).
- In dentistry, remote learning led to knowledge gained (low confidence), but **self-reported practical and interpersonal skills were lower** with remote rather than in-person learning (very low confidence).
- In nursing, remote learning led to knowledge gained (low confidence). However, **knowledge and self-reported competency levels were similar (**very low confidence**)**, but confidence higher when learning or assessment was conducted virtually (2020) compared to in-person, pre-COVID (2019) (low confidence).
- In pharmacy, **virtual learning was associated with higher skills** (in objective structured clinical examinations) but lower knowledge (exam scores) than in the pre-COVID cohort; self-reported competency and confidence scores were similar between the two groups (very low confidence).

The best quality evidence
- RCT of e-Learning module with interactive content vs standard video-based distance learning of the National Institutes of Health Stroke Scale to 5th year medical students (n=75) (Suppan et al. 2021) showing increased knowledge scores.

Policy implications
- Remote learning is appreciated by students and enables continued teaching and learning in the short-term within the emergency circumstance.
- **Supplementary alternative or in-person practical sessions** may be required post-emergency to address learning needs for some disadvantaged student groups.
- The transition from the **traditional into remote teaching methods seems to affect students' performance at exams**, particularly for practical-based subjects in dentistry and medicine.
- The available evidence is insufficient to demonstrate equivalence **for other healthcare student speciality groups**.
- It is unclear whether planned remote teaching, rather than relying on emergency adaptation, would be more effective.
- **Further research with robust methods** to evaluate alternative education delivery strategies is needed to inform policy decision-making in this area.

Strength of Evidence

Currently, the confidence in the strength of evidence is rated as **"low confidence"**.

TABLE OF CONTENTS

1. BACKGROUND

This Rapid Review was conducted as part of the Wales COVID-19 Evidence Centre Work Programme. The above question was suggested by Professor Steve Riley (Head of School of Medicine, Dean of Medical Education, Cardiff University). Traditional education delivery in higher education institutes has been severely affected by the COVID-19 pandemic. This has been a particular issue for healthcare students whose continuing education is imperative to maintain a well-educated healthcare workforce ready for practice. A transition to emergency remote learning has been implemented worldwide and a wide range of alternative education delivery strategies utilised, ranging from blended programmes, where remote and classroom learning are combined, to fully remote learning. Remote learning programmes vary widely from synchronous 'virtual classroom' approaches (where resources are delivered live, allowing real time questions and discussion, and student participation follows the pattern of a traditional face-to-face course) to asynchronous (i.e., all the resources are available online, allowing students to access pre-recorded lectures whenever they like, and as many times as they like) (TASO, 2021). The aim of such approaches is to enable efficient remote learning, using digital tools to replace the in-person teaching environment and in the context of COVID-19 it is therefore important to be able to determine their effectiveness.

1.1 Purpose of this review

This Rapid Review investigated the effectiveness of alternative education delivery strategies that have been put into place to ensure healthcare students acquire the relevant knowledge to become effective, theoretically informed practitioners with the ability to translate learning into clinical practice. Prior to preparing this review, a Rapid Evidence Summary, as part of the PHASE I rapid evidence process was initiated (May 2021). Following searches of repositories specific to COVID-19 literature, a number of reviews were identified. One previous systematic review looked at the effectiveness of virtual teaching for medical education and suggested that was effective, but the review was poorly conducted (Wilcha 2020). A further systematic review explored the use of synchronous distance education (videoconference or web conference, online classroom or virtual classroom) compared with traditional education for medical, dental, nurse, pharmacy students and other health science–related students). It was found that there were no significant differences in terms of knowledge or skills, but that satisfaction was rated higher for distance education (He et al. 2021). For nursing students, a scoping review suggested that when delivered purposefully, blended learning (a mix of face-to-face and online study) can positively influence and impact on the achievements of students, especially when utilised to manage and support distance education (Jowsey et al. 2020). It was determined that there were no reviews that specifically explored effectiveness of alternative education delivery strategies for medical, nursing, dental and pharmacy students, or allied health professionals during the COVID-19 pandemic. A further initial scope of the evidence base for these healthcare disciplines identified a large volume of primary research in the area for medical, nursing, dental and pharmacy students but very little for other healthcare disciplines including allied health professionals. This rapid review therefore focused on medical, dental and pharmacy education and a separate summary was produced for each discipline.

1.2 Research Question

Review question	
What is the effectiveness of alternative education delivery strategies for undergraduate and postgraduate medical, dental, nursing and pharmacy students during the COVID-19 pandemic?	
Participants	Undergraduate students Post-graduate students Medicine Dentistry Nursing

	Pharmacy
Intervention / exposure	Specific educational delivery (including clinical skills delivery) during COVID-19
Comparison	Education delivery (including clinical skills delivery) prior to COVID-19
Outcomes	Educational outcomes of knowledge, skills, confidence, competency
Other Study Considerations	
Primary research Quantitative (experimental and observational)	

2. RESULTS

Of the 10,978 citations retrieved from our searches, **21 descriptive studies and two RCTs** met our eligibility criteria. These focused on medical students (n=14), dental students (n=2), nursing students (n=3) and pharmacy students (n=4).

2.1 Summary of evidence base for medical students

Five comparative descriptive studies, seven single cohort descriptive studies and two RCTs provided evidence of the effectiveness of alternative education delivery strategies for undergraduate medical students during the COVID-19 pandemic (see Table 1). The majority (n=7) were conducted in the USA (Martini et al. 2021; Monday et al. 2020; Nathaniel and Black 2021; Pang et al. 2021; Qaranto et al. 2021; Redinger and Greene. 2021; Rosenthal et al. 2021). The remaining studies were conducted in Germany (Darici et al. 2021; Harendza et al. 2020; Schmitz et al. 2021); Japan (Kasai et al. 2021); South Korea (Kim et al. 2020); Switzerland (Suppan et al. 2021) and Greece (Totlis et al. 2021).

These covered a wide range of both university and clinical based modules/ courses and included neurosurgery (Martini et al. 2021), surgical instruments, knot tying and suturing (Qaranto et al. 2021), digital histology (Darici et al. 2021), a residency preparation course (Monday et al. 2020), simulated patient consultations, documentation, and case presentation (Harendza et al. 2020), simulated clinical experience in respiratory unit and general medicine (Kasai et al. 2021), generic medical education (Kim et al. 2020), neuroanatomy (Nathaniel and Black 2021), emergency medicine (Redinger and Greene. 2021; Rosenthal et al. 2021), musculoskeletal system anatomy and neuroanatomy (Totlis et al. 2021), the National Institutes of Health Stroke Scale (Suppan et al. 2021), operative techniques and skills (Schmitz et al. 2021) and informed consent for surgical procedures (Pang et al. 2021).

A large variety of different online platforms were used to deliver synchronous learning; five used the Zoom video conferencing platform (Darici et al. 2021; Kasai et al. 2021; Martini et al. 2021; Qaranto et al. 2021; Harendza et al. 2020), three used the University Supported Management Systems: CANVAS (Monday et al. 2020; Nathaniel and Black 2021) or Meducator (Totlis et al. 2021), one used Microsoft teams (Redinger and Greene . 2021), another Skype for business (Totlis et al. 2021), and three did not specify the type of video communication software used (Kim et al. 2020; Pang et al. 2021; Rosenthal et al. 2021). Other methods included neuroanatomical interactive virtual activities using “Digital Neuroanatomy” software (Nathaniel and Black 2021), Simulated patient encounters employing online MedEd Case X videos (Redinger and Greene 2021), and structural specimens replaced by photographs (Totlis et al. 2021). Five studies also incorporated asynchronous elements using pre-recorded lectures (Kim et al. 2020; Totlis et al. 2021; Pang et al. 2021) or readily available podcasts (Redinger and Greene 2021; Rosenthal et al. 2021). For one further study the course content (8 topics) was organised by 12 rising fourth-year medical students under supervision (Redinger and Greene 2021). The two RCTs used bespoke interactive online platforms (Schmitz et al. 2021; Suppan et al. 2021) and compared the outcomes to those students learning the same topic via a standard video format (Schmitz et al. 2021) or textbook based preparation (Suppan et al. 2021). Two studies were RCTs (Schmitz et al. 2021; Suppan et al. 2021), six were pre-test / post-test designs (Kasai et al. 2021; Martini et al 2021; Monday et al. 2020; Pang et al. 2021; Qaranto et al. 2021; Rosenthal

et al. 2021) and six were post-test only designs (Darici et al. 2021; Harendza et al. 2020; Kim et al. 2020; Nathaniel and Black 2021;. 2021; Totlis et al. 2021).

Seven studies were conducted with final year (Clerkship / Interns) students (Harendza et al. 2020, Kasai et al. 2021; Monday et al 2020; Qaranto et al. 2021; Redinger and Greene 2021; Rosenthal et al. 2021; Suppan et al. 2021). Two were conducted with first years (Totlis et al. 2021; Nathaniel and Black 2021), one with second and third years (Darici et al. 2021), one with third years (Pang et al. 2021), one across all years (Martini et al 2021) and a further two did not specify the year of study (Kim et al. 2020; Schmitz et al. 2021). Outcomes explored were confidence (n= 5) (Harendza et al. 2020; Martini et al 2021; Monday et al. 2020; Rosenthal et al. 2021; Qaranto et al. 2021), competency (n=2) (Kasai et al. 2021; Pang et al. 2021) and knowledge (n=6) (Darici et al. 2021; Kim et al. 2020; Nathaniel and Black 2021; Redinger and Greene 2021; Suppan et al. 2021; Totlis et al. 2021).

2.1.1 Competency

Self-reported competency was assessed using pre-test / post-test Likert scales (Kasai et al. 2021; Pang et al. 2021). Items assessed were four domains around obtaining informed consent and the ability to apply recommended quality frameworks (Pang et al. 2021), or across nine domains relevant to clinical practice in respiratory and general medicine (medical interviewing, physical examination, humanistic qualities/professionalism, clinical judgment, counselling, organization or efficiency, overall clinical competence, writing daily medical records, writing medical summaries) (Kasai et al. 2021). Over the course of the learning in both studies the self-assessed evaluation scores indicated significant improvements in competency ($p<0.001$) in all domains.

2.1.2 Confidence

Self-reported confidence was assessed using Likert scales (Harendza et al. 2020; Martini et al. 2021; Monday et al. 2020; Rosenthal et al. 2021) in relation to emergency medicine (Rosenthal et al. 2021), patient history taking, management phase time and case presentations (Harendza et al. 2020), core concepts across various neurosurgical subdisciplines (Martini et al. 2021), or the American Academy of Medical Colleges core competencies (Monday et al. 2020). One further study used a baseline and follow-up questionnaire to assess students' confidence in their knot tying and suturing techniques, but the question format was not reported (Quaranto et al. 2021).

For the comparative descriptive study there were no significant differences in self-assessed levels of confidence when learning was conducted virtually (2020) compared to in-person pre COVID (2019) (Harendza et al. 2020). All of the single cohort studies used pre-test/post-test design and reported significant increases in confidence across all learning objectives over the course of the learning: knot-tying ($p=0.028$) and suturing ($p<0.002$) (Quaranto et al. 2021), eight topics related to emergency medicine ($p<0.05$) (Rosenthal et al. 2021), eight core concepts of neurosurgery ($p<0.001$) (Martini et al. 2021) and thirteen core competencies of the American Academy of medical Colleges ($p<0.001$) (Monday et al. 2020).

2.1.3 Knowledge

Knowledge was assessed though end of course/module examinations (Darici et al. 2021; Kim et al. 2020; Monday et al. 2020; Nathaniel and Black 2021; Totlis et al. 2021; Redinger and Greene 2021; Schmitz et al. 2021) or quizzes (Suppan et al. 2021), covering anatomy, biochemistry, histology, gastrointestinal system, respiratory system and the circulatory system (Kim et al. 2020), digital histology (Darici et al. 2021), musculoskeletal system anatomy and neuroanatomy (Totlis et al. 2021), neuroanatomy (Nathaniel and Black 2021) or the American Academy of Medical Colleges core competencies (Monday et al. 2020).

The two RCTs compared bespoke interactive platforms with standard video format as the control (Suppan et al. 2021) or textbook based preparation (Schmitz et al. 2021). They found significant differences in mean quiz scores ($p<0.001$) (Suppan et al. 2021) and percentage of correct and incorrect choices ($p=0.0001$ and $p=0.04$ respectively) (Schmitz et al. 2021), all in favour of the bespoke platform interventions. The four comparative descriptive studies reported mixed results. Nathaniel and Black, 2021 reported that in-person neuroscience laboratory activities (conduced pre-COVID) which involved the dissection of the brain during wet neuroanatomy laboratory activities and small group discussion of clinical cases were associated with a better performance when compared with the adaptive blended learning of all the materials used during COVID ($p=0.009$). Redinger and Greene 2021 found that there were no significant differences in students' knowledge at the course conclusion between those participating in a virtual clerkship in emergency

medicine compared to those who had completed a traditional rotation in the specialty. Kim et al. 2020 found significantly decreased scores were observed for anatomy, biochemistry and the respiratory system when learning was conducted virtually (2020) compared to in-person pre COVID (2019), but that knowledges scores for the other domains were similar ($p>0.05$). Totlis et al. 2021 reported that students who had experienced a mixture of asynchronous and synchronous learning in musculoskeletal system anatomy and neuroanatomy in 2020, performed significantly worse in musculoskeletal anatomy ($p<0.001$) and neuroanatomy ($p<0.001$) compared to the in-person pre-COVID cohort. Both single cohort descriptive studies reported that knowledge had improved over the course of the learning. Darici et al. 2021 reported that 75% of second years and between 74%# and 75% of third years (repeating and without repeating respectively) had passed the final multiple choice exam after undertaking an online digital histology course undertaken an online digital histology course. Monday et al. 2020 reported that there was a significant increase in self-assessed knowledge ($p<0.001$) over the course of the learning and all students passed the post-test assessment, with 94% achieving a score of 70% or higher.

2.1.4 Skills

Knot tying and suturing techniques were assessed in one study (Quaranto et al. 2021). All students successfully visually demonstrated successful two-handed knot and simple suture techniques skills via Zoom.

2.1.5 Bottom line results for medical students

This section summarised evidence from five comparative descriptive studies, seven single cohort descriptive studies and two RCTs from across six countries. Low to very low quality evidence from single cohort descriptive studies showed that levels of competency, confidence and skills were found to have improved across the course of learning. Very low quality evidence from one comparative descriptive study suggested that levels of confidence were the same when learning was conducted virtually (2020) compared to in-person pre COVID (2019). Low to very low quality evidence from the RCTs showed that knowledge was greater when learning was conducted using bespoke interactive platforms as compared with a standard video format or textbook based preparation during the COVID pandemic. Low to very low quality evidence from the comparative descriptive studies showed mixed results for knowledge assessed and compared between cohorts at the end of virtual learning (2020) and in-person learning (2019). Three of the studies reported lower levels of knowledge for students in the virtual cohort and one reported found no difference. Low quality evidence from single cohort descriptive studies suggested that knowledge had improved over the course of the learning.

2.2 Summary of the evidence base for dental students

One single cohort descriptive study and one comparative descriptive study provided evidence of the effectiveness of alternative education delivery strategies for undergraduate dental students studying specific modules or courses in conservative dentistry with endodontics (Nijakowski et al. 2021) or operative dentistry (Kanzow et al. 2021) during the COVID-19 pandemic (see Table 2). These were both post-test descriptive studies conducted in Poland (Nijakowski et al. 2021) and Germany (Kanzow et al. 2021) In one study the teaching consisted of asynchronous online screencasts (screen-captured PowerPoint presentations with narrated audio), using Stud-IP, a source learning management system, and discussions via synchronous video meetings using the Zoom video videoconferencing platform (Kanzow et al. 2021). The other study used a blended learning approach using the Blackboard Collaborate platform (Nijakowski et al. 2021). The outcomes of interest that were explored across both studies was knowledge and skills .

2.2.1 Knowledge and skills

One study assessed knowledge in operative dentistry via examination (Kanzow et al. 2021) and the other study explored self-reported theoretical knowledge, practical skills, and interpersonal skills in conservative dentistry with endodontics using a Likert scale (Nijakowski et al. 2021). There were significant increases in self-assessment scores for theoretical knowledge, practical skills, and interpersonal skills between third and fourth years. However, when in-person learning was compared to virtual learning for third year students, those who had experienced virtual learning reported significantly lower practical skills (Kanzow et al. 2021).

2.2.2 Bottom line results for dental students

This section summarised evidence from single cohort descriptive study and one comparative descriptive from Poland and Germany regarding a blended learning approach in conservative dentistry with

endodontics using the Blackboard Collaborate and asynchronous learning with synchronous video meetings. Low quality evidence from the single cohort study demonstrated that these approaches could improve knowledge in conservative dentistry with endodontics or operative dentistry and improve skills in operative dentistry as assessed at the end of the learning only. However, very low quality evidence from the comparative descriptive study suggests lower levels of knowledge for the subtopic of periodontology and lower levels of practical skills for 3rd year dental students when learning was conducted virtually compared to in-person.

2.3 Summary of evidence base for nursing students

Two comparative descriptive studies and one single cohort descriptive study (see Table 3) provided evidence for the effectiveness of alternative educational delivery strategies for nursing students studying a specific module in human genomics (Kawasaki et al. 2021), simulation in paediatric clinical practice (Weston and Zauche 2020) and for the delivery of remote OSCEs for COPD patients (Arrogante et al. 2021) during the COVID-19 pandemic. These were conducted in Spain (Arrogante et al. 2021), Japan (Kawasaki et al. 2021) and USA (Weston and Zauche 2020). All three studies compared a group of students receiving a remotely delivered educational package with a group receiving standard, in-person education. In two studies the comparison group were students from the previous, pre-COVID academic year, however, Weston and Zauche studied a cohort of students from the same academic year, 2019-2020, where half had received the standard educational package before the alternative version was introduced. Only one study used a pre-test / post-test design and thus compared results within as well as between groups (Kawasaki et al. 2021). In this study, the conventional course was transferred to remote synchronous learning (narrative over PowerPoint) and uploading handouts and worksheets with no changes to content (Kawasaki et al. 2021). Arrogante et al. used the virtual classroom platform Blackboard Collaborate to conduct OSCEs comprising eight simulated clinical scenarios with standardised patients. Weston and Zauche substituted virtual simulation using the i-Human platform to replace in-person clinical practice and simulation laboratory learning. Outcomes explored were competency (n=2) (Arrogante et al. 2021, Kawasaki et al. 2021), confidence (n=1) (Kawasaki et al. 2021), and knowledge (n=2) (Kawasaki et al. 2021; Weston and Zauche 2020).

2.3.1 Competency

Two comparative descriptive studies assessed self-reported competency using a Likert scale (Kawasaki et al. 2021) or a checklist (Arrogante et al. 2021), to evaluate participants' ability to apply four elements of human genomics knowledge in different clinical scenarios (Kawasaki et al. 2021) or for nursing competencies applied to the OSCE for patients with COPD (Arrogante et al. 2021). Kawasaki et al. reported that students in both groups (virtual and in-person learning) achieved a statistically significant increase in mean scores for all four competencies ($p<0.001$), but between groups there was only one statistically significant finding; the mean score for competency relating to explaining human diversity using genomic information was significantly higher ($p=0.003$) when learning was conducted virtually (2020) compared to in-person pre COVID (2019). There were no significant differences in levels of competency when undertaking OSCEs virtually (2020) or in-person pre COVID (2019) (Arrogante et al. 2021).

2.3.2 Confidence

Self-reported confidence was assessed in one study using a Likert scale, based on a single question in the course evaluation questionnaire, 'I gained confidence in human genetic health counselling' (Kawasaki et al. 2021). The mean score was significantly higher ($p=0.009$) when learning was conducted virtually (2020) compared to in-person pre COVID (2019).

2.3.3 Knowledge

Knowledge was assessed in two studies using end of course assessments/examinations (Kawasaki et al. 2021; Weston and Zauche 2020). Kawasaki et al. reported a significant increase in mean knowledge at the end of the course regardless of whether the learning had taken place virtually (2020) or in-person pre COVID (2019) and when cohorts were compared levels of knowledge post-test were similar. There were no significant differences in the Assessment Technologies Institute examination in the nursing care of children between students who had paediatric clinical practice in person and students who completed their paediatric clinical practicum hours using the virtual simulation, i-Human ($p>0.05$) (Weston and Zauche, 2020).

2.3.4 Bottom line results for nursing students

This section summarised evidence from two comparative descriptive studies and one single cohort studies from three countries. Low to very low evidence suggests that levels of competency were the same when learning or assessment was conducted virtually (2020) compared to in-person pre COVID (2019). Low quality evidence suggests that levels of confidence were higher when learning or assessment was conducted virtually (2020) compared to in-person pre COVID (2019). Low quality evidence indicates that knowledge improves regardless of whether the learning has been conducted virtually (2020) or in-person pre COVID (2019).

2.4 Summary of the evidence base for pharmacy students

Two comparative descriptive studies and two single cohort studies (see Table 4), all conducted in the USA, provided evidence for the effectiveness of alternative education delivery strategies for undergraduate pharmacy students studying specific modules or courses in integrated patient care (Phillips et al. 2021), hypertension/drug information (Cowart and Updike 2020), advanced pharmacy experience (Singh et al. 2020) and delivery of remote OSCEs for patient counselling and taking a medical history (Scoular et al. 2021) during the COVID-19 pandemic. Two studies used a pre-test/post-test design (Cowart and Updike 2020; Singh et al. 2020), the remaining two reported a post-test only study design, with a comparison between the study population and an earlier (pre-COVID) cohort of students (Phillips et al. 2021; Scoular et al. 2021).

In one study the teaching comprised an element of remote synchronous learning (Singh et al. 2020), three studies used the Zoom video videoconferencing platform (Phillips et al. 2000; Scoular et al. 2021; Singh et al. 2020), two studies used the University platform Blackboard Collaborate (Cowart and Updike, 2021) and one study also used the University Supported Management System: CANVAS (Singh et al. 2020). The outcomes of interest that were explored were competency (n=2) (Cowart and Updike 2020; Phillips et al. 2000), confidence (n=2)(Cowart and Updike 2020; Singh et al. 2020), knowledge (n=2) (Phillips et al. 2000; Singh et al. 2020), skills (n=2) (Scoular et al. 2021; Singh et al. 2020).

2.4.1 Competency

Self-reported competency was assessed using Likert scales (Cowart and Updike 2020; Phillips et al. 2020), relating to blood pressure techniques, application of drug information and communication skills (Cowart and Updike 2020) and application of drug therapy guidelines, clinical reasoning and patient care skills (Phillips et al. 2020). Cowart and Updike in the single cohort descriptive study reported a significant improvement in competency for communication skills ($p=0.007$) but no significant change in competency for blood pressure techniques ($p>0.05$) or application of drug information ($p>0.05$) over the course of the learning. Philips et al. found no significant differences in levels of self-reported competency between the current virtual (2020) and retrospective in-person pre COVID (2019) cohorts in the comparative descriptive study.

2.4.2 Confidence

Self-reported confidence was assessed using Likert scales (Cowart and Updike 2020; Phillips et al. 2020) or a purposefully designed scale (Singh et al. 2020), relating to blood pressure techniques, application of drug information and communication skills (Cowart and Updike 2020); the application of drug therapy guidelines, clinical reasoning and patient care skills (Phillips et al. 2020) or in relation to eight specific learning outcomes (Singh et al 2020). Over the course of the learning in a single cohort study, Cowart and Updike reported a statistically significant improvement in confidence across all three domains ($p=0.002$) for application of drug information; $p<0.001$ for to blood pressure techniques and communication skills). Singh et al. found the mean difference in the students' response showed a greater than average 10-point improvement in their ability to demonstrate learning outcomes, although no statistical analysis was conducted to confirm this. However, Phillips et al. found no significant difference in the level of student confidence in skill development and performance between the current virtual (2020) and retrospective in-person pre COVID (2019) cohorts ($p>0.05$) in the comparative cohort study.

2.4.3 Knowledge

Knowledge was assessed by quizzes and examinations (Phillips et al. 2020) or across multiple activities including quizzes, presentations, journal clubs and an examination (Singh et al 2020). More specifically, knowledge was explored in relation to drug therapy (Phillips et al. 2020) or in relation to eight specific learning outcomes (Singh et al 2020). Phillips et al. found that there was a mixed effect on the development

of knowledge and that the improvements made during the initial period of online learning decreased when higher levels of skills or knowledge were assessed at the end of the course. They also found that students in the current virtual cohort (2020) scored significantly lower compared to the retrospective, in-person, pre-COVID (2019) cohort ($p>0.05$). In a single cohort study, Singh et al. reported that the mean scores for knowledge and skills combined across the eight student learning outcomes examined ranged from 75.51% to 80.42%. There was a target minimum average of 80%, which was only achieved in two of the student learning outcomes.

2.4.4 Skills

One comparative descriptive study assessed skills via remotely-delivered OSCEs (specifically: empathy, trust, professionalism, and general verbal and non-verbal communication skills and patient centred communication (Scoular et al. 2021). Student scores were significantly higher for the patient-centred communication OSCE across all domains ($p<0.005$). For the cumulative OSCE, student scores were significantly higher in the 2020 cohort for the global feedback variable of establishing trust but students performed similarly between virtual (2020) and in-person pre COVID OSCE (2019) on all other variables.

2.4.5 Bottom line results for pharmacy students

This section summarised evidence from two comparative descriptive studies and two single cohort studies in four countries. Very low quality evidence suggests competency outcomes improved across the course of learning and were similar when learning was conducted virtually (2020) compared to in-person pre COVID (2019). Very low quality evidence also found that confidence improved across the course of learning and levels of confidence were the same when learning was conducted virtually (2020) compared to in-person pre COVID (2019). However, very low quality evidence suggested that lower levels of knowledge when learning was conducted virtually compared to in-person pre COVID. Additionally, very low quality evidence suggests that, overall, students performed similarly between in-person (2019) and online (2020) OSCEs although for some skills performance was higher when student undertook these virtually.

2.5 Summary table

	Medicine	Overall confidence in the evidence	Dental	Overall confidence in the evidence	Nursing	Overall certainty in the evidence	Pharmacy	Overall confidence in the evidence
Comparative descriptive study designs								
Competency					Post-test only (n=1) Summative assessment (Arrogante et al. 2021) Pre-test/post-test Self-assessment Kawasaki et al.2021	Low to Very low	Post-test only (n=1) Self-assessment (Phillips et al. 2021)	Very low
Confidence	Post-test only (n=1) Self-assessment (Harendza et al. 2020)	Very low			Pre-test/post-test (n=2) Self-assessment (Kawasaki et al.2021)	Low	Post-test only (n=1) Self-assessment (Phillips et al. 2021)	Very low
Knowledge	Post-test only (n=4) Summative assessment (Kim et al. 2020; Nathaniel & Black, 2021; Redinger & Greene 2021; Totlis et al. 2021)	Low to very low	Post-test only (n=1) Self-assessment (Nijakowski et al. 2021)	Very low	Pre-test/post-test (n=1) Summative assessment (Kawasaki et al. 2021)	Low	Post-test only (n=1) Summative assessment (Phillips et al. 2021)	Very low
Skills			Post-test only (n=1) Self-assessment (Nijakowski et al. 2021)	Very low			Post-test only (n=1) Summative assessment (Scoular et al. 2021)	Very low
Single cohort descriptive study designs								
Competency	Pre-test/post-test (n=2) Self-assessment (Kasai et al. 2021; Pang et al. 2021)	Very low					Pre-test/post-test (n=1) Self-assessment (Cowart & Updike 2021)	Very low
Confidence	Pre-test/post-test (n=4) Self-assessment (Martini et al. 2021; Monday et al. 2020;	Low to very low					Pre-test/post-test (n=1) Self-assessment (Cowart & Updike 2021) Pre-test/post-test (n=1)	Very low

	Quaranto et al.2021; Rosenthal et al. 2020)						Formative assessment (Singh et al. 2021)	
Knowledge	Pre-test/post-test (n=1) Summative assessment (Monday et al. 2020) Post test (n=1) Summative assessment (Darici et al. 2021)	Low	Post-test only (n=1) Summative assessment (Kanzow et al. 2021)	Low	Post-test only[b] (n=1) Summative assessment (Weston & Zauche, 2020)	Very low	Post-test only (n=1) Formative assessment (Singh et al. 2021)	Very low
Skills	Pre-test/post-test (n=1) Summative assessment (Quaranto et al. 2021)	Very low						
Randomised control trials								
Competency								
Confidence								
Knowledge	RCT (n=2) Summative assessment (Schmitz et al. 2021; Suppan et al. 2021)	Low to very low						
Skills								

[a] didn't compare the results of the 2020 COVID cohort to the 2019 pre COVID cohort for this outcome

[b] compared the results of 2020 COVID cohort before and after the introduction of virtual learning

3. DISCUSSION

3.1 Summary

Previous reviews conducted as a result of COVID-19 have identified that healthcare education has been severely impacted with many courses transitioning to a period of remote emergency teaching (Dedeilia et al. 2020; NSW Health COVID-19 Critical Intelligence Unit, 2020; Wilcha, 2020). Other reviews have highlighted the challenges in migrating to remote education (Moretti-Pires et al. 2021; Santos et al. 2021) which include poor knowledge by staff on how to deal with technology, poor internet connections and difficulty in transitioning content for online learning (Moretti-Pires et al. 2021; Santos et al. 2021). Students and staff report satisfaction with remote learning (He et al. 2021; NSW Health COVID-19 Critical Intelligence Unit, 2020), especially when collaboration and engagement with peers is facilitated (NSW Health COVID-19 Critical Intelligence Unit, 2020). None of these reviews, however investigated the effectiveness of alternative education delivery strategies for undergraduate and postgraduate medical, dental, nursing and pharmacy students during the Covid 19 pandemic.

The findings of this rapid review are based on very limited poor-quality evidence for medical (12 descriptive studies and two RCTs), dental (2 descriptive studies), nursing (3 descriptive studies) and pharmacy education (2 descriptive studies) . As expected, levels of knowledge, competency and confidence improved over the course of the virtual learning. However, when results were compared to students who had completed in-person learning in the years before the Covid-19 pandemic, results were mixed. The majority of studies across the disciplines reported similar levels across all outcome variables suggesting that virtual learning was just as effective as in-person learning. One study that involved the asynchronous presentation of the course content using voice of PowerPoint reported higher levels of confidence in human genomics for the virtual (2020) cohort of nursing students compared to the in-person cohort (2019), however this finding was rated as having low confidence. Another study reported that student scores were higher when the effectiveness of remotely delivered OSCEs was compared to in-person OSCEs for pharmacy students. However, the effect sizes were small and authors concluded that the difference was more likely to be due to changes in grading patterns due to the pandemic.

Very low and low quality confidence evidence from the two RCTs in medical education showed that knowledge was greater when learning was conducted using bespoke interactive platforms compared with non-interactive formats, reported during the COVID pandemic. In one of these studies (Schmitz et al. 2021), the authors reported that students randomised to the intervention arm studied six surgical topics using interactive videos that were developed by “processing” video-recorded procedures that took place in their operating theatres, and achieved higher exam scores than the control group who studied the relevant section of a textbook. Unfortunately, there was no further description of the content of the videos, how the students interacted with them, or the methods by which they were processed. In the second study (Suppan et al. 2021) an e-learning intervention was developed to teach National Institutes of Health Stroke Scale. The intervention was based on an existing video, that acted as the control, and was developed using Articulate Storyline 3 (Articulate Global) software to create content that could be accessed on regular computers as well as on smartphones and tablets. Students in the intervention group performed better in a 50-question quiz than the control group who watched the traditional video.

All of these findings concur with research conducted in the field prior to Covid-19, with three systematic reviews suggesting that online eLearning for undergraduates in health professions is equivalent, possibly superior to traditional learning (George et al. 2014; Liu et al. 2016; Vallee et al. 2020). George et al conducted a systematic review of the effectiveness of online eLearning in terms of knowledge, skills, attitudes and satisfaction. Sixty RCTs were identified that compared online eLearning and traditional learning or various modes of online learning. Post–intervention knowledge was not significantly different between eLearning and traditional learning in 24 (48%) of the studies, and 29% showed significantly higher knowledge gains. Forty percent of studies showed significantly greater skill acquisition; 67% of the studies showed no difference in attitude and 14% of the studies showed higher satisfaction with online eLearning than traditional learning. Liu et al. explored the effectiveness of blended learning for health professionals (a combination of traditional face-to-face learning and asynchronous or synchronous) and demonstrated a consistent positive effect in comparison with no intervention, and to be more effective than or at least as

effective as non-blended instruction for knowledge acquisition in health professions (Liu et al. 2016). More recently, another systematic review on blended learning demonstrated consistently better effects on knowledge outcomes when compared with traditional learning in health education (Vallee et al. 2020). However, the majority of these reviews also found that the evidence was of low quality, meaning that further research is very likely to change the findings and that strong conclusions cannot be drawn. This rapid review concurs with these reviews conducted before the pandemic and with earlier scoping work conducted during the Covid-19 pandemic in identifying a lack of high quality studies that can serve as models for future development in remote learning and teaching (Daniel et al. 2021; Gordon et al. 2020).

This rapid review also reported that the transition from the traditional teaching method into remote methods seems to affect the students' performance at exams, particularly so for the practical based subjects in dentistry and medicine. It is recognised that emergency remote teaching and learning differs from planned on-line learning (Hodges et al. 2020; TASO, 2021). The majority of remote teaching and learning that initially took place during the Covid-19 pandemic was not planned and was adapted promptly due to the emergency circumstances that presented.

3.2 Implications for policy and practice

For some healthcare students, academic achievement appears to decline when practical learning is insufficient, and this is something that will need to be addressed. However, this could be attributed to the sudden transition to online learning mid semester in which students did not have a chance to mentally prepare to plan and how they may need to adjust their own learning strategies.

There is insufficient high-quality programme evaluation, especially RCTs on remote teaching and learning for healthcare students and no evidence from the UK.

3.3 Limitations of the available evidence

Out of the 23 included studies none were conducted within the UK, all focused on undergraduates and the majority (n=21) were descriptive studies. Of these, nine studies employed a pre-test/post-test design and the remainder were post-test evaluations. The post-test evaluations utilised Likert scales as part of a wider evaluation questionnaire or formal assessment processes customarily applied to the standard, in-person version of the course and thus allowing comparison with previous academic year groups. However, two of the studies did not make any comparisons with previous cohorts. Statistically significant outcomes were reported following remote learning, compared with baseline, as would be expected. Studies that only made this comparison could not assess whether the level of achievement was adequate. However, between-group comparisons generally found no significant difference between the virtual delivery group and previous academic year groups implying that the virtual delivery of learning was effective or there was insufficient power to detect a difference, which more likely to be the case in most studies. The two RCTs both used a quiz or examination to assess knowledge, but these evaluated two different interventions and therefore statistical pooling of data using meta-analysis was not appropriate. Furthermore, both studies had small sample sizes and poor response rates (75/158 and 44/58).

All but one of the descriptive studies that evaluated students' knowledge and/or performance (n=12) used objective measures that included quizzes, tests, or examinations. Two of these used externally set examinations; in the remaining seven the content appeared to be internally set and was often not described, therefore it is difficult to draw any firm conclusions from the findings of such studies. However, one descriptive study evaluated dental students' knowledge (Nijakowski et al. 2021) using subjective measures through a Likert scale asking them if they felt their knowledge had increased. Only one descriptive study assessed competency using objective measures, with five using subjective measures through a Likert scale asking them if they felt their competency had improved. Four studies assessed knowledge, skills and competencies in medicine, nursing and dentistry using interactive platforms that allowed students to be tested in real time based on a physical or oral assessment of their performance, for example in knot-tying and suturing or via an objective structured clinical examination. A limitation of using subjective assessments is that self-perceived confidence, competence, knowledge, or skill may not

accurately reflect *actual* confidence, competence etc. It is well recognised that Likert scale surveys are subject to biases including extreme responding bias, where respondents choose only the most extreme options available, or central tendency bias, where they avoid the extremes and choose responses close to the midpoint. Furthermore, it is difficult to say whether responses in relation to two different conditions, standard teaching methods and distance learning, are directly comparable.

In the context of the COVID-19 pandemic, educational interventions were designed and implemented with remarkable speed, as were the means to evaluate them. It is probable that no appropriate validated outcome measures existed, and there was little time to develop new ones. Overall, the pre-existing questionnaires used were likely not specifically designed for research, but for teaching purposes i.e. for evaluating the acceptability to students of the course content and delivery as well as for assessing the achievement of learning objectives.

The quality of reporting in some studies was poor. There was often little baseline data reported with respect to the student population, including non-responders, and on the whole, there was no comparison with previous academic year groups in terms of these variables. This leads to the possibility of sampling bias and, where different groups are compared, no certainty that they were directly comparable. In some studies, the learning platform and/or the course content were not described.

There was considerable heterogeneity among the included studies in terms of the study population (professional course, stage/year of study, topic, or module), type of distance learning (synchronous or asynchronous) and platform used (videoconference, virtual reality, webinar, online recorded lectures etc.), and outcome measures (questionnaires, quizzes, examinations, practical skills demonstrations etc.) making it difficult to draw generalisable conclusions.

The majority of findings in this rapid review were of low or very low quality. The quality was rated for each outcome using the GRADE or adapted GRADE approach. The low ratings were mainly due to serious imprecision because of small samples sizes and/or confidence intervals not being reported and/or serious limitations because of baseline levels of the outcome of interest not being controlled for and/or inappropriate outcome measures.

3.4 Strengths and limitations of this Rapid Review

3.4.1 Strengths

Several previous systematic reviews have shown online learning outcomes to be comparable to in-person learning. However, none have evaluated the effects of suddenly and unexpectedly transitioning to an online format in the middle of a semester. To our knowledge this is the first rapid review of the effectiveness of alternative education delivery strategies for undergraduate and postgraduate medical, dental, nursing and pharmacy education during the Covid 19 pandemic. Although this review was conducted rapidly, it should be noted that data screening, data extraction and critical appraisal of each study were undertaken by different reviewers and then independently checked for accuracy and consistency by the same second reviewer.

3.4.2 Limitations

In order to complete the review within a short timeframe a limited number of databases were searched, and it is difficult to say whether further studies would have been identified if additional bibliographic databases were used to carry out the literature search.

Initially a rapid review of published systematic reviews was intended but there were insufficient reviews across any of the healthcare disciplines. The searches for primary research, however, identified a large volume of literature and given the short time-frame, it was decided, with the guidance of the stakeholder group, to only include studies from OECD countries and to exclude publications relating to medical residents or fellows. The tool used for evaluating the confidence of the quantitative descriptive studies is an adaptation of GRADE and has not been approved by the tool's originators.

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5. APPENDICES

Table 1: Characteristics of included studies focusing on medical students

Author/s **Country** **Focus** **Remote platform**	**Participants** **Outcomes/outcome measures**	**Study design** **Type of analysis**	**Findings**
Darici et al. 2021 Germany Online digital histology course Zoom video conferencing platform 19 days	Participants Academic year 2019/2020 Second years (n=132/192 sat the exam) Third years (n=175/201 sat the exam) Outcomes Knowledge Outcome measures Multiple choice final exam	Study design Single cohort Descriptive study Post-test only Type of analysis Descriptive statistics % passing exam Quality appraisal rating Score of 6 out of 7 Confidence evaluation Knowledge –Low	Knowledge Second years Median was 71% correct answers (SD 18.5%, 95% CI 65%, 72%) Third years including repeating students Median was 74% correct answers (SD 20.2%, CI 67%, 73%) Third years without repeating students Median 76% correct answers (SD 19.8, 95% CI 68%, 75%)
Harendza et al. 2020 Germany Virtual training including simulated patient consultations, documentation, and case presentation Zoom video conferencing platform Training included a consultation hour with four simulated patients per participant, patient documentation and management with a newly developed electronic patient chart, and one case presentation per participant in hand-off format	Participants Academic year 2020/2021 Final years (n=32) Online learning Academic year 2019/2020 Final years (n=103) Clinical learning Outcomes Confidence Outcome measures 5-point self-assessment Likert scale 1=does not apply, 2= somewhat applies, 3=partly applies, 4=rather applies, 5= fully applies	Study design Comparative descriptive study Post test Type of analysis Analytical statistics Mean scores Comparison between remote and in person learning across two academic years Quality appraisal rating Score of 4 out of 7 Confidence evaluation Confidence – Very low	Confidence (Mean±SD) I felt confident during history taking Clinical learning (3.67±0.87); Virtual (3.88±0.79), p>0.05 I felt confident during the management phase time Clinical learning (3.12±0.9); Virtual (3.16±0.72), p>0.05 I felt confident during the case presentation Clinical learning (3.33±0.96); Virtual (3.42±0.92), p>0.05
Kasai et al. 2021 Japan Online simulated clinical practice for the respiratory unit and general medicine Zoom video conferencing platform 4 weeks	Participants Academic Year 2019/2020 Fifth years (Clerkship)(n=43) Outcomes Competency Across 9 domains Medical interviewing, physical examination, humanistic qualities/professionalism, clinical judgment, counselling, organization or efficiency, overall clinical competence, writing daily medical records, writing medical summaries Outcome measures 9-point self-assessment Likert scale 1 (extremely poor) to 9 (extremely good)	Study design Single cohort Descriptive study Pre-test / Post test Type of analysis Analytical statistics Mean scores Quality appraisal rating Score of 3 out of 7 Confidence evaluation Competency– Very low	Students indicated improvement across all nine competency domains which were all significant at p<0.001
Kim et al. 2020 South Korea Remote teaching for medical undergraduates e-Teaching and Learning System	Participants Academic years 2017/2018 (n=149 to 152) sitting exams (year of study ns) Academic year 2018/2019 (n=147 to 158) sitting exams (year of study ns)	Study design Comparative Descriptive study Post-test only Type of analysis Analytical statistics Mean scores	Knowledge (Mean±SD) Anatomy 2018 (86.0±7.0); 2019 (88.1±10.3); 2020 (82.0±11.5), p<0.001 Effect size 2018 & 2019 compared to 2020, p=-0.5150 Biochemistry

Pre-recorded video lectures or live-streamed using video communication software Platforms not specified	Academic year 2019/2020 (n=143 to 145) sitting exams (year of study ns) Outcome Knowledge Anatomy, biochemistry, histology, gastrointestinal system, respiratory system, circulatory system Outcome measures Examination scores	Comparison across three academic years Quality appraisal rating 3 out of 7 Confidence evaluation Knowledge– Low	2018 (79.7±11.5); 2019 (70.9±17.1); 2020 (74.1±17.3), p<0.001 Effect size 2019 & 2019 compared to 2020 = -0.0754 Histology 2018 (86.2±6.7); 2019; (85.1±12.9); 2020 (83.4±12.0), p=0.0754 Effect size 2019 & 2019 compared to 2020 = -0.2127 Gastrointestinal system 2018 (86.6±8.8); 2019 (88.4±10.5); 2020 (85.9±10.4), p=-0.0825 Effect size 2019 & 2019 compared to 2020 = -0.1605 Respiratory system 2018; (78.7±13.1); 2019 (88.2±9.2); 2020 (76.9±11.7); p<0.0001 Effect size 2019 & 2019 compared to 2020 = -0.5504 Circulatory system 2018 (79.2±10.6); 2019 80.1±10.5); 2020 (77.3±12.1), p=0.0854 Effect size 2019 & 2019 compared to 2020 =-0.2116
Martini et al. 2021 USA Virtual neurosurgery seminar series Zoom video conferencing platform 16 one-hour seminars that were conducted biweekly over the course of a 2-month period	Participants June, July 2020 595 medical students (from all school years 1 to 5) across the countries registered with an average of 82 students participating live in each weekly lecture (range, 41-150) Completing pre and post-test study (n=32) Outcomes Confidence with material pertaining to core concepts across various neurosurgical subdisciplines. Outcome measures Self-assessment scale of 1-10 (1=not confident at all; 10= very confident)	Study design Single cohort descriptive study Pre-test / Post-test Type of analysis Analytical statistics Mean scores Quality appraisal rating Score of 7 out of 7 Confidence evaluation Confidence – Low	Confidence (Mean±SD) Cerebrovascular neurosurgery Pre (5.90±0.34); Post (8.36±0.19), p<0.0001 Malignant brain tumours Pre (4.95± 0.45); Post (8.28 ± 0.23), p<0.0001 Head trauma Pre (5.54± 0.34); Post (7.97± 0.27), p<0.0001) Spine trauma Pre (4.96± 0.38); Post (8.19± 0.26, p<0.0001) Neuroendocrinology/pituitary pathology Pre (6.79± 0.31); Post (8.74± 0.19), p<0.0001) Pediatric neurosurgery Pre (5.79± 0.33); Post (8.25±0.26) p<0.0001) Neurocritical care Pre (4.86± 0.44); Post (8.25± 0.26), p<0.0001) Minor neurosurgical procedures Pre (4.48± 0.44); Post (7.86± 0.28), p<0.0001)
Nathaniel and Black, 2021 USA Remote, blended learning approach for teaching neuroanatomy	Participants Academic year 2019/2020 First years n=103) and 2020 (n=104) Academic year 2020/2021 First years (n=104)	Study design Comparative Descriptive study Post-test only Type of analysis Analytic statistics Mean scores	Knowledge (Mean±SD) Final laboratory summative examination 2019 (92± 0.15); 2020 (90± 0.11), p=0.009

Neuroanatomical interactive virtual activities "Digital Neuroanatomy" software Lectures Recorded on WebEx/Panopto and posted online on the Canvas platform 4 weeks	Outcome Knowledge Outcome measures Weekly laboratory quizzes Final laboratory examinations	Comparison across two academic years Quality appraisal rating 5 out of 7 Confidence evaluation Knowledge – Very low	
Monday et al. 2020 USA Online virtual internship boot camp Residency preparation course Canvas online learning management system 26 sessions (22 mandatory and 4 optional) over one month	Participants Academic years 2019/2020 Fourth years (n=89) Self-assessed confidence and knowledge response rates Pre-test (76–87%) Post-test (60-82%) Post-test assessment Response rate 99% Outcomes Confidence and knowledge for 14 out of the 26 sessions across the American Academy of Medical Colleges 13 core competencies Outcome measures 5-point self-assessment Likert scale (1 meaning confidence or knowledge was very poor, 3 meaning neutral, and 5 meaning very high) *Knowledge* 53 item competency-based exam	Study design Single cohort Descriptive study Pre-test / Post-test Type of analysis Analytical statistics Mean scores Quality appraisal rating Score of 4 out of 7 Confidence evaluation Confidence – Low Knowledge – Low	Confidence A significant increase in self assessed confidence across all the American Academy of Medical Colleges 13 core competencies was demonstrated (p<0.001) Knowledge A significant increase in self assessed knowledge across all the American Academy of Medical Colleges 13 core competencies was demonstrated (p<0.001) All students passed post-test assessment 83 (94%) achieved a score of 70% or higher, 4 (4.5%) scored in the 60-70% range, and 1 scored 55%
Pang et al. 2021 USA An Informed Consent activity module within a virtual surgical clerkship A pre-recorded lecture with presentation slides A videoconference with 3 students, 2 standardised patients and a facilitator to practice obtaining informed consent for a common surgical procedure Platforms not specified	Participants Academic year 2019/2020 Third years (34/ 90; 38%) who completed the module and took part in the evaluation Outcomes Competency in 4 domains: The ability to identify the key elements of informed consent The ability to describe common challenges in the informed consent process The ability to apply the recommended quality framework (NM-CCS) The ability document informed consent. Outcome measure Self-assessment 6-point scale (0 being none/no competence and 5 being an extremely high level of competence)	Study design Single group descriptive study Pre-test / Post-test (retrospective) Type of analysis Analytical statistics Mean scores Quality appraisal rating Score 3 out of 7 Confidence evaluation Competency – Very low	Results for 4 domains: (Mean±SD) Identifying the elements of informed consent: Pre-test (1.9±1.4); Post-test (3.5±.0.93), p<0.001 Describing common challenges in informed consent: Pre-test (1.0±1.15); Post-test (3.3±0.90), p<0.001 Applying NM-CCS quality framework: Pre-test (2.1±1.24); Post-test (3.5±0.66), p<0.001 Documenting informed consent: Pre-test (2.0±1.19); Post-test (3.4±0.61), p<0.001
Redinger and Greene, 2021 USA	Participants Academic year 2019/2020 Traditional rotation Fourth years (Clerkship) (n=48)	Study design Comparative Descriptive study Post-test only	Knowledge (Mean±SD) Virtual rotation (81.18± 6.55); Traditional rotation (79.38±6.85), p= 0.174, 95% CI [-0.808, 4.415].

Virtual clerkship in emergency medicine Microsoft Teams platform for video conferences, news feed with chat functions, class assignments, daily quizzes, and grade book. Simulated patient encounters employing Online MedEd Case X (Online MedEd, Austin, TX) videos and Emergency Medicine Reviews and Perspectives (EM:RAP) podcast audio of emergency medicine patients and relevant cases 4 weeks	 Academic year 2020/2021 Virtual rotation Fourth years (Clerkship) (n=56) <u>Outcome</u> Knowledge <u>Outcome measures</u> Emergency medicine shelf exam	<u>Type of analysis</u> Analytical statistics Mean scores Comparison across two academic years <u>Quality appraisal rating</u> 4 out of 7 <u>Confidence evaluation</u> Knowledge – Very low	
Rosenthal et al. 2020 USA Peer led online learning course in emergency medicine Course content (8 topics) organised by 12 rising fourth-year medical students under supervision of faculty mentor/Director for Undergraduate Medical Education Online Video Conferencing software Pre-lectures and lectures made use of: Podcasts; Publications, Clinical vignettes, Online content reviews, Video conferencing Platforms not specified	<u>Participants</u> Academic year 2019/2020 Fourth years (n=61) <u>Outcomes</u> Confidence (Comfort) Imaging Chest pain and EKG Stroke and lumbar puncture Abdominal pain Altered mental status and toxicology Shortness of breath and ventilators Shock and sepsis Trauma and FAST Exams <u>Outcome Measures:</u> Self-assessments using a 5-point Likert scale of 1-5, ranging from “very uncomfortable” to “very comfortable.”	<u>Study design</u> Single cohort descriptive study Pre-test / Post-test <u>Type of analysis</u> Analytic statistics Mean scores <u>Quality appraisal rating</u> Score 4 out of 7 <u>Confidence evaluation</u> Confidence– Very low	Mean confidence scores improved across all learning objectives ($p<0.05$)
Quaranto et al. 2021 USA Interactive remote sessions on surgical instruments, knot tying and suturing (“remote coach model” Zoom video conferencing platform Three sessions	<u>Participants</u> Academic year 2019/2020 Third years enrolled in surgical clerkship (n=31) <u>Outcomes</u> Knot tying confidence and skills Suturing ability confidence and skills <u>Outcome measures</u> Visual demonstration of knot tying and suturing Self-assessment of confidence but details of the scale not reported	<u>Study design</u> Single cohort Descriptive study Pre-test / Post-test <u>Type of analysis</u> Analytical statistics Mean scores <u>Quality appraisal rating</u> Score of 4 out of 7 <u>Confidence evaluation</u> Confidence – Very low Skills – Very Low	<u>Confidence</u> (Mean<u>+</u>SD) Knot tying Pre (7.86<u>+</u>0.66); Post (9.65<u>+</u>0.85), $p=0.028$ Suturing techniques Pre (8.0<u>+</u>1.3); Post (13.8<u>+</u>0.9), $p<0.001$ <u>Skills</u> All students successfully demonstrated their ability to tie two-handed knots and perform simple sutures
Schmitz et al. 2021 Germany Surgical online learning platform Interactive online platform to teach operative techniques and	<u>Participants</u> Academic year ns (n=44/58 completed the study) Second years (82%) Intervention group (n=21) Control group (n=23)	<u>Study design</u> RCT Intervention group Video based preparation Control group	Percentage of correct choices Intervention group:(0.67±0.02); Control group (0.60±0.02), $p=0.0001$ Percentage of incorrect choices Intervention group (0.24±0.19); Control group (0.29 ± 0.223); $p=0.04$

skills. Surgical procedures were videorecorded in our operating theatre and processed in order to design an interactive video format Seven educational sessions	 Outcomes Knowledge Outcome measures Online exam consisting of 10 multiple choice questions	Textbook based preparation Type of analysis Analytical statistics Percentage of correct, incorrect and 'don't know' choices Quality appraisal rating Score of 7 out of 11 Confidence evaluation Knowledge Very Low	
Suppan et al. 2021 Switzerland Asynchronous distance learning of the National Institutes of Health Stroke Scale Web-based platform e-learning module interactive content, including gamified modules and serious games, which can be accessed on regular computers as well as on smartphones and tablet compared to standard video based learning	Participants Academic year 2019/2020 Fifth years (n=75/158; rr 47.5% completed the trial) Numbers completing course evaluation E learning module (n=35/79; rr 44.3%) Video group (26/79; rr 32.9%) Outcomes Knowledge Outcome measures 50-question quiz	Study design RCT Intervention group E-Learning module Control group Video Type of analysis Analytical statistics Mean scores Quality appraisal rating Score of 10 out of 11 Confidence evaluation Knowledge - Low	Overall quiz score (Mean±SD) e-learning module (38±3, 95% CI 37-39); video group (35±3, 95% CI 34-36), p<0.001
Totlis et al. 2021 Greece Musculoskeletal system anatomy and neuroanatomy Skype for Business; the university platform Meducator. Structural specimens replaced by photographs 5 weeks Online or pre-recorded theoretical lectures and laboratory lectures	Participants Academic year 2018/2019 In-Person First years studying musculoskeletal anatomy (n=252) Second years studying neuroanatomy (n=211) Academic year 2019/2020 Virtual First years studying musculoskeletal anatomy (n=272) Second years studying neuroanatomy (n=295) Outcomes Knowledge Outcome measures Exam grades Exam grades compared with previous year (2018/2019) when traditional teaching was used (face to face including practical sessions, anatomical models, cadaveric bones etc)	Study design Comparative descriptive study Post-test only Type of analysis Analytical statistics Mean scores Comparison between remote and in person learning across two academic years Quality appraisal rating Score of 4 out of 7 Confidence evaluation Knowledge – Very low	Knowledge (Mean±SD) Musculoskeletal anatomy: In-Person (6.88±2.12); Virtual (6.59±1.67), p<0.001 Neuroanatomy In-Person (6.10±2.23); Virtual (5.70±1.61), p<0.001

Key: EKG : Electrocardiogram; FAST: Focused Assessment with Sonography for Trauma; NM-CCS: New Mexico Clinical Communication Scale; RCT: Randomised Controlled Trial

[a] High-fidelity simulation refers to simulation experiences that are extremely realistic and provide a high level of interactivity and realism for the learner

Table 2: Characteristics of included studies focusing on dental students

Author/s **Country** **Focus** **Remote platform**	**Participants** **Outcomes / Outcome measures**	**Study design** **Type of analysis** **Quality appraisal rating**	**Findings**
Kanzow et al. 2021 Germany Preclinical phantom course in operative dentistry Theoretical knowledge was taught via screen-captured PowerPoint presentations with narrated audio) Stud.IP, an open-source learning management system by using a MediaCast plugin 3 a week for 10 weeks Live and interactive video meetings using Zoom video conferencing platform Physical skills taught onsite using phantom heads with natural tooth model	Participants Summer term 2020 Students enrolled in the pre-clinical phantom course in operative dentistry (n=33) 31 students were eligible to take the final exam Outcomes Knowledge Cariology, restorative dentistry and, preventative dentistry, endodontology and periodontology Outcome measures Summative electronic examination of theoretical knowledge. 30 equally-weighted questions including multiple choice, true/false and open-ended items. A fixed pass mark of 60%. Students had to perform a pre-defined number of treatments in the physical skills part of the course to be admitted to the exam	Study design Single cohort descriptive study Post-test only Analytical statistics Mean scores Comparison of scores between topics Quality appraisal rating Score 4 out of 7 Confidence evaluation Knowledge - Low	Knowledge Credit (%) awarded in each topic (mean±SD) Cariology, Restorative Dentistry and Preventive Dentistry: 75.8±34.5 Endodontology: 79.2±31.2 Periodontology:58.9±37.2 Overall credit:74.5±34.6 Examination items in periodontology showed inferior results compared with other topics (p<.001)
Nijakowski et al. 2021 Poland Blended learning in conservative dentistry with endodontics Blackboard Collaborate 2019/2020 Online classes 2021/2021 Full blended learning, clinical classes, e-learning seminars, and online meetings via Microsoft teams	Participants Academic year 2019/2020 Third years Clinical classes (n=39) Online only classes (n=35) Who then progressed to Fourth years (n=74) In the following academic years 2020/2021 Outcomes Theoretical knowledge, practical skills, and interpersonal skills Outcome measures 5-point self-assessment Likert scales	Study design Comparative descriptive study Post test only Type of analysis Analytic statistics Mean scores Comparison between remote and in person learning within the same academic year Comparison between academic years (retrospective self-assessment during the third year compared to fourth year) Quality appraisal rating Score 4 out of 7 Confidence evaluation Knowledge – Very low Skills – Very low	Theoretical knowledge (Mean: Q_1-Q_3) 3rd year (retrospective) 3.0 (3.0 -4.0); 4th Year 4.0 (4.0-4.0), p=0.001 3rd year (retrospective) In-Person 3.0 (3.0-4.0); 3rd year (retrospective) Virtual 3.0 (3.0-4.0), p=0.702 4th year In-Person 4.0 (4.0-4.0); 4th year Virtual 4.0 (4.0-4.0), p=0.879 Practical skills 3rd year (retrospective) 3.0 (2.0-4.0); 4th Year 4.0 (3.0-4.0), p<0.001 3rd year (retrospective) In-Person 3.0 (2.0-4.0); 3rd year (retrospective) Virtual 2.0 (1.0-2.0), p<0.001 4th year In-Person Year 4.0 (3.0-4.0), 4th year Virtual 3.0 (3.0-4.0), p=0.083 Interpersonal skills 3rd year (retrospective) 4.0 (3.0-5.0); 4th Year 4.0 (4.0-5.0), p=0.048 3rd year (retrospective) In-Person 4.0 (3.0-5.0);3rd year (retrospective) Virtual 3.0 (2.0-4.0), p=0.008 4th year In-Person 4.0 (4.0-5.0), 4th year Virtual 4.0 (4.0-5.0), p=0.952

Key: Q: quartiles

Table 3: Characteristics of included studies focusing on nursing students

Author/s **Country** **Focus** **Remote platform**	**Participants** **Outcomes/outcome measures**	**Study design** **Type of analysis**	**Findings**
Arrogante et al. 2021 Spain High-fidelity[a] virtual OSCEs with standardized patients Blackboard Collaborate A total of eight simulated clinical scenarios were designed related to hospitalized patients or treated in primary care	Participants Academic year 2018/2019 Fourth years In-person OSCEs (n=111) Academic year 2019/2020 Fourth years High fidelity virtual OSCEs (n=123) Outcomes Competency - Nursing assessment - Clinical judgment/decision-making - Clinical management / nursing care - Communication / interpersonal relationships - Teamwork Outcome measures Checklist of the required nursing competencies in the exacerbation of Chronic Obstructive Pulmonary Disease	Study design Comparative descriptive study Post-test only Type of analysis Analytical statistics Mean scores Comparing nursing competencies acquisition through virtual and in-person OSCE modalities across two academic years Quality appraisal rating Score 4 out of 7 Confidence evaluation Competency – Low	Competence (Mean±SD) Nursing assessment) (In-Person 11.89±4.31; Virtual 11.67±4.11, p=0.50, effect size 0.27) Clinical judgement and decision-making (In-Person 10.27±5.39; Virtual 9.84±4.70, p=0.33, effect size 0.29) Clinical management and nursing care (In-Person 21.08±5.29; Virtual 20.88±5.38, p=0.56, effect size 0.26) Communication and interpersonal relationships (In-Person 12.65±2.75; Virtual 12.13±2.44, p=0.10, effect size 0.32) Teamwork (In-Person 12.97±5.20; Virtual 12.45±4.07, p=0.24, effect size 0.30) Overall (In-Person 68.82±13.96; Virtual 68.13±17.96, p=0.10, p=0.42)
Kawasaki et al. 2021 Japan Remotely taught course in human genomics PowerPoint presentations prepared previously for the conventional face-to-face course by adding recorded explanations to the slides, along with uploading the handouts and worksheets to the online educational system with no changes to the topics or content.	Participants Academic year 2019/2020 In-Person Third years (n=46/62, 74.2%) Academic year 2020/2021 Virtual Third years (n=56/59, 94.9%) Outcomes Knowledge Confidence Competency Outcome measures *Knowledge* Genetics knowledge assessment consisting of 12 true/false, 12 fill-in-the-blanks, and 14 essay questions. Points were allocated to each problem for a perfect score of 100 *Confidence* Single question	Study design Comparative descriptive study Pre-test / Post-test Type of analysis Analytical statistics Mean scores Comparison within and between academic years Quality appraisal rating Score 4 out of 7 Confidence evaluation Knowledge – Low Confidence – Low Competency – Very low	Knowledge (Mean ±SD) In-Person: Pre (19.09±7.03); Post (71.24±16.84), p<0.001 Virtual: Pre-test (34.05±8.81); Post-test (91.34±9.05), p<0.001 Mean difference In-Person (52.15±16.47); Virtual (57.29±9.53), p>0.05 Confidence (Mean ±SD) In-Person (2.89±0.90); Virtual (3.38±0.91), p=0.009 Competency (Mean ±SD) I am familiar with the term “human genomics” In-Person: (Pre 3.13±0.89); Post (4.11+0.80), p<0.001 Virtual: (Pre 3.52±0.85); Post (4.52±0.57), p>0.001 I can explain diabetes by referring to hereditary and environmental factors In-Person: (Pre 2.28±0.83); Post (3.17±0.85), p<0.001 Virtual: (Pre 3.05±0.86); Post (3.91±0.84), p>0.001

	'I gained confidence in human genetic health counselling' 5-point self-assessment Likert scale was used to assess the attainment of course goals. 1=Not at all true of me; 2=A little true of me; 3=True of me half the time; 4=Quite true of me; and 5=Very true of me *Competency* Self assessment question within wider study I am familiar with the term human genomics I can explain diabetes by referring to hereditary and environmental factors I can fully explain human diversity by using genomic information I can respond to concerns raised by a member of the community by using knowledge of genetics (same Likert scale as above)		I have had the opportunity to obtain accurate information about genomic diseases In-Person: (Pre 2.26±0.90); Post (3.74±0.80), p<0.001 Virtual: (Pre 2.87±1.01); Post (4.25±0.72), p>0.001 I can fully explain human diversity using genomic information In-Person: (Pre 1.52±0.62); Post (2.98±0.88), p<0.001 Virtual: (Pre 2.07±.0.74); Post (4.02±0.80), p>0.001 I can respond to concerns raised by a member of the community by using knowledge of genetics In-Person: (Pre 1.46±0.55); Post (2.98±0.72), p<0.001 Virtual: (Pre 1.75±.0.75); Post (3.46±0.85), p>0.001 I can fully explain human diversity using genomic information In-Person: (Pre 1.46±0.89); Virtual: (1.95±0.92), p=0.003 All other learning domains non significant
Weston and Zauche, 2020 USA Virtual simulation to clinical practice for prelicensure nursing students in pediatrics Half completed in-person pediatic clinical practice and simulation Half completed virtually using I-Human www.ihuman.com In-Person simulation Laboratory 5 weeks Virtual simulation 35 hours of virtual simulation using the i-Human platform over 5 weeks	Participants Academic year 2019/2020 First years (n=186) In-Person (n=88) Virtual (n=98) Traditional BSN students In-person (n=47) Virtual (n=45) Second-degree BNS students In-Person (n=41) Virtual (n=53) Outcomes Knowledge Outcome Measure: Assessment Technologies Institute (ATI) Nursing care of children examination Including foundations of nursing care of children, age-specific developmental expectations, and care for children with chronic conditions and acute illnesses	Study design Single cohort descriptive study Post-test Type of analysis Analytical statistics Mean scores Comparing knowledge through virtual and in-person simulation Quality appraisal rating Score of 4 out of 7 Confidence evaluation Knowledge – Very low	ATI Scores (Mean±SD) Total sample In-Person (61.91±10.76); Virtual (60.64±12.99%), p=0.485; 95% CI −2.24 to 4.71 Second-degree BSN students In-Person (63.95±9.50); Virtual (64.59 ± 11.01), p=0.77; 95% CI −4.93 to 3.65. Second-degree BSN students In-Person (60.13 ±11.55); Virtual (56.06±13.75), p=0.13, 95% CI −1.19 to 9.32

Key: ATI: Assessment Technologies Institute; OSCE's: Objective Structured Clinical Examinations

Table 4: Characteristics of included studies focusing on pharmacy students

Author/s **Country** **Focus** **Remote platform**	**Participants** **Outcomes / Outcome measures**	**Study design** **Type of analysis**	**Findings**
Cowart and Updike, 2021 USA Remote delivery of a hypertension/drug information simulation-based learning Blackboard Collaborate Across 3 days after 1.5 hours didactic lectures and 2.5 hours laboratory instructive session, pre case vignettes	Participants Academic year 2019/2020 First years (n=87) Response rate pre-test (95%) Response rate post test (62%) Outcomes Blood pressure techniques Application of drug information Assessment of communication skills Outcome measures *Competency* 4-point self-assessment Likert scale (1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree) *Confidence* 5-point self-assessment Likert-scale (0=not at all confident, 1=slightly confident, 2=somewhat confident, 3=moderately confident, 4=very confident)	Study design Single cohort descriptive study Pre-test / Post-test Type of analysis Analytical statistics Mean scores Quality appraisal rating Score 3 out of 7 Confidence evaluation Confidence - Low Competency – Very low	Confidence (Mean ±SD) Blood pressure techniques (Pre 2.75±0.99; Post 4.13±0.7, p<0.001) Application of drug information (Pre 3.55±1.06; Post 4.39±0.81; p=0.002) Assessment of communication skills (Pre 3.05±0.99; Post 3.87±0.83), p<0.001) Competency (Mean ±SD) Blood pressure techniques (Pre 3.28±0.57, Post 3.22±0.67, p=0.859) Application of drug information (Pre 3.17±0.51, Post 3.30±0.66, p=0.864) Assessment of communication (Pre 3.17±0.51, post 3.44±0.54, p=0.007)
Phillips et al. 2021 USA Remote delivery of Integrated Patient Care Capstone course Zoom video conferencing platform 60% of the course competed in-person before transitioning to remote learning which consisted of weekly class sessions	Participants Academic year 2019/2020 In-person Third (n=134) Academic year 2020/2021 60% course completed in person before moving to remote learning Third years (n=126) Outcomes Drug therapy knowledge Application of drug therapy guidelines Improving clinical reasoning, strengthening pharmacists' patient care process, skill development Outcome measures *Knowledge / performance:* Quizzes Mid-term examination result Final examination results *Competency & confidence:* 6-item self-assessment scale	Study design Comparative descriptive study Post-test only Type of analysis Analytical statistics Mean scores Comparison between remote and in person learning within the same academic year Comparison between two academic years Quality appraisal rating Score 3 out of 7 Confidence evaluation Knowledge – Very Low Confidence - Low Competency – Low	Knowledge Quiz average (Mean ±SD) 2019 cohort (23.0±3.0); 2020 cohort (23.6±1.9), p>0.05) 2020 Spring semester In-Person (7.7 ± 1.8); 2020 summer semester Virtual (8.2 ± 1.6), p<0.05) Mid-term examination (Mean ±SD) 2019 cohort (21.3±4.8); 2020 cohort 22.1±5.0, p>0.05) Final examination (Mean ±SD) 2019 cohort (23.1±5.4); 2020 cohort 21.3±5.4, p<0.01) 2020 Spring semester In-Person (23.1 ± 5.4), 2020 summer semester Virtual (21.3 ± 5.4); p<0.05) Competency No significant difference in self-assessed skill development when compared between 2019 and 2020 using anonymous course evaluation data (Mann-Whitney U test; p>0 05). Confidence No significant associations were found between level of student confidence in skill development and performance on the final practical exam or in the overall

			course in 2020 (Spearman Correlation test, p>0.05)
Scoular et al. 2021 USA Remote delivery of OSCEs in patient counselling and taking a medical history Zoom video conferencing platform	Participants Academic year 2019/2020 First years (n=144) Academic years 2020/2021 First years (n=106) Outcomes Skills (Patient centred communication; empathy; trust; professionalism; general verbal and non-verbal communication skills) Outcome measures Cumulative OSCE Patient centred communication OSCE Students were required to counsel a standardized patient on two prescription products with unique dosage forms (e.g., inhalers). Students' skills were graded by standardized patients	Study design Comparative descriptive study Post-test only Type of analysis Analytical statistics Mean scores Comparison between remote and in person learning Comparison of performance scores between two academic years Quality appraisal rating Score 5 out of 7 Confidence evaluation Skillssupp – Very low	Patient centred communication OSCE Overall score (Median, range) 2019 (96.47, 36.47); 2020 (99.00, 23.00), p=0.000 effect size -0.29 Comparison between 2019/2020 for sub domains Establishing a trusting relationship (p=000), effect size -0.32 Effective verbal and non-verbal communication (p=0.001, effect size -0.21) Provided patient friendly education (p=0.026, effect size -0.14) Organizing the encounter (p=0.044, effect size -0.13) Cumulative OSCE Total variable score (Median) 2019 (16.00, 10.00); 2020 (16.0,16.00), p=0.039, effect size -0.13 Comparison between 2019/2020 for sub domains Demonstrates empathy (p=0.245) Appropriate non-verbal communication (p=0.259) Professionalism (p=0.750) Global feedback: Establishing Trust (p=0.015, effect size -0.15)
Singh et al. 2021 USA Virtual case-based learning elective rotation for Advanced Pharmacy Experience Asynchronous independent work and synchronous video conferencing University Supported Management System: CANVAS Zoom video conferencing platform 6-weeks	Participants Students (n=68/70) No further details provided Outcomes Confidence (based on SLOs below) Knowledge Student Learning Outcomes (SLOs) (n=8) SLO 1: Retrieve evidence-based medicine in the patient decision-making process SLO 2: Evaluate and apply evidence-based medicine in the patient decision-making process SLO 3: Analyse patient-specific background (i.e., informational, functional, socioeconomic, cultural, and behavioural) to establish patient-specific goals SL0 4: Prepare and communicate patient care plans SLO 5: Design, and redesign as appropriate, a safe, and effective patient specific plan SLO 6: Develop patient-specific monitoring plans to assess efficacy and safety SLO 7: Develop drug-related education materials	Study design Single cohort descriptive study *Confidence* Pre-test / Post test *Knowledge* Post-test Type of analysis Descriptive statistics Mean scores Quality appraisal rating Score 4 out of 7 Confidence evaluation Knowledge – Very Low Confidence – Low	Knowledge (SLO's: mean scores) SLO 1: 76.31% SLO 2 80.42% SLO 3 76.31% SLO 4 81.14% SLO 7 :75.51% SLO 8: 75.77%. The average score for the one graded activity mapped to SLO 5 and SLO 6 was 76.31% Confidence The mean difference in the students' responses showed a greater than average 10-point improvement in their ability to demonstrate learning outcomes

	SL0: 8: Clearly communicate educational materials to preceptors and peers Outcome Measures: *Confidence* 100-point levelled ability scale with each of five levels of ability spanning a range of 0 to 20 *Knowledge* Seven graded activities (case-based quizzes, drug consultations and presentations, journal club activities, and the closeout exams) were used to assess the achievement of SLOs, with a target minimum average of 80% as an acceptable level for achieving outcomes		

Key: OSCE's : Objective Structured Clinical Examinations; SLO: Student Learning Outcomes

6. RAPID REVIEW METHODS

6.1 Eligibility criteria

We included any quantitative primary research designed to determine the effectiveness of any alternative education delivery strategies (including clinical skills delivery) for undergraduate and postgraduate medical, dental, nursing and pharmacy students during the COVID-19 pandemic? The outcomes of interest were knowledge, skills, confidence and competency. The context was all academic and healthcare institutions that deliver undergraduate or post graduate education.

Exclusions

- All other allied health professions
- Research conducted within non-OECD countries
- Assessment / examination processes
- Continuing professional development not leading to a postgraduate qualification

6.2 Literature search

Search strategy

An initial search of MEDLINE was undertaken (medicine or medical or nurs* or dental or dentistry or pharmacy or pharmacist or education* or train* or teach* or student* or undergraduate* or postgraduate* AND COVID* or coronavirus) followed by analysis of the text words contained in the title and abstract, and of the index terms used to describe article. This informed the development of a search strategy which was then tailored for each information source. The reference list of all included studies was screened for additional studies.

Sources searched

Searches were conducted across four databases. On the OVID platform: MEDLINE and Embase, on the EBSCO platform: CINAHL and ERIC, from December 2019 to 8th June 2021 for English language citations.

6.3 Study selection process

All citations retrieved from the database searches were imported or entered manually into EndNote™ (Thomson Reuters, CA, USA) and duplicates removed. Irrelevant citations were removed by searching for keywords within the title using the search feature within the Endnote software. The project team agreed which keywords to use to identify papers which did not meet the inclusion criteria. At the end of this process the citations that remained were exported as an XML file and then imported to Covidence™.

Two reviewers dual screened 20% of the citations using the information provided in the title and abstract, using the software package Covidence™, and resolved all conflicts. The remaining citations were then screened by a single reviewer, screening into categories of include and exclude. To streamline the review process, the project team decided against a third category of 'unsure' and instead, where there was uncertainty about a citation, it was categorised as 'include' to enable a decision to be made based on the full text.

For citations that appeared to meet the inclusion criteria, or in cases in which a definite decision could not be made based on the title and/or abstract alone, the full text of all citations were retrieved.

The full texts were screened for inclusion by one reviewer using a purposely designed form which was piloted using approximately 10 manuscripts. One reviewer then screened full text manuscripts, and another reviewer checked all excluded manuscripts.

6.4 Data extraction

All demographic data were extracted directly into tables by one reviewer, and checked by another. The data extracted included specific details about the interventions, populations, study methods and outcomes of significance to the review question and specific objectives. A template for the data extraction process

was piloted on manuscripts for each of the included study designs before use. All outcome data were extracted directly into tables by one reviewer and checked by another.

6.5 Quality appraisal

The methodological quality of all the research studies was assessed by one reviewer, and judgements verified by a second reviewer, using JBI design-specific critical appraisal tools (https://jbi.global/critical-appraisal-tools). When a study met a criterion a score of one was given. Where a particular item was regarded as "unclear" it was given a score of zero. Where a particular item was regarded as "not applicable" a point was deducted from the total score. All included studies were assessed using this method and their overall critical appraisal scores calculated.

6.6 Synthesis

Two RCTs were included in the review but there was insufficient homogeneity across the studies and therefore we were unable to perform a meta-analysis. The findings from the RCTs, along with data from descriptive studies, were thematically presented (Thomas and Harden, 2008).

6.7 Assessment of body of evidence

The confidence in the synthesised findings were assessed by one reviewer and judgements verified by a second reviewer and these were conducted separately for the RCTs and the descriptive studies as follows:

- RCTs - Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach (Guyatt et al. 2008).
  Final quality ratings were
  - High quality (it is highly likely that new research will not modify the finding substantially)
  - Moderate quality (it is somewhat likely that new research will not modify the finding substantially)
  - Low quality (it is somewhat likely that new research will modify the finding substantially)
  - Very low quality (it is highly likely that new research will modify the finding substantially)

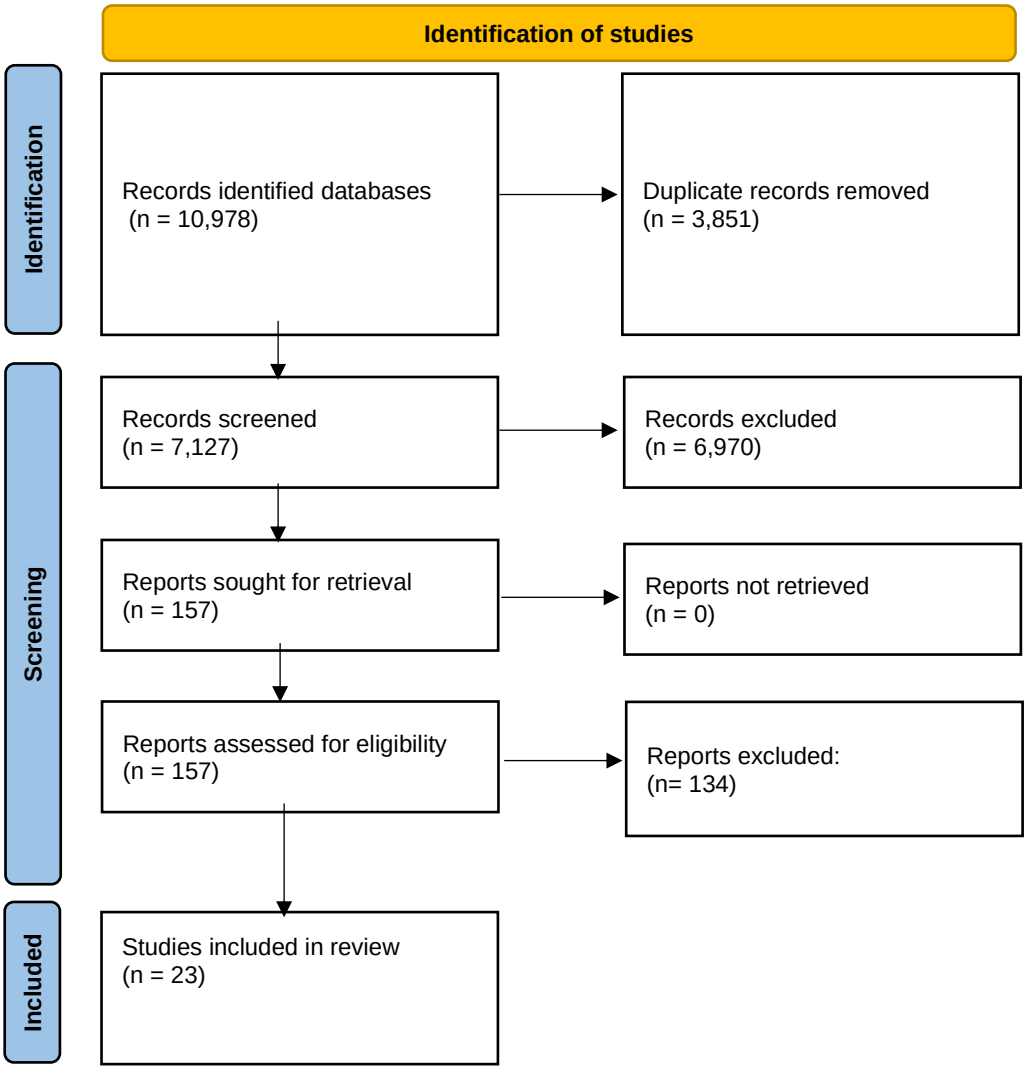
- Quantitative descriptive studies by applying the principles of GRADE (World Health Organisation, 2017).
  Final quality ratings were
  - High quality (highly likely that new evidence will not substantially modify the study findings)
  - Moderate quality (somewhat likely that new evidence will not substantially modify the study findings)
  - Low quality (somewhat likely that new evidence will substantially modify the study findings)
  - Very low quality (highly likely that new evidence will substantially modify the study findings)

Due to heterogeneity of the different interventions within similar settings outcome, data was only available for results that arose from single studies and guidance was followed on undertaking GRADE for data of this type (Ryan and Hill, 2016).

6.8 Study selection flow chart

The flow of citations through each stage of the review process is displayed in a PRISMA flowchart (Page et al. 2021), see Figure 1.

Figure 1: PRISMA flow diagram



7. ADDITIONAL INFORMATION

7.1 Information available on request or please download here:
http://www.primecentre.wales/resources/RR/Clean/RR00004_Supplementary_information_Healthcare_education.pdf

- Critical appraisal scores
- Tool for assessing the confidence of synthesised findings from quantitative descriptive studies
- Evaluation of confidence using GRADE
- Excluded studies

7.2 Conflicts of interest
The authors declare they have no conflicts of interest to report.

7.3 Acknowledgements
The authors would like to thank Steve Riley, Michal Tombs and Assim Javaid for their contributions during stakeholder meetings to guide the focus of the review and interpret findings. In addition, thanks to Professor Jane Noyes for passing on the information regarding the adaption of the GRADE approach for quantitative descriptive studies.

7.4 Abbreviations

Acronym	Full Description
GRADE	Grading of Recommendations, Assessment, Development and Evaluation
RCT	Randomised controlled trial
OECD	Organisation for Economic Co-operation and Development
OSCEs	Objective structured clinical examination
TASO	Transforming Access and Student Outcomes in Higher Education

8. ABOUT THE WALES COVID-19 EVIDENCE CENTRE (WC19EC)
The WC19EC integrates with worldwide efforts to synthesise and mobilise knowledge from research. We operate with a core team as part of Health and Care Research Wales, are hosted in the Wales Centre for Primary and Emergency Care Research (PRIME), and are led by Professor Adrian Edwards of Cardiff University.

The core team of the centre works closely with collaborating partners in Health Technology Wales, Wales Centre for Evidence-Based Care, Specialist Unit for Review Evidence centre, SAIL Databank, Bangor Institute for Health and Medical Research/ Health and Care Economics Cymru, and the Public Health Wales Observatory.

Together we aim to provide around 50 reviews per year, answering the priority questions for policy and practice in Wales as we meet the demands of the pandemic and its impacts.

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https://healthandcareresearchwales.org/about-research-community/wales-covid-19-evidence-centre