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BEME REVIEW

Implementation of virtual pathology teaching in health professions education: A systematic review: BEME Systematic Review No. 95

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ABSTRACT

Purpose: Rapid changes to learning technologies, accelerated by the COVID-19 pandemic, have led to the widespread adoption of virtual education. Pathology is an important medical science that is central to many curricula in health professions education (HPE). It has been impacted by the broader transition to virtual education. This systematic review and meta-ethnography evaluated the experiences of virtual pathology education within HPE.

Methods: MEDLINE and EMBASE were systematically searched for peer-reviewed qualitative journal articles describing the experiences of virtual pathology in HPE. Of 1119 articles identified, 17 were synthesised using a meta-ethnographic approach.

Results: The final synthesis represented a total of 2126 participants, including 1256 undergraduate medical students, 297 resident doctors, 473 senior clinicians, and 100 teaching faculty. We identified the following third-order constructs: 'Adaptability to learner's needs', 'negative human consequences', and 'uncertainty about trajectory'.

Conclusion: This review highlights both positive and negative impacts of transitioning pathology education to virtual delivery. The need to enhance current educational practice according to these findings is particularly pressing since the shift to virtual education in pathology looks set to accelerate in years to come.

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Continuing medical education; professional development; virtual; digital; pathology; systematic review

Introduction and background

The increasingly digital landscape over the past decade has altered medical education and how students learn [1]. This technological transformation in education has taken many forms and was especially accelerated by the COVID-19 pandemic [2].

Pathology is an important medical science that is central to many curricula in health professions education (HPE) and has been impacted by this broader transition to virtual education. Teaching within pathology has historically been delivered through in-person didactic curricula to provide contact with pathological specimens, and consequently has been somewhat insulated from technological transformation. For example, conventional light microscopy with glass slide assessment, tissue analysis and clinical tests (blood, urine, pleural fluid, etc.) naturally includes towards in person teaching in a laboratory setting [3]. The subject of pathology involves the study of disease and encompasses multiple disciplines including haematology, histopathology, microbiology and more [4]. Understanding pathology is fundamental to our understanding of disease aetiology and pathogenesis, and provides the basis of diagnosis and therapy within clinical medicine [3].

However, the face-to-face delivery of pathology teaching has become increasingly less feasible due to university and clinical laboratory closures, and became extremely challenging due to the social distancing measures put in place during the response to the global pandemic between 2020 and 2022 [5]. This fostered the development of various innovative digital platforms, virtual microscopy, e-learning modules, podcasts, education pages on social media and utilization of tele-conferencing to facilitate

Practice points

- Virtual pathology provides greater adaptability to learner's needs primarily through increasing accessibility.
- There are some negative consequences through reducing human interaction, limiting exposure to practical skills, and introducing distractions.
- Current literature suggests there is uncertainty about the trajectory of virtual pathology education, due to the mix of positive and negative impacts, the technical hurdles, and the inevitability of adoption to virtual platforms.
- There is a need to enhance current educational practice, which is particularly pressing since the shift to virtual education in pathology is set to accelerate in years to come.

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Table 1. Some use of digital material considered within this study.

1	Virtual microscopy for teaching: Using digital slides instead of physical microscopes in classroom settings, allowing all students to view the same high-quality specimens.
2	Self-directed learning: Providing students with access to digital slide collections they can study independently at their own pace.
3	Case-based learning: Creating interactive case studies with annotated digital slides that guide students through diagnostic reasoning.
4	Assessment: Tools that allow instructors to highlight specific features on slides and create assessments based on digital images.
5	Remote teaching: Enabling instructors to conduct demonstrations and teaching sessions across multiple locations simultaneously.
6	Collaborative learning exercises: Having students work together on digital slides, adding annotations and discussing findings in shared digital spaces.

ongoing medical education and pathology teaching despite lockdown restrictions [6].

For the digital modalities we used in this study we focused on any use of digital slides for educational activity. A list of some uses is included in Table 1.

Due to the limited amount of data available and our focus on student experience, undergraduate and residents' learning experiences were both considered. Also, it is difficult to make single judgement about individual studies as different medical schools deliver pathology curriculum to a different extent [7].

Pathology educators face additional pressures. This includes larger learner numbers, the limited flexibility of face-to-face learning for students, and ensuring pathology teaching is delivered as part of a high-quality reproducible curriculum to provide all future clinicians and pathologists with a standardised level of knowledge [8]. Recent years have also seen rapid technical progress in the clinical specialty of pathology, and more widely across a range of diagnostic specialties. Digital pathology in a clinical setting includes the integration of whole slide images into pathologists' clinical workflow [9]. The benefits have been identified as improved access, reduced cost and time savings [9,10]. It also allows for remote working which carries its own benefits, including facilitating second opinions, external quality assurance and education programmes [9]. However, this alternative has high initial acquisition costs, and addition ongoing costs relating to IT support, slide scanning and digital storage [9].

Digital pathology has the potential to improve exchange between experts, such as within a multidisciplinary tumour board conference [11], and can also improve diagnostic accuracy and clinical practice [11]. Artificial intelligence (AI) software can be applied to digital pathology to automate time-consuming processes, and assist with diagnosis and decision making [12,13]. The AI algorithms used can counter inter-observer variability in clinical practice by providing objectivity, inter-reader reliability and prognostic clarity [13]. Despite the benefits, there remain ethical concerns in multiple domains, such as the validation of algorithms and the datasets used [13].

The rapid transition of traditional pathology practice to digital pathology presents many uncertainties and the educational implications are also unclear. In view of this uncertainty, this study will evaluate the experiences of students, trainees, faculty and senior clinicians of virtual pathology within health professions education.

Aim

This study sought to evaluate the experience of online and virtual teaching of pathology across both undergraduate and resident health professions education to determine the opportunities and challenges of virtual teaching for both learners and teachers.

The study will focus on the research question: *What are health professions learners' and teachers' experiences of virtual pathology in health professions education?*

Methodology

This study reviews qualitative articles as we found that studies that use quantitative data, often used academic performance or personal satisfaction comparing between virtual and optical microscopy [14]. Academic performance has shown a mix of virtual microscopy being superior and comparable with optical microscopy [15] and the common use of likert scale in medical education [16] and presentation of ordinal results are not usually helpful [17]. Qualitative research provides context, nuance and understanding of a process that is limited in quantitative research [18] and hence suitable for our research question on individual's experience that is not offered in quantitative research.

Qualitative research provides an analytical depth within a particular context and thus provides invaluable information to research [19]. We adopted a meta-ethnographic approach due to its effectiveness in synthesising qualitative research about complex social phenomena, such as virtual education delivery, and its capacity to develop a model that interprets findings across multiple studies [20].

The meta-ethnographic approach was first proposed by Noblit and Hare [21] and provides a platform for analysing studies and translating key concepts. The opportunity to increase understanding, refine medical education research and practice has led to the growing use of qualitative studies within medical education research [22]. This meta-ethnography adhered to eMERGe guidance, which aims to increase transparency and rigour in reporting [23].

Selection of studies

The databases MEDLINE and Embase were systematically searched for articles on 9th July 2024. The following search terms and strategies were used for the keywords: (virtual* OR remote* OR simulat* OR computer* OR digital*) AND (patholog* OR histolog*) AND (education* OR teach* OR learn* or train*). Limits were published in English, published within the last 10 years (2014-2024) and journal articles, books, chapter publications or editorials.

This identified a total of 1,119 studies. Search strategy and screening adhered to PRISMA guidelines [24]. Studies was reduced to 699 after removing duplicates. This was further reduced to 389 after studies relating to 'deep learning' were removed. The resulting papers were screened, using titles, by two reviewers (JK and JH). This reduced the total to 163 studies using the criteria in Table 2. Abstracts were then reviewed by the same two reviewers using the same

Table 2. Inclusions and exclusion criteria.

Inclusion criteria	Exclusion criteria
Qualitative methodology studies (including mixed-method studies) Participants included candidates or faculty members within health professions education programmes Articles evaluating virtual pathology (students and/or teacher) Articles published in journal articles books, chapter publications or editorials Articles published in English Published in the last 10 years (2014–2024)	Exclude articles evaluating clinical uses of virtual pathology Exclude articles relating to 'deep learning', since this concerns the training of AI algorithms rather than health professions students.

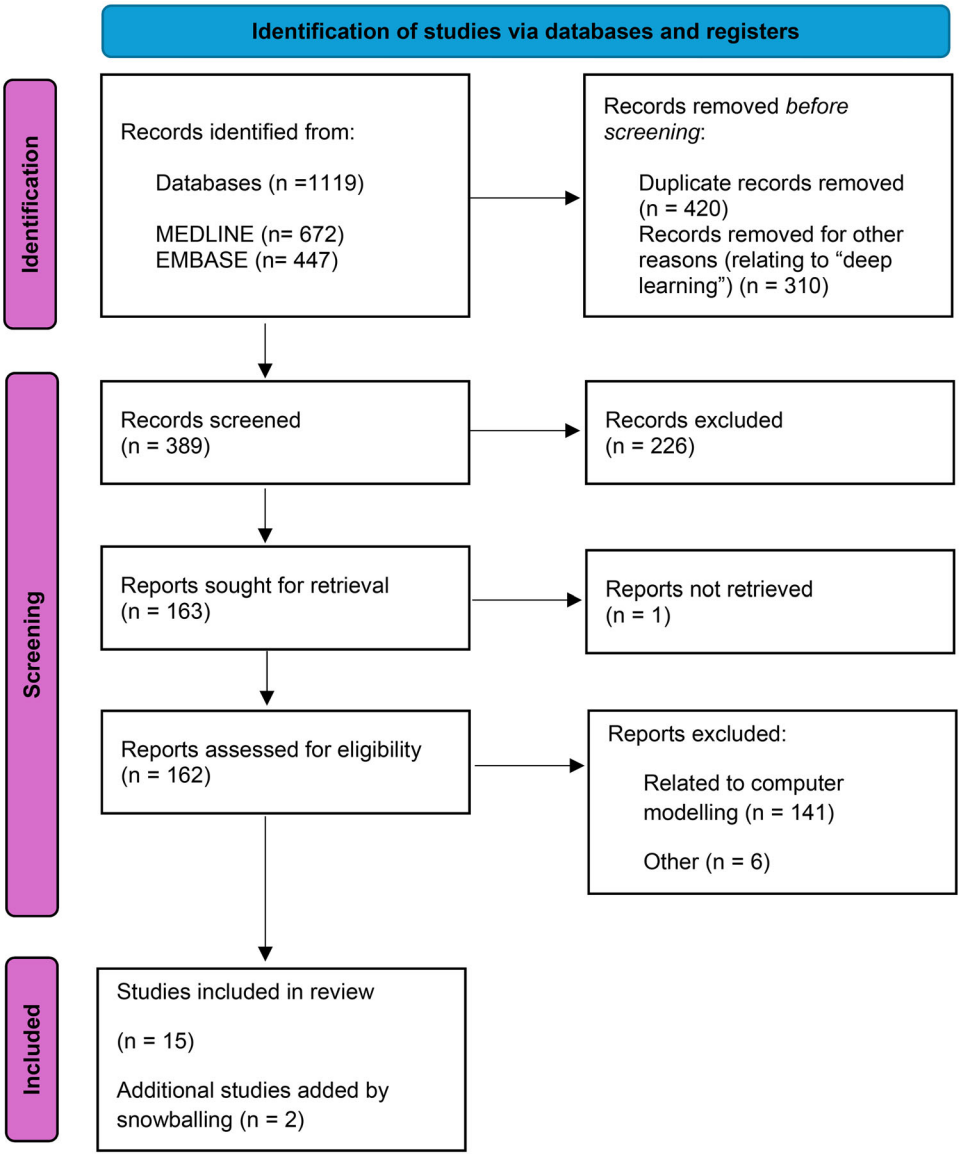

Figure 1. Summarises the article selection process based on the preferred reporting items for systematic reviews and meta analyses (PRISMA).

criteria in Table 2. Studies that were found not to be related to educational use of pathology (i.e. clinical pathology) and papers involved with quantitative review were excluded during this stage. The subject of clinical pathology was not actively excluded, though its clinical constituents were not searched independently i.e. clinical pathology (e.g. microbiology, chemical pathology and haematology). However, any activity that was clinical in nature without an educational component was excluded.

Any discrepancies in selection were discussed with a third reviewer (MAR). This left a total of 15 studies. Two further studies were included with 'snowballing', a process that involves searching for studies that have cited the eligible articles (Figure 1).

Seventeen articles met the defined inclusion criteria and were included in the meta-ethnography. Table 2 details the final inclusion and exclusion criteria. Studies were included if they described their methods as qualitative and involved the collection, analysis or interpretation of non-numerical data. Studies examining the use of digital pathology, including undergraduate or residents were included.

Findings

Critical appraisal

The subjective nature of qualitative synthesis has led to much debate on quality appraisal [25]. To maintain a transparent and valid appraisal, all included articles were

Table 3. Characteristics of articles included in the meta-ethnography.

#	First author, Year	Relevance	Sample group and size	Methods	Country	Article
1	Browning, 2020	SAT	Histopathology trainees, 16	Survey	United Kingdom	[29]
2	Browning, 2023	SAT	Histopathology trainees, 19	Survey	United Kingdom	[30]
3	Cheng, 2021	SAT	Medical schools, 83	Survey	China	[31]
4	Dimopoulos, 2023	SAT	Residents of histopathology fellowships, 64	Survey	United States	[32]
5	Francis, 2023	KEY	Undergraduate medical students (1st year), 164 + 161	Cohort study, Survey	India	[33]
6	Grover, 2020	SAT	Undergraduate medical students (2nd year), 70	Cohort study, Survey	India	[34]
7	Ishak, 2022	KEY	Undergraduate medical students, 173	Literature review, Survey	Cyprus	[35]
8	Kwon, 2020	SAT	Cytopathology residents, number unclear	Survey	United States	[36]
9	Laohawetwanit, 2023	SAT	Pathologists, 453 Trainees, 109	Survey	Global (79 countries)	[37]
10	Michelow, 2022	KEY	Pathology consultants, 20; Pathology residents, 18	Survey	South Africa	[38]
11	Moore, 2023	SAT	Pathology residents, 28	Cohort study, Survey	United States	[39]
12	Paul, 2022	SAT	Anatomy teachers, 100	Survey	India	[40]
13	Sakthi-Velavan, 2023	KEY	Undergraduate osteopathic medical students (1st and 2nd year), 477 (239 responses)	Exam performance, survey	United States	[41]
14	Samueli, 2020	SAT	Undergraduate medical students, 59 (25 responses)	Survey	Israel	[42]
15	Then, 2023	SAT	Undergraduate medical physiology and therapeutics students		United Kingdom	[43]
16	Van, 2015	SAT	Histopathology trainees, 43	Assessment, questionnaire	Australia, New Zealand, Malaysia	[44]
17	Wan, 2022	KEY	Undergraduate medical students, 69	Knowledge gain test, focus group	Australia	[45]

appraised independently by three other reviewers (IH, JK, JH) using the Critical Appraisal Skills Programme (CASP) qualitative research checklist [26,27]. This checklist follows a structured approach to identify any poor quality studies for exclusion from appraisal [26,27]. Classification of key papers was made based on collective author's judgement on whether it met important themes and applicability for our study. Articles whose contents that mirrored closely to our research question was assigned as 'Key Paper' (KEY) and papers whose contents provided a smaller contribution was assigned 'Satisfactory Paper' (SAT), which was based on Dixon-Woods et al. criteria [28]. The classification of the seventeen articles is presented in Table 3 and no studies were removed during this process.

Synthesis

The seventeen studies were then synthesised using a meta-ethnographic approach [21]. Firstly, first-order constructs were extracted as direct quotations from research participants. The studies were evaluated independently by 4 researchers (IH, JK, JH and MAR). Next, second-order constructs was obtained by taking authors' interpretation of the results from these studies. Finally, all researchers came together to formulate their interpretations of the first- and second-order constructs, known as third-order constructs. The 'line of argument synthesis' was used to identify similarities and differences between the themes observed and develop an overall argument that accounts for the range and diversity of the seventeen studies. According to eMERGe guidance, this collaborative process decreased the possibility of biases by challenging each researcher's individual interpretation and allowed for a more comprehensive insight from the results [23].

Results

A total of 17 studies were included. The aggregated populations studied were 1256 undergraduate medical students, 297 resident doctors, 473 senior clinicians and 100 teaching faculty. Only studies relating to medical undergraduates and residents fulfilled the full criteria for inclusion. Studies involving nursing students, dental students, veterinary students and allied health professions students were mostly excluded because they did not include qualitative data. 4 studies were conducted in the United States, 3 in the United Kingdom, 3 in India, 2 in Australia, 1 in South Africa, 1 in Israel, 1 in Malaysia, 1 in New Zealand, 1 in Cyprus and 1 across 79 countries. A total of 12 s-order constructs were identified from the included studies. These second-order constructs were then synthesised by the authors into three third-order constructs. These are summarised below in Table 4.

Adaptability to learner's needs

The development of virtual pathology resources and courses has provided increased adaptability to individual learner needs. Students see this new provision as more convenient and accessible, allowing them to learn from home often at a time of their choosing and at their own pace [35,37,38,41,44]. Virtual teaching can also be more engaging, with the difficulties of asking questions and seeing demonstrated materials in an in-person session mitigated by the virtual platform [35]. Furthermore, virtual teaching can be more responsive to individual needs through providing a customised experience to each user, and to the changing needs of a cohort, as it has been seen as easier to update [39,46].

Negative human consequences

Virtual learning reduces human interaction – both with peers and with faculty [35]. This was seen by some as a particular problem in pathology, which tends to be more isolated than other medical specialties [38]. It was also

Table 4. Collating the formulated third-order constructs by researchers based on second-order constructs extracted from research articles.

Third-order construct	Related second-order construct	Illustrative first-order constructs	Articles contributing to the second-order construct
Adaptability to learner's needs	More engaging	'Participation was easier for all students during online sessions as well as asking questions.' [35] 'Both the interactive e-learning module and PDF reading exercise were associated with high user engagement' [39] 'Both the interactive e-learning module and PDF reading exercise were associated with high user engagement' [40]	[33,35,39,40,42,44]
	More convenient	'Attending from home is very convenient and less time-consuming.' [35] 'I strongly favour virtual meetings, because they are very convenient and we can choose to listen to the lectures any time were are available to do so … ' [37]	[33,35,37]
	Improved responsiveness	'Quicker and easier than "real"' [43] 'Less time consuming overall as we were able to divide the time to study/focus for each class according to our personal needs.' [35] 'I appreciated the format of the class. I liked the frequent, short quizzes because it gave us time to focus on one part of the body at a time' [42]	[33,35,37,42,43]
	More accessible for students	'easy access to study from home.' [44] 'Increased accessibility. More people can join from anywhere, traffic/parking is not an issue, travel time and time away from a desk is minimised.' [38] 'Can be accessed after class hours, Accessed outside histology lab' [33]	[33,38,44]
Negative human consequences	Hard to concentrate	'Focusing for a long period of time in front of a screen was difficult.' [35] 'Long hours in front of a laptop made it unbearable to focus after some point.' [35] 'It was impossible being in front of a screen literally all day; my eyes were hurting, I constantly had headache, I couldn't study on my computer more hours etc.' [35]	[35]
	Reduced interaction with peers	'The lack of personal interaction makes it really hard to focus and listen to classes.' [35] 'Not having interaction and discussions with my classmates and professors.' [35] 'The absence of a face-to-face, more "human" relationship with my instructors.' [35] ' … when it comes to events that requires more interaction with each other (slide seminars, networking events, poster and paper presentations) in person conferences are better.' [37]	[35,37]
	No practical experience	'Will forget how to use a microscope' [33] 'I think the microscope part of lab is really important and I think it can't be replaced.' [35]	[33,35]
	Reduced relationship with faculty	'difficulty in efficient interaction with students' [40] 'difficulty in grasping student progress and results of learning' [34]	[40]
	Additional faculty workload	'longer time for preparing online teaching than traditional teaching' [40] 'The downside of this process may be too much information which needs to be curated to be of real educational value.' [46] 'Workflow impeding factors including workload, meetings, teaching might offset reduction in time to getting cases to a pathologist' [29] 'Additional workflow steps introduced, such as slide scanning, might impact turnaround' [29]	[29,40,46]
Uncertainty about trajectory	Future-proof	'one of the main sources of teaching for the (pathology) trainee in the near future.' [44]	[44]
	Technological issues	'The stress during the examinations because of possible technical problems.' [35] 'unstable online teaching environments, platforms and tools' [40] 'Difficult to use' [42] 'poor pixelated quality of scanned-in images' [38]	[32,33,35,38,40,42]
	Reduced environmental impact	'Isn't it our duty towards society and the next generation of pathologists to avoid travelling whenever possible? Virtual meetings are a great option to stay connected!' [35] 'time-cost saving by alleviating the need for physical presence or travel between sites' [46]	[35,46]

associated by some with difficulties in concentrating, due to distractions in the home environment and to the need to look at a screen for extended periods [35]. For faculty, a significant disadvantage experienced by some was an increased workload associated with converting material into a digital format and in administering virtual meetings

[29,38,40,42]. For students, a particular concern was the lack of practical experience which could be gained from virtual sessions, with a consequent impact on their readiness for a clinical career in pathology and on their ability to pass exams which still assume a significant amount of practical experience [29,30,33,35]. This is distinct from the construct *improved responsiveness*, which relates specifically to the platform and digital material allowing students increased interaction with digital cases [33].

Uncertainty about trajectory

The significant technical obstacles encountered by a number of students and faculty were seen as a significant hurdle which virtual platforms would need to overcome in order to be a viable alternative to in-person teaching [29,30,42]. However, many describe virtual platforms as an inevitable reality of future educational and clinical practice, and cite this as a reason to engage with the technologies now, despite their current limitations [37,44]. Additionally, several students and faculty noted the contribution virtual teaching could make to reducing the environmental footprint of pathology education, noting that this is likely to become increasingly important [37].

Discussion

Summary of results

Three third-order constructs were identified in this review of qualitative literature about the virtual delivery of pathology teaching: adaptability to learner's needs; negative human consequences; and uncertainty about trajectory.

The studies demonstrate both benefits and drawbacks of digital pathology. On the one hand, they are more adaptable to individual learner needs through greater accessibility, allowing learners to go at their own pace and be more engaged in learning [35,37,38,41,44]. On the other, they necessarily involve some loss of human interaction and often involve an increase in distractions (despite being engaging and interactive) [35]. They also provide limited practical exposure (in the light of increasing access and thus pathology exposure to many). The difficult balance between maximising potential benefits and mitigating potential drawbacks has led to some uncertainty about its future trajectory – predominantly relating to the many technical hurdles which need to be overcome for its successful implementation. Nevertheless, some authors describe the adoption of virtual platforms as an inevitability [44].

Comparison with existing literature

Recent technological advances have allowed the delivery of digital content [47] that has proved invaluable in medical education. E-learning [47] has been used by medical school for at least 10-20 years and has been demonstrated to share many similar qualities as our findings including accessibility, flexibility and environmental sustainability [47,48]. Shared recognised limitations included lack of motivation and reduced interaction [47]. Banker et al. [47] found limitations with e-learning due to inadequate teacher training and lack of standardisation impacting learning.

The unprecedented period of the COVID-19 pandemic further propelled the use of virtual teaching in medical education including anatomy education using virtual reality (VR) and augmented reality (AR) [49]. Sinou et al. [49] demonstrated certain traditional methods of teaching could not be replace with virtual alternatives, including 'dissection, prosection, and lectures by physical presence' [49]. Medical assessment was also subjected to virtual modality, being virtual OSCE [50] and remains to be a live debate in medical education.

Previous studies have similarly found that students benefited from ease of use, accessibility and efficiency [51,52]. Shared concerns included loss of practical experience and reduced personal contact between faculty-student relationship [51,52]. Saco et al. [52] identifies the initial technological barrier relating to the high initial financial investment for the acquisition of a scanner and disk memory and ongoing costs including regular server maintenance and high internet connection. Student performance is an important area in medical education, Laohawetwanit [51] suggests that the difference in student performances using virtual pathology and traditional light microscopy is not much different and virtual pathology is not necessarily the superior option.

The unresolved debate between the two modalities in medical education would mean various other factors need to be considered for whether an institution wants to adopt a purely virtual pathology teaching, purely traditional light microscopy teaching or a blend between the two.

Strengths and limitations

Meta-ethnography is a well-established methodology for synthesising qualitative studies and is widely used in health professions education [53]. Its interpretative framework allows for a nuanced understanding of complex and context-specific educational experiences. Specifically, the culturally diverse review team has varied clinical, academic, and technological backgrounds. This diversity integrates multiple perspectives to reduce interpretative variability. Furthermore, by adhering to the eMERGe guidance, the review aims to increase transparency and rigour in reporting [23]. The systematic searches followed strict inclusion criteria and are documented through the PRISMA flowchart. Study quality was appraised using the CASP checklist and criteria from Dixon-Woods et al. [28] to strengthen thoroughness and credibility of the review. The inclusion of seventeen articles in this review achieves a balanced synthesis and offers sufficient depth and nuances without sacrificing breadth [53].

However, the seventeen included studies vary significantly in methodological approach, such as focus groups, interviews and mixed-method surveys. The differences in data collection and analytical techniques could have affected the interpretation of second- and third-order constructs [54]. Although the included studies represented at least 79 countries, most perspectives are from developed regions. This predominance may therefore limit the applicability and transferability of findings across different educational systems and resource settings.

Some studies chose only to record second-order constructs and some extract first- and second-order constructs [23]. At times, the distinction between first- and second-order constructs was not necessarily clear [23] and a challenge that was encountered during this study's appraisal.

Implications for medical education

Evidence within the literature suggests the future of pathology education lies within a hybrid curriculum or a blended model whereby educators and learners can leverage the flexibility of digital resources while preserving the hands-on skills of conventional microscopy [35]. This reflects other areas of medical education, for example digital anatomy learning, where in-person dissection labs have been supplemented with digital tools, prosections, and applied anatomy labs [55]. Our findings suggest a hybrid curriculum is a good approach to adopt a blend between traditional and virtual pathology, as both have positive and negative aspects (mentioned previously) and a hybrid approach can better balance the drawbacks that is within the institution's capacity.

Virtual pathology additionally brings opportunities never previously possible with traditional pathology teaching. Global collaborative platforms such as Path Elective and Path presenter provide learners with the opportunity to connect with students across the world. This software can facilitate accessible virtual small group discussions, problem based and case-based learning [56,57]. Virtual connectivity also contributes to sustainable educational practices by reducing the need for physical travel and the consequential environmental impact.

Finally, moving forward, as AI tools and predictive analytics become increasingly significant in diagnosis and management within clinical care, the integration of relevant modules on these topics and its impact on pathology may be valuable to prepare learners for future practice [13]. Currently, there is lack of data to verify the accuracy and effectiveness of AI in medical education [58]. Its ability to process large quantities of data and automate time-consuming processes in clinical pathology [13] can be translated in medical education in a variety of applications including AI teaching and learning, assessment, marking, and more [59]. However, challenges encountered in the use of AI in medical education includes the large amount of data and initial time needed to set up machine and deep learning and the ethical implication of data privacy [58,59]. As the technology of AI improves, there is a great need to consider the use of AI and set clear institutional framework that keeps up-to-date with the evolution of AI.

Implications for future research

There are many areas in which this research could be developed in the future. Firstly, this review has identified that relatively little is said about faculty members' perceptions and experiences of virtual pathology teaching relative to students' experiences, with only four papers including faculty opinion. Paul et al. [40] discussed faculty difficulties with unstable online teaching environments and platforms, unfamiliarity and difficulty with managing online teaching platforms and tools and a lack of training for using online resources. It is unclear, however, how widespread this viewpoint is beyond the institutions included in this meta-ethnography. Therefore, there is a need for more comprehensive research on teachers to validate these findings or determine contrasting opinions.

The synthesis also lacked deeper exploration into the interactions between students and faculty members, and how this dynamic may influence their individual perceptions of virtual pathology teaching. Our results demonstrate that from a learner and teacher perspective there are concerns surrounding reduced interaction and collaborative work [35,38,42]. Exploring such dynamics is crucial in the context of the rapid advancements in technology where newer generations are more familiar and attuned to technological developments, thereby presenting a new opportunity for greater connectivity between teachers and learners in a virtual space [60].

An additional area for further assessment is the feasibility of virtual teaching globally. If virtual pathology teaching increasingly progresses to be the future of pathology education, it must be financially and culturally inclusive. Research comparing high-resource and low-resource contexts will be important in assessing how virtual pathology should be adapted to meet and provide equal opportunities to those from all economic backgrounds.

Finally, triangulating existing quantitative analysis alongside this qualitative meta-ethnography on how virtual pathology teaching reflects in objective educational outcomes in standardised examinations within undergraduate and resident pathology education would be valuable in determining a measurable positive or negative impact to virtual teaching compared for traditional direct contact pathology teaching.

Conclusion

Learning technologies have changed rapidly over the last decade. The move to virtual delivery has been expedited by the need to respond to the COVID-19 pandemic but were in progress well beforehand. The existing literature is mixed, with several studies demonstrating positive impacts of this move, and several demonstrate negative impacts. A blended approach may be a suitable approach, depending on the individual institution's circumstance to adopt virtual pathology fully or not. The impact of the transition to virtual education is particularly interesting in pathology education, as this is not only a key element of many HPE curricula, but has also been historically delivered in laboratory spaces face-to-face. The evolution of AI use in medical education and application in virtual pathology cannot be ignored. There is a pressing need to further explore the impact of the wider shift to virtual education on pathology teaching to promote the magnification of the positive and the mitigation of the negative aspects of virtual educational delivery in current educational practice. This should be accompanied by further exploration of ways to overcome barriers to implementation in low resource settings, and exploration of implementation policies more generally. This is particularly urgent, since the shift to virtual education in pathology looks set to accelerate in years to come.

Disclosure statement

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