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Consensus statement on the content of clinical reasoning curricula in undergraduate medical education

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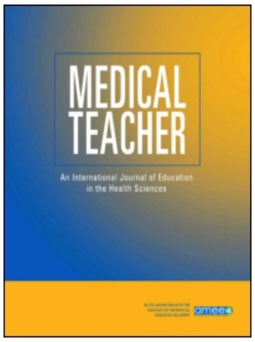
Published in:
Medical Teacher

DOI:
10.1080/0142159X.2020.1842343

Publication date:
2020

Document Version
Publisher's PDF, also known as Version of record



Medical Teacher

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/imte20

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To cite this article: Nicola Cooper , Maggie Bartlett , Simon Gay , Anna Hammond , Mark Lillicrap , Joanna Matthan , Mini Singh & On behalf of the UK Clinical Reasoning in Medical Education (CReME) consensus statement group (2020): Consensus statement on the content of clinical reasoning curricula in undergraduate medical education, Medical Teacher, DOI: 10.1080/0142159X.2020.1842343

To link to this article: https://doi.org/10.1080/0142159X.2020.1842343

MEDICAL TEACHER
https://doi.org/10.1080/0142159X.2020.1842343

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Consensus statement on the content of clinical reasoning curricula in undergraduate medical education

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ABSTRACT

Introduction: Effective clinical reasoning is required for safe patient care. Students and postgraduate trainees largely learn the knowledge, skills and behaviours required for effective clinical reasoning implicitly, through experience and apprenticeship. There is a growing consensus that medical schools should teach clinical reasoning in a way that is explicitly integrated into courses throughout each year, adopting a systematic approach consistent with current evidence. However, the clinical reasoning literature is 'fragmented' and can be difficult for medical educators to access. The purpose of this paper is to provide practical recommendations that will be of use to all medical schools.

Methods: Members of the UK Clinical Reasoning in Medical Education group (CReME) met to discuss what clinical reasoning-specific teaching should be delivered by medical schools (*what* to teach). A literature review was conducted to identify what teaching strategies are successful in improving clinical reasoning ability among medical students (*how* to teach). A consensus statement was then produced based on the agreed ideas and the literature review, discussed by members of the consensus statement group, then edited and agreed by the authors.

Results: The group identified 30 consensus ideas that were grouped into five domains: (1) clinical reasoning concepts, (2) history and physical examination, (3) choosing and interpreting diagnostic tests, (4) problem identification and management, and (5) shared decision making. The literature review demonstrated a lack of effectiveness for teaching the general thinking processes involved in clinical reasoning, whereas specific teaching strategies aimed at building knowledge and understanding led to improvements. These strategies are synthesised and described.

Conclusion: What is taught, how it is taught, and when it is taught can facilitate clinical reasoning development more effectively through purposeful curriculum design and medical schools should consider implementing a formal clinical reasoning curriculum that is horizontally and vertically integrated throughout the programme.

KEYWORDS
Consensus; clinical reasoning; curriculum; undergraduate; medical education

Introduction

Clinical reasoning can be defined as, '*A skill, process, or outcome wherein clinicians observe, collect and interpret data to diagnose and treat patients. Clinical reasoning entails both conscious and unconscious cognitive operations interacting with contextual factors such as the patient's unique circumstances and preferences and the characteristics of the practice environment*' (Daniel et al. 2019).

Clinical reasoning is of interest to educators because of its importance in clinical practice, particularly in relation to diagnostic error. Diagnostic errors tend to occur in common diseases (Gunderson et al. 2020) and are a significant cause of preventable harm to patients worldwide (Tehrani et al. 2013; World Health Organization 2016). Cognitive failures, such as failure to synthesise all the available information correctly or failure to use the physical examination findings or test results appropriately, have been found to

Practice points

- Existing training programmes may not provide adequate education regarding clinical reasoning and diagnostic safety.
- Five domains of clinical reasoning education have been identified, each of which requires specific knowledge, skills and behaviours. These domains are: (1) clinical reasoning concepts, (2) history and physical examination, (3) choosing and interpreting diagnostic tests, (4) problem identification and management, and (5) shared decision making.
- To date, there is a lack of evidence that teaching the general thinking processes involved in clinical decision making by itself improves performance, whereas specific teaching strategies aimed at building knowledge and understanding lead to improvements.

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Supplemental data for this article can be accessed here.

- What is taught, how it is taught, and when it is taught can facilitate clinical reasoning development more effectively; this can be achieved through purposeful curriculum design.

contribute to the majority of diagnostic errors (Graber et al. 2005). The National Academy of Medicine's seminal report *Improving Diagnosis in Health Care* (2015) found that diagnosis and diagnostic errors have been largely unappreciated in efforts to improve the quality and safety of healthcare. It called for curricula to explicitly address teaching in the diagnostic process using educational approaches that are aligned with evidence from the learning sciences.

Undergraduate medical curricula provide instruction in the basic elements of the diagnostic process, for example taking a history, performing a physical examination, and generating a differential diagnosis. However, students and postgraduate trainees largely learn the knowledge, skills and behaviours required for effective clinical reasoning implicitly, through experience and apprenticeship (Graber et al. 2018). While accurate diagnosis requires knowledge of epidemiology, basic sciences and clinical medicine, several components of clinical reasoning have been described. They each require specific knowledge, skills and behaviours but may not be explicitly emphasised in some curricula. Examples include: accurate interpretation of diagnostic test results, which has been shown to be poor (Whiting et al. 2015); generating a problem representation, which correlates with diagnostic accuracy (Bordage 1994); and shared decision making, which improves outcomes for patients (National Academies of Sciences, Engineering, and Medicine 2015). In one survey of US medical schools, 84% of internal medicine clerkship directors indicated that students entered clinical clerkships with poor, or at best fair, knowledge of key clinical reasoning concepts and most institutions lacked sessions dedicated to these topics, citing lack of both time and faculty expertise (Rencic et al. 2017). In reviewing the published literature on education related to diagnosis, Graber et al. (2018) found that existing training programmes may not provide adequate education regarding diagnostic safety.

There is a growing consensus that medical schools and postgraduate training programmes should teach clinical reasoning in a way that is explicitly integrated into courses throughout each year of the programme, adopting a systematic approach consistent with current evidence (Trowbridge et al. 2015). However, the clinical reasoning literature has been described as 'fragmented' (Young et al. 2018) and consequently can be difficult for medical educators to access and adopt. Few published clinical reasoning curricula exist covering both what should be taught and how it should be taught, based on expert consensus and a review of current evidence. The purpose of this paper is therefore to provide medical teachers, curriculum planners and policy makers with practical recommendations on the content of clinical reasoning curricula in undergraduate medical education. These recommendations may also provide a framework for future research. Practical recommendations for clinical reasoning assessment methods have been published elsewhere (Daniel et al. 2019).

Methods

The recommendations in this paper were developed by members of the UK Clinical Reasoning in Medical Education group (CReME) in a series of meetings over a twelve-month period. CReME consists of representatives from over half of UK medical schools, many of whom also have specific responsibility for undergraduate medical curricula and clinical reasoning education. A three-stage approach was used to develop the recommendations. In the first stage, 20 members from 12 medical schools attended a whole-day meeting to identify a list of clinical reasoning-specific teaching that should be delivered by medical schools (*what* to teach). All the submitted ideas were shared and discussed, duplicates removed, and further content added if required, based on the discussions. Following this process, 30 ideas were recorded. These were grouped into five domains of clinical reasoning education and then mapped against the UK General Medical Council's 'Outcomes for Graduates' (General Medical Council 2018) to allow educators to see how they might fit into a curriculum mapping process.

In the second stage, a literature review was conducted to identify teaching strategies that are successful in improving the clinical reasoning ability of medical students (*how* to teach). The literature review was conducted of English language papers published within the last 30 years through the electronic databases MEDLINE, PsycINFO, CINAHL, EMBASE, ERIC and Google Scholar using the terms 'clinical reasoning' OR 'clinical decision making' OR 'diagnostic reasoning' OR 'diagnostic decision making' AND 'medical students' OR 'teaching' OR 'curriculum'. English language articles that described a teaching intervention designed to improve clinical reasoning ability among medical students, which also described empirical findings, were included. Articles that merely described a particular approach to teaching clinical reasoning, with or without student/faculty evaluation, were excluded. These inclusion and exclusion criteria resulted in 27 eligible articles. The included studies described a wide range of strategies, using variable study designs, so no attempt was made to systematically organise the findings other than to categorise and describe them with the purpose of informing the consensus statement. A PRISMA diagram is shown in Supplementary File 2. Articles that did not meet the inclusion criteria but cited evidence (e.g., review articles) were also used to inform the recommendations.

In the final stage, practical recommendations for the content of undergraduate clinical reasoning curricula were made based on these findings in the form of a consensus statement and the text was circulated to all the members of the consensus statement group for comments. This final iterative process was undertaken through e-mail discussions. The final statement was then written and approved by the authors.

Results

Domains of clinical reasoning education (what to teach)

The agreed consensus ideas were grouped in to five domains of clinical reasoning education:

1. Clinical reasoning concepts
2. History and physical examination

Table 1. Knowledge, skills and behaviours in the different domains of clinical reasoning.

Domain	Areas of knowledge, skills and behaviours
Clinical reasoning concepts	Demonstrate an understanding of: • Clinical reasoning theories (e.g. script, dual process) • How clinical reasoning ability develops • The role of clinical reasoning in safe and effective care for patients • Cognitive errors • Other factors that may impair the clinical reasoning process/outcome
History and physical examination	Demonstrate the ability to use: • Effective communication skills and purposeful interviewing • History taking from all available sources when relevant • Hypothesis-driven enquiry • Knowledge of epidemiology, probability of the presence of signs and symptoms in specific diseases, and likelihood ratios to estimate clinical probability
Choosing and interpreting diagnostic tests	Demonstrate a practical understanding of and ability to use the following: • Pre-test (clinical) probability and post-test probability • Sensitivity and specificity • Predictive values • Factors other than disease that influence test results • Important characteristics of commonly used tests relevant to local context • Evidence-based guidelines
Problem identification and management	Demonstrate an ability to produce: • An accurate problem representation or problem list • Use of semantic qualifiers and precise medical terms • Prioritised differential diagnosis, including relevant 'must not miss' diagnoses • Safe actions when a diagnosis is not possible • Management plans taking patient's preferences, co-morbidities, resources, cost-effectiveness and local policies in to account • Metacognition and critical thinking in decision making
Shared decision making	Demonstrate the ability to make decisions with: • Patients and carers • Clinical teams • Guidelines, scores and decision aids • Evidence-based medicine applied to the patient's circumstances • Professional values and behaviours that support decision making

3. Choosing and interpreting diagnostic tests
4. Problem identification and management
5. Shared decision making.

These domains are expanded on in Table 1 and in the text below. Supplementary File 1 lists the individual consensus ideas, mapped against the UK General Medical Council's 'Outcomes for Graduates' (General Medical Council 2018), and also includes suggestions for *when* to teach during a 5 year programme.

Clinical reasoning concepts

It is important for both teachers and learners to have a shared definition, vocabulary and concepts for clinical reasoning in order to facilitate meaningful discussion and learning (Wu 2018). Key theories (e.g., script, dual process), how clinical reasoning ability develops, the problem of diagnostic error, the role of clinical reasoning in safe and effective care for patients, cognitive errors and other factors that may impair the clinical reasoning process or outcome should be taught in medical schools and integrated into courses throughout the programme.

History and physical examination

Effective communication skills are vital in eliciting information and gaining trust from a patient, relative or carer. The UK consensus statement on the content of communication curricula in undergraduate medical education (Noble et al. 2018) presents a framework and recommends key content for the development of communication skills. In addition, by graduation, learners should appreciate that a patient's history may also come from sources other than the patient (e.g., relatives, carers, ambulance sheet, medical records). They should be able to purposefully gather information and explore patients' symptoms through hypothesis-driven enquiry (Hasnain et al. 2001). This extends to the physical examination which should involve anticipating physical examination findings to confirm or refute hypotheses and performing physical examination manoeuvres to elicit and interpret findings in order to reach a working diagnosis or generate new hypotheses (Yudkowsky et al. 2009).

Learners should be able to accurately synthesise data from the history and physical examination to judge the clinical probability of disease using their knowledge of epidemiology, the probability of the presence of particular symptoms and signs in specific diseases (see example in Box 1) and likelihood ratios, where relevant. While typical

Box 1 . Example: does this adult patient have meningitis?
Many medical students are taught that meningitis in adults presents with a 'characteristic combination of fever, headache and meningism' – i.e. photophobia and neck stiffness (Leach and Davenport 2018). In fact, this teaching is inaccurate and inadequate. In countries like the UK, nearly all adults present with headache and a fever, but only around half have symptoms of photophobia and neck stiffness (Thomas et al. 2002). If, by graduation, teaching does not evolve to include an understanding of probabilities of features being present, doctors may make inaccurate and inappropriate decisions about referral, investigation and treatment of patients.
Elieson and Papa (1994) contrasted learning the probabilities of symptoms in various diseases with learning lists of features with qualifiers such as 'usually'. They showed a difference in favour of probability learning for diagnostic accuracy. However, meaningful information is easier to recall, and Woods et al. (2005) used the same materials, with one group learning probabilities, while a second group learned basic science explanations of the features. They showed that, after one week, the group that had learned basic science explanations outperformed the probability group. Only patients with severe meningeal inflammation are likely to have bedside signs of meningism. Simply teaching medical triads may encourage superficial pattern recognition that results in overconfidence and premature closure (Manzoor and Redelmeier 2019).

presentations of diseases and simple lists of features may be taught in the early years, by graduation learners should have a clear understanding, relevant to their local context, that many patients do not present with the classical features of diseases as described in textbooks (Manzoor and Redelmeier 2019). Learners need to be able to estimate the clinical probability of disease in order to be able to accurately interpret diagnostic test results, including normal results and incidental findings.

Choosing and interpreting diagnostic tests

By graduation, learners should be able to demonstrate a practical understanding of concepts such as clinical (pre-test) probability, sensitivity and specificity, post-test probability, prevalence of disease, predictive values, factors other than disease that influence test results and important characteristics of commonly used tests relevant to their local context. Learners should know that many test results require *interpretation* in the light of clinical findings and they should be able to apply this knowledge during the clinical reasoning process. They should be able to suggest investigations based on knowledge of what question a particular test can answer, and be able to use evidence-based guidelines and decision aids to assist in their decisions regarding appropriate investigations.

Problem identification and management

By graduation, learners should be able to accurately formulate a problem representation and, based on this, construct a prioritised differential diagnosis, including relevant 'must-not-miss' diagnoses. Sometimes there is more than one problem, and in these situations learners need to be able to construct a problem list. The ability to 'encapsulate' a problem clearly, using semantic qualifiers and precise medical terms, *before* thinking through potential diagnoses, is an important skill that helps to organise and retrieve knowledge from long term memory relevant to the case and is associated with higher diagnostic accuracy, particularly in complex cases (Bordage 1994).

Sometimes, it is not possible to make a diagnosis and learners must learn to manage diagnostic uncertainty (Ilgen et al. 2019; Gheihman et al. 2020). By graduation, learners should be able to decide what is the most likely diagnosis for this patient at this point in time, what can be safely excluded and whether there are any rare but serious diagnoses that must be excluded (Murtagh 1990). At such times the decision may be, 'How well or unwell is this patient?' or 'Should I involve a senior colleague and how urgently?' and advanced learners need to be provided with opportunities to make supervised decisions in these situations.

In the clinical reasoning literature, the outcome is often considered to be the diagnosis, but this is often not the case in clinical practice (Ilgen et al. 2016; Cook et al. 2018). The development of an appropriate management plan may sometimes be more complex than that of a problem list or differential diagnosis. Diagnoses are determined by a patient's symptoms and signs or diagnostic tests, in which there is a finite range of identifiable problems, solutions and interacting factors. However, for any given diagnosis, there may be numerous potential management options, all of which may be appropriate but dependent on a number of factors including patient preferences, co-morbidities, resources, cost-effectiveness and local policies. The learner needs to be able to take these factors into account in the process of formulating a management plan (Cook et al. 2018).

Learners should also be able to use metacognitive knowledge and critical thinking to improve their performance (Krathwohl 2002; Olson, Rencic, et al. 2019). In the UK, patient safety training, with a focus on systems and human factors, is becoming established in undergraduate and postgraduate medical education (General Medical Council 2015), but effective clinical reasoning also requires a focus on cognitive strategies. Guided reflection has been shown to improve diagnostic performance and foster the learning of clinical knowledge (Chamberland et al. 2015; Prakash et al. 2019) and this process should be facilitated by educators.

Shared decision making

By graduation, learners need to develop the skills required for shared decision making. Shared decision making requires effective communication and the ability to identify and understand others' values (Elwyn et al. 2012; Fulford et al. 2012). Management decisions are often co-produced with patients and carers, but shared decision making also refers to teams, evidence-based guidelines, technology, scores and decision aids. Learners should understand that in real world situations, knowledge is not something that is 'all in your head' but is distributed throughout the environment in people, computers, books, and other tools or instruments (Artino 2013).

Learners should also be able to demonstrate professional values and behaviours that support decision making, including teamwork, valuing the contributions of others, civility, listening, asking for help, clear communication (especially when handing over care of a patient), and involving the patient and/or carers in the diagnostic and management process (National Academies of Sciences, Engineering, and Medicine 2015).

Teaching strategies (how to teach)

Twenty-seven studies were identified that included empirical findings and described a teaching intervention designed to improve the clinical reasoning ability of medical students. Two studies involved teaching schemas/illness scripts; three involved teaching the principles of clinical decision making; four used strategies that employed thinking aloud, brainstorming or cognitive mapping; seven taught 'cognitive forcing strategies' (five of which used structured reflection); and eleven used practice cases with feedback. All were short term interventions with none describing a long term curriculum approach. Teaching the principles of decision making to medical students did not improve performance. Teaching cognitive forcing strategies designed to reduce error from cognitive biases also did not improve performance. However, teaching illness scripts, using thinking aloud/brainstorming strategies, structured reflection, and practicing cases with feedback did improve performance. A detailed description of the results of the literature review can be found in Supplementary File 2.

In the wider published literature on teaching clinical reasoning, there is agreement that formal and experiential knowledge of medicine is central for the development of effective clinical reasoning ability (Norman et al. 2006, 2017). To date, there is little evidence to demonstrate that teaching about thinking itself (e.g., teaching dual process theory, cognitive de-biasing strategies) *by itself* improves diagnostic performance (Sherbino et al. 2014; Smith and Slack 2015). In a review of the literature on teaching clinical reasoning, Schmidt and Mamede (2015) found that educational approaches aimed at teaching the general thinking processes involved in clinical decision making were largely ineffective, whereas teaching strategies aimed at building knowledge and understanding led to improvements. However, one area of ongoing research is in the use of reflective strategies. Whether reflection during diagnostic decision making is simply a means of mobilising existing knowledge, or can also be understood within a broad framework of dual process theory (i.e. *how* we think), is a matter of ongoing debate (Norman et al. 2017; Prakash et al. 2019; Stanovich 2009).

Examples of teaching strategies that have been demonstrated to be effective in improving the clinical reasoning ability of medical students are listed in Table 2 and expanded on below.

Strategies that build understanding

Meaningful information is easier to retain and recall. Self-explanation/elaboration has been shown to improve diagnostic performance in medical students and helps learners consolidate their knowledge (Chamberland et al. 2011, 2015). Self-explanation outperforms explanation by the instructor because of the cognitive processes learners use, which include their idiosyncratic matching of prior knowledge to new knowledge (Bisra et al. 2018). Woods et al. (2005) showed that understanding the basic science mechanisms for symptoms and signs also improved diagnostic performance among medical students. Teachers should use strategies that promote understanding as well as recall.

Strategies that employ structured reflection

Structured or guided reflection has been shown to improve diagnostic performance in medical students (Lambe et al. 2016; Prakash et al. 2019). The impact is greatest when the case is more complex relative to the learner (Norman et al. 2017). Examples of structured reflection include encouraging students to ask themselves questions like, 'What's the evidence for this?' and 'What else could it be?' (Chew et al. 2016), or asking students to list findings that are compatible or not compatible with each differential diagnosis (Myung et al. 2013). Mamede et al. (2012, 2014) performed two studies on structured reflection, both of which found that students who used it while practicing diagnosing clinical cases outperformed controls in diagnosing new examples of the same diseases a week later. The authors concluded that, 'Structured reflection while practicing with cases appears to foster the learning of clinical knowledge.'

Practice with cases and corrective feedback

Practice with as many different cases as possible in as many different contexts as possible is critical for learning (Eva et al. 1998). However, practice alone is insufficient; corrective feedback, effort and coaching are also required to develop expertise (Ericsson 2004). This requires the provision of a safe learning environment where discussion of mistakes is encouraged and where there is recognition of uncertainty (Eva 2009). Regular practice helps learners develop illness scripts (Schmidt et al. 1990), which is important because knowledge organisation rather than generic knowledge is key to effective clinical reasoning ability (Lubarsky et al. 2015). There is also evidence that a whole case approach, rather than revealing a case in stages (the 'serial-cue' approach) is more effective when teaching,

Table 2. Effective teaching strategies.

Strategy	Examples
Strategies that build understanding	• Self-explanation (getting learners to make connections and elaborate by explaining their thinking and rationale) • Explaining the basic science mechanisms for symptoms and signs
Strategies that employ structured reflection	• Encouraging students to ask themselves questions like, 'What's the evidence for this? What else could it be?' • Asking students to list findings compatible or not compatible with each differential diagnosis
Practice with cases and corrective feedback	• Providing opportunities to practice with as many different cases as possible in as many different contexts as possible • Using a whole case approach for novices to reduce cognitive load (have all the information they need to solve the problem readily available throughout) • Ensuring coaching and feedback on the clinical reasoning process
Strategies that structure knowledge around problem-specific concepts	• Learning a diagnostic 'decision tree' in later years of medical school once fundamental concepts have been learned, underpinned by relevant basic science, clinical knowledge and evidence
Strategies that employ retrieval practice	• Activities that promote effortful recall of information during teaching activities rather than the teacher explaining information • Use of structured reflection while solving cases • Spaced practice (studying topics in shorter, spaced apart blocks rather than a single block and moving on) • Contrastive learning (getting learners to list features they would expect in one diagnosis compared with another)
Strategies that differ according to stage of learning	• Low complexity, low fidelity tasks with high instructional support in the early years moving to high complexity, high fidelity tasks with minimal instructional support by final year at medical school • Approaching graduation, opportunity to work as part of a clinical team in a real supervised environment

especially for novices, because it decreases cognitive load on working memory (Schmidt and Mamede 2015).

Strategies that structure knowledge around problem-specific concepts

High-performing learners organise their knowledge in a qualitatively different way to low-performing ones, despite similar levels of knowledge (Coderre et al. 2009). Structuring knowledge around problem-specific concepts has been shown to promote spontaneous analogical transfer – that is, the use of information from one problem to solve another problem in a different context (Needham and Begg 1991; Eva et al. 1998). By graduation, educators should facilitate learners in gaining organised problem-specific knowledge (akin to a concept map or decision tree, underpinned by relevant knowledge and evidence) for a range of common clinical presentations.

Strategies that employ retrieval practice

Several studies have shown that strategies that promote long term retention and recall of information improve performance (Eva 2009; Weinstein and Sumeracki 2019). Strategies that promote effortful recall of information during teaching and learning lead to improvements in diagnostic performance. These include structured reflection (Norman et al. 2017; Prakash et al. 2019), low stakes quizzing (Green et al. 2018; Larsen et al. 2009), spaced practice (Kerfoot et al. 2007) and contrastive learning (Ark et al. 2007). Small changes in instruction and study habits can yield significant benefits in terms of retention and recall of information and higher order thinking (Dobson et al. 2018).

Strategies that differ according to stage of learning

All of the above need to be tailored appropriately to different stages of learning and developed within a 'spiral curriculum' (Harden and Stamper 1999). Meaningful learning in medicine requires substantial cognitive processing, so instruction should be structured in a manner that takes into account the effort being used in working memory when learners are dealing with particular tasks (Van Merrienboer and Sweller 2010). For each competency to be learned, instruction should move from high instructional support on low complexity, low fidelity tasks through to minimal support on high fidelity, high complexity tasks (Leppink and Duvivier 2016). Approaching graduation, learners' clinical reasoning abilities benefit from working as part of a clinical team and making decisions in a real but supervised clinical environment (Lefroy et al. 2017). Learners in these later stages of training should be exposed to unfiltered cases with structured debriefing. Curriculum design and its assessment programme must ensure this transition.

Conclusion

Clinical reasoning education has origins in the medical education, cognitive psychology, diagnostic error and health systems literature (Olson, Singhal, et al. 2019). A number of theories from diverse fields inform research on clinical reasoning (Ratcliffe et al. 2015), shedding light on what should be taught and how. However, this fragmented literature can be difficult for medical educators to access and adopt meaningfully into their daily practice. The purpose of this paper is to provide practical recommendations that will be of use to all medical schools and can be adapted to different local contexts.

While all medical schools teach knowledge, skills and behaviours, there is good evidence that careful attention to what is taught, how it is taught, and when it is taught can facilitate clinical reasoning development more effectively, through purposeful curriculum design. This does not necessarily require additional teaching time. Instead, a specific approach to teaching is envisaged and recommended, and this is likely to require a programme of faculty development. Stand-alone modules designed to teach clinical reasoning skills are unlikely to be successful. Clinical reasoning should be explicitly integrated, both horizontally and vertically, into courses throughout undergraduate and postgraduate medical training in a developmental fashion.

Author contributions

A small working group consisting of the authors of this paper was established to write the consensus statement on behalf of the consensus statement group, members of which are listed below. NC chaired the process. NC and MB wrote the first draft. All authors contributed to, edited and approved the final manuscript. All authors (apart from first author) are listed in alphabetical order.

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Acknowledgments

The authors would like to thank Hull York Medical School for the use of its facilities during the development of this consensus statement.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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