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Clinical reasoning—the essentials for teaching medical students, trainees and non-medical healthcare professionals

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Abstract

Clinical reasoning is fundamental for effective clinical practice. Traditional consultation models for teaching clinical reasoning or conventional approaches for teaching students how to make a diagnosis or management plan that rely on learning through observation only, are increasingly recognised as insufficient. There are also many challenges to supporting learners in developing clinical reasoning over time as well as across different clinical presentations and contexts. These challenges are compounded by the differences in how experts and novices make sense of clinical information, and the different cognitive processes each use when processing and communicating this information using precise medical language. Diagnostic errors may be due to cognitive biases but also, in a majority of cases, due to a lack of clinical knowledge. Therefore, effective educational strategies to develop clinical reasoning include identifying learners' knowledge gaps, using worked examples to prevent cognitive overload, promoting the use of key features and practising the construction of accurate problem representations. Deliberate reflection on diagnostic justification is also recommended, and overall, contributes to a growing number of evidence-based and theory-driven educational interventions for reducing diagnostic errors and improving patient care.

Key words: Clinical reasoning; Medical education; Diagnostic accuracy; Diagnostic error; Cognitive bias

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Introduction

Making a diagnosis and medical management are stated as professional skills in the General Medical Council's (GMC) Outcomes for Graduates (GMC, 2018), underlining the importance of clinical reasoning as a core competency for newly qualified doctors at the point of graduation. In fact, Outcomes for Graduates states that applying biomedical scientific, psychological and social principles in practice; prescribing medications safely; using information effectively and safely; and dealing with complexity and uncertainty are also necessary for newly qualified doctors to demonstrate, underlining that clinical reasoning, necessary for all of these things, is fundamental for effective clinical practice (GMC, 2018).

All medical schools would attest to having clinical reasoning as an explicit part of their curriculum and, by extension, testing clinical reasoning at assessment across various stages of the course. Likewise, all training programme directors would also contend their curricula continue to develop the clinical reasoning ability throughout postgraduate education ensuring trainees emerge as safe, independent practitioners. However, clinical educators in both primary and secondary care can struggle to make explicit their clinical reasoning, as well as find it difficult to give specific feedback on clinical reasoning development among their learners.

To help bridge some of these challenges, this article attempts to describe what clinical reasoning is and discusses some of the difficulties of both defining this multi-component construct and teaching it in practice. The relevance of clinical reasoning to safe and effective clinical practice is also presented, specifically in reference to diagnostic error and patient safety. Finally, several evidence-based teaching strategies are shared, many of which can

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be easily applied by clinical educators as they go about their everyday business delivering clinical service while also supervising learners at different stages of training.

What is clinical reasoning

Taken literally, the term 'clinical' relates to activities involving or concerned with the direct observation and treatment of patients, while 'reasoning' relates to the ability of the mind to think and understand things in a logical way. However, within the context of medical education, the meaning of clinical reasoning is not necessarily a combination of the two dictionary terms. Traditionally, clinical reasoning has been defined as the process of history taking and examination, sometimes with the addition of tests in order to make a diagnosis (Norman and Eva, 2010). However, closer inspection confirms the general understanding of the term clinical reasoning among healthcare professionals is less clear, with various synonyms used interchangeably and inaccurately. A systematic review identified 110 different terms for clinical reasoning, partly explaining the lack of shared understanding within and across different healthcare professional groups, and demonstrating a need to gain consensus among clinical educators who may be responsible for supervising learners (Young et al, 2019).

In a clinical practice context, most healthcare professionals would accept that clinical reasoning involves much more than making a diagnosis, since the diagnosis is merely a prequel for starting treatment. Against this backdrop, clinical reasoning is much more about the way healthcare professionals, either as individuals or as a team, take in information about a patient presenting for medical attention, formulate a differential diagnosis, confirm a most likely diagnosis (and/or a list of problems as appropriate), propose a management plan and communicate that plan to patients and other healthcare professionals. Therefore, clinical reasoning can be seen as having a number of components (Daniel et al, 2019) (see Table 1), and these are all important for ensuring diagnostic accuracy but also minimising diagnostic error.

Why teach clinical reasoning

Reducing avoidable harm is a patient safety priority in the National Health Service (NHS), with an estimated 19,800 to 32,200 episodes of avoidable harm in 2020 (Illingworth et al, 2022). There is a growing body of literature demonstrating that diagnostic error contributes

Table 1. The seven components of clinical reasoning, adapted from Daniel et al (2019)

Component	Definition
Information gathering	The process of gathering data to generate or refine diagnostic hypotheses
Hypothesis generation	An analytic or non-analytic process by which a physician tries to find diseases that could explain a patient's clinical findings
Problem representation	A dynamic mental representation of the key aspects of the case, communicated as a summary involving semantic qualifiers and key findings
Differential diagnosis	A list of diagnostic hypotheses that best represent categorisations of the problem representation
Working diagnosis	A diagnosis that the physician feels has crossed their personal probability of a disease being present to warrant further investigation or treatment
Diagnostic justification	The use of key clinical findings to choose one or more diagnoses as most likely and to defend that choice
Management and treatment	Actions that follow the clinical reasoning process, including prognosis, management, treatment, and prevention strategies

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a significant proportion of adverse outcomes for patients, with at least three-quarters of diagnostic errors due to individual rather than system-related factors (Graber et al, 2005). Diagnostic error is common, with some series demonstrating a 20–40% discrepancy between antemortem and postmortem diagnoses. Furthermore, the frequency of diagnostic errors has been reported to occur at a rate of 10–15% (Graber et al, 2005; Graber, 2013); hence, reducing individual errors is also a priority for clinical educators. Individual errors are essentially classified into three categories based on where errors tend to occur in the thinking process.

Faulty knowledge and skills describe the group of diagnostic errors occurring when individuals are unaware of a particular diagnosis or unable to recall the diagnosis when it is necessary to do so (Graber et al, 2005). For example, a clinician does not consider a diagnosis of subarachnoid haemorrhage in patients presenting with a headache that reaches maximal intensity within five minutes. Faulty data gathering describes the group of errors occurring when individuals do not collect sufficient information about the patient's presentation, either through history taking, physical examination or any other stage of information gathering (Graber et al, 2005). For example, clinicians may not identify papilloedema in patients presenting with headaches because they do not perform fundoscopy. Finally, faulty information synthesis describes the group of errors occurring when individuals do not synthesise information correctly, identifying incorrect diagnoses or differentials (Graber et al, 2005). For example, clinicians may incorrectly propose vasculitis in patients presenting with rash and headache when the diagnosis was meningococcal meningitis.

Teaching about clinical reasoning, and specifically these categories, may raise individual awareness about diagnostic error, but may not necessarily reduce the problem next time around (Norman and Eva, 2010). Conversely, evidence from the clinical reasoning literature does demonstrate that increasing knowledge, and in the context of experts who 'have knowledge', increasing the ability to recall knowledge faster, does reduce diagnostic error (Norman and Eva, 2010).

The challenges of teaching clinical reasoning

Fundamentally, the general approach to teaching many difficult-to-measure concepts in medical education, such as reflection, professionalism or clinical reasoning, has been to define or describe them as best as possible and then develop ways to teach and assess them. However, clinical reasoning may be one of those concepts where attempting to just define it and then immediately proceed to teach or assess it may be a less ideal way of going about things (Monteiro et al, 2020). As noted above, there is evidence that simply defining clinical reasoning is insufficient, as the term can mean different things to different people. This lack of consistency in understanding across individuals means learners are likely getting variable teaching and likely also less reliable assessment of clinical reasoning ability (Young et al, 2019).

There are several different challenges for experts, such as consultants, in teaching clinical reasoning to novices such as medical students, junior doctors or allied health professionals. Firstly, clinical reasoning is invisible and takes place inside someone's head (Norman and Eva, 2010). Being implicit rather than explicit in this way, novices are left to infer what may be happening inside the heads of experts by from what they do. For example, if a consultant, after a patient interaction on a ward round, requests a lumbar puncture, the novice may deduce the differential may include meningitis or subarachnoid haemorrhage.

Secondly, the reasons individuals share to explain their thinking or behaviour may actually not be the ones that truly represent their reasoning or prompted their actions at the time. There is a large body of literature that demonstrates memory, specifically our working memory, is finite, and is only able to hold and process a finite number of things at any one moment (Sweller, 1988; Baddeley, 2003; Miller, 1956). Therefore, over the course of even a 10-minute interaction where a consultant is performing clinical reasoning and a medical student or others are watching, there will be any number of things which may not get shared at the end of the consultation in discussion which may have been relevant to the forming of a diagnosis and differential.

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Thirdly, the way in which experts store knowledge changes over time, so the way they teach something will invariably not be constant (Schmidt and Rikers, 2007). Each patient interaction in clinical practice leads to a re-constitution of their knowledge as it gets retrieved from long-term memory, further built on from new and different experiences, and new learning emerges from subsequent patients presenting with the same problem. Over time, each expert's illness scripts (i.e., mental models representing what they know about something) get chunked down into more and more sophisticated bits of networked knowledge (Boshuizen and Schmidt, 2008). Furthermore, these illness scripts are unique to them and inaccessible for others to truly examine, but fundamentally, they can never be the same as the illness scripts of their learners, who have, by definition, had different experiences over time. Therefore, some of this knowledge in everyone becomes unconscious and impossible even for the experts to make explicit for others.

Fourthly, the traditional way we have taught clinical reasoning in medical schools, specifically around a consultation model, is looking less likely to represent how it happens in clinical practice and, indeed, how we understand humans take in and process information. Evidence from cognitive psychology suggests that we have two systems for information processing when we think through a clinical problem—System 1 and System 2 (Croskerry, 2009; Kahneman, 2011). System 1 is a form of rapid, unconscious information processing, which is effectively a form of pattern recognition (Kahneman, 2011). For example, the spot diagnosis as a form of instruction is based on System 1 information processing, with the expectation novices who either 'know' or 'should know' a diagnosis and don't have to think through things after inspecting a clinical sign (Croskerry, 2009).

System 2 is a slower, more effortful, analytical form of information processing whereby information is collected and weighed up deliberatively (Kahneman, 2011). For example, the structured history taking of a medical student systematically exploring a presenting complaint and evaluating each diagnostic hypothesis which comes to mind. Bayes' theorem is another example of System 2 information processing and we can consider it in terms of conditional probability, i.e., the degree to which if one statement is true, another will also be true (Stone, 2013). For example, pain moving to the right iliac fossa changes the probability of the diagnosis being acute appendicitis (Ohle et al, 2011).

However, many undergraduate medical schools teach clinical reasoning, and consequently the design of many consultation models, such as the hypothetico-deductive model, predominantly draw from System 2 rather than System 1 or both. The history taking approach, i.e., the ways in which open and closed questioning are used to generate diagnostic hypotheses-involves analysis of patient responses to act as cues or prompts for the next line of enquiry in an attempt to rule hypotheses in our out (Elstein et al, 1978), with assessment rewarding systematic and logical approaches to data-gathering first and foremost.

Clinical reasoning has conventionally also been seen as an individual activity, happening at one moment in time, which ends after the patient interaction. Whereas in practice, clinical reasoning is ongoing and evolving, involving lots of professionals iterating and refining diagnoses and management plans over time (Al Fayyadh et al, 2017; Daniel et al, 2020a; 2020b). For example, when a patient presents for medical attention complaining of a headache, their general practitioner (GP), due to their concern about a serious cause, arranges for admission and further investigation. The patient then arrives in the Emergency Department with a letter, seen by the admitting nurse, who requests some initial tests before the patient is reviewed by a junior doctor, who then may request a computed tomography (CT) scan and organise admission to the acute medical unit. By the time the patient is reviewed by the consultant on call, the clinical reasoning of all these healthcare professionals has contributed towards their care, rather than just that of the referring GP at the start of the patient journey.

Finally, clinical reasoning is prone to cognitive biases, and teaching about these doesn't necessarily mean clinicians are any less likely to be prone to them (Norman et al, 2017). Cognitive biases are systematic patterns of deviation from norm or rationality in judgement (Haselton et al, 2015), and are associated with errors in thinking in many contexts (Tversky and Kahneman, 1974). They have also been demonstrated to play a role in cases of diagnostic error and patient harm (Schiff et al, 2009; Singh et al, 2013; Okafor et al, 2015). However, it would be oversimplistic to simply suggest that 'a bias is bad' since biases are

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inherently human phenomena, just like reflection or imagination. Biases are essentially mental shortcuts and are effective in reducing the amount of cognitive overload individuals would otherwise have to think through as they go about their daily business. For example, in a clinical context, our bias towards acting rapidly when a patient experiences central, crushing chest pain radiating down the left arm leads to benefits to patient care. While there has been considerable interest and some evidence for cognitive de-biasing techniques, for some it seems implausible that interventions can completely de-bias unconscious processes (Norman and Eva, 2010).

Effective strategies for teaching clinical reasoning

The evidence to date from various clinical reasoning studies and investigations into diagnostic error, confirm the importance of knowledge for increasing diagnostic accuracy (Graber et al, 2012). Therefore, it is important when teaching clinical reasoning that teachers have a clear understanding of what knowledge challenges are associated with diagnostic error and what strategies are effective for supporting novices to apply their knowledge appropriately when undertaking a task.

Novices and experts have different amounts and types of knowledge, similar to the differences between children and adults. Therefore, it follows that novices are not mini-experts in the same way that children are not mini-adults. However, it is easy for clinical teachers to overlook this difference and assume their learners' personal and professional development will be the same or similar to theirs. The evidence from the wider clinical reasoning literature, and specifically expertise development in psychology, suggests expert illness scripts are not identical from one expert to the next therefore teaching novices to perform clinical reasoning 'this way' or 'that way' may not be effective (Schmidt and Rikers, 2007).

Rather, a sound basis upon which to start any teaching session is for experts instead to identify what a learner, or group of learners, already know about a clinical area or problem and adapt instruction to build on their knowledge base. For example, a teaching session on renal medicine for learners in the later years of the curriculum could proceed straight into a topic such as acute kidney injury or chronic kidney disease. However, starting instead with a question about the functions of the kidney to ascertain what foundational knowledge learners have at the start of the session so that subsequent layering of information about either acute kidney injury or chronic kidney disease is modified to address any gaps, which may themselves be perquisites for developing later understanding, is more beneficial for learners.

Expert clinicians also develop a large and detailed body of knowledge in their particular specialist area over time. In some cases, however, there is also a loss of knowledge in other specialist areas over time. This does not mean they no longer 'know something'. Rather, they are unable to recall some knowledge as fast as other knowledge they perhaps use more frequently in practice. Likewise, this struggle with recall does not make experts any less of an expert, but reflects the way in which memory works across all humans. Therefore, the teaching challenge for experts in areas outside their primary subject domain is to ensure they have retrieved the pre-requisite knowledge for teaching a given topic beforehand.

Perhaps even more importantly, the challenge for these experts is also to assimilate information and knowledge relevant to novices at their stage of development. Once one 'knows something', it's not easy over time to remember the difficulties associated with learning encountered previously. Likewise, experts can overlook the way in which knowledge should be deconstructed into constituent parts to help novices chunk up ideas and concepts and develop true understanding. The risk of not ensuring novices have sufficient knowledge of underlying principles before teaching more advanced or complicated ideas, is that novices are overwhelmed due to cognitive overload.

To overcome cognitive overload when teaching clinical reasoning, using worked examples as part of the activity is an effective teaching strategy. Worked examples provide mental scaffolds for System 2 thinking, which novices may not have independently developed themselves. The worked examples also make explicit abstract concepts that may have been taught in a classroom context but now become visible in the context of patient presentation. By talking through worked examples, experts are also able to help novices plug any gaps

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in their knowledge of the clinical sciences, as well as clarify any misconceptions about their reasoning of the clinical problem.

The ability of novices to synthesise and then construct an accurate problem representation is critical for effective clinical reasoning (Norman et al, 2002). A problem representation is 'a dynamic mental representation of the key aspects of the cases communicated as a summary involving semantic qualifiers (which are adjectives such as 'acute' or 'chronic') and key findings' (Daniel et al, 2019). Experts can synthesise problem representations very quickly, using them to efficiently communicate case presentations to one another. Novices are often challenged with constructing them because they struggle with reasoning through the problem and lack knowledge of the precise language for describing what they see in front of them.

Therefore, experts can really help novices who lack both clinical science and contextual knowledge when clinical reasoning, better use precise medical terms when describing their clinical findings, and help them understand differences between words such as 'acute' or 'chronic' when communicating their problem representations (Bordage, 2007). Making explicit distinctions between terms and sharing insight into when the use of terms is appropriate also helps novices to learn the implications of not using terms correctly, for example, when referring patients who cause concern to seniors in a timely manner.

Finally, deliberate reflection is also an effective clinical reasoning teaching strategy that involves experts systematically examining the way in which novices make sense of their most likely diagnosis and providing diagnostic justification for any plausible differentials for a given clinical presentation. Novices are asked to indicate which case features support a given diagnosis, which features make a plausible differential less likely, and crucially, also which features should be present if a given diagnosis were to be true but, crucially, are not. This diagnostic justification is repeated for each diagnosis that is under consideration (Mamede and Schmidt, 2023), with evidence the technique is particularly effective among novices using simple cases. There remains debate around the use of this technique for more complex cases and with more experienced clinicians (Mamede and Schmidt, 2023).

Conclusion

Clinical reasoning is a multi-faceted construct which underpins much of what we do in healthcare after a patient presents for medical attention through. Each clinician across the will, individually and as part of a multi-professional team, will engage in clinical reasoning to establish a diagnosis and construct management. Therefore, ensuring a shared mental model between individuals is critical for improving diagnostic accuracy and reducing diagnostic errors. Teaching novices to develop clinical reasoning requires more than just providing them opportunities to watch experts in practice. Several strategies are effective for teaching individuals to remain circumspect when undertaking clinical reasoning, and deliberately reflect on diagnoses and management plans to keep patients safe.

Key points

- This paper emphasises the importance of clinical reasoning and addresses the challenges that educators face in developing clinical reasoning ability among learners.
- This paper highlights the necessity of a shared understanding of clinical reasoning among educators, and the multi-faceted nature of clinical reasoning as a construct.
- This paper discusses evidence-based strategies for developing clinical reasoning, such as worked examples, promoting the use of precise medical terms, constructing an accurate problem representation, and deliberate reflection.

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Availability of data and materials

All the data of this study are included in this article.

Author contributions

RJ, CD and RP designed the educational guide. All authors contributed to the manuscript's drafting, revisions, and made important editorial changes to the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to be agreed to be accountable for all aspects of the work.

Ethics approval and consent to participate

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Conflict of interest

The authors declare no conflict of interest.

References

Al Fayyadh MJ, Hassan RA, Tran ZK et al. Immediate auditory feedback is superior to other types of feedback for basic surgical skills acquisition. J Surg Educ. 2017;74(6):e55–e61. https://doi.org/10.1016/j.jsurg.2017.08.005

Baddeley A. Working memory: looking back and looking forward. Nat Rev Neurosci. 2003;4(10):829–839. https://doi.org/10.1038/nrn1201

Bordage G. Prototypes and semantic qualifiers: from past to present. Med Educ. 2007;41(12):1117–1121. https://doi.org/10.1111/j.1365-2923.2007.02919.x

Boshuizen HP, Schmidt HG. The development of clinical reasoning expertise. In Higgs J, Jensen G, Loftus S, Christensen N eds. Clinical reasoning in the health professions. Elsevier: Edinburg, UK. 2008:113–121.

Croskerry P. A universal model of diagnostic reasoning. Acad Med. 2009;84(8):1022–1028. https://doi.org/10.1097/ACM.0b013e3181ace703

Daniel M, Rencic J, Durning SJ et al. Clinical reasoning assessment methods: a scoping review and practical guidance. Acad Med. 2019;94(6):902–912. https://doi.org/10.1097/ACM.0000000000002618

Daniel M, Durning SJ, Wilson E, Abdoler E, Torre D. Situated cognition: clinical reasoning and error are context dependent. Diagnosis. 2020a;7(3):341–342. https://doi.org/10.1515/dx-2020-0011

Daniel M, Torre D, Durning SJ, Wilson E, Rencic JJ. Ecological psychology: diagnosing and treating patients in complex environments. Diagnosis. 2020b;7(3):339–340. https://doi.org/10.1515/dx-2020-0008

Elstein AS, Shulman LS, Sprafka SA. Medical problem solving: an analysis of clinical reasoning. Harvard University Press: Cambridge, MA, USA. 1978.

GMC. Outcomes For Graduates. Retrieved from. 2018. https://www.gmc-uk.org/-/media/documents/outcomes-for-graduates-2020_pdf-84622587.pdf (accessed 20 June 2024)

© 2024 The Author(s).

Downloaded from magonlinelibrary.com by 147.188.245.136 on July 25, 2024.

Graber ML. The incidence of diagnostic error in medicine. BMJ Qual Saf. 2013;22(Suppl 2):ii21–ii27. https://doi.org/10.1136/bmjqs-2012-001615

Graber ML, Franklin N, Gordon R. Diagnostic error in internal medicine. Arch Intern Med. 2005;165(13):1493–1499. https://doi.org/10.1001/archinte.165.13.1493

Graber ML, Kissam S, Payne VL et al. Cognitive interventions to reduce diagnostic error: a narrative review. BMJ Qual Saf. 2012;21(7):535–557. https://doi.org/10.1136/bmjqs-2011-000149

Haselton MG, Nettle D, Andrews PW. The evolution of cognitive bias. In Buss D.M. ed. The Handbook of Evolutionary Psychology. Wiley: Hoboken, NJ, USA. 2015:724–746. https://doi.org/10.1002/9780470939376.ch25

Kahneman D. Thinking, fast and slow. Farrar, Straus and Giroux: New York, USA. 2011.

Illingworth JS, Fernandez Crespo R, Leis M et al. The national state of patient safety: what we know about avoidable harm in England. Imperial College London. 2022. https://www.imperial.ac.uk/media/imperial-college/institute-of-global-health-innovation/National-State-of-Patient-Safety-2022.pdf

Mamede S, Schmidt HG. Deliberate reflection and clinical reasoning: founding ideas and empirical findings. Med Educ. 2023;57(1):76–85. https://doi.org/10.1111/medu.14863

Miller GA. The magical number seven, plus or minus two: some limits on our capacity for processing information. Psychol Rev. 1956;63(2):81–97. https://doi.org/10.1037/h0043158

Monteiro S, Sherbino J, Sibbald M, Norman G. Critical thinking, biases and dual processing: the enduring myth of generalisable skills. Med Educ. 2020;54(1):66–73. https://doi.org/10.1111/medu.13872

Norman GR, Eva KW. Diagnostic error and clinical reasoning. Med Educ. 2010;44(1):94–100. https://doi.org/10.1111/j.1365-2923.2009.03507.x

Norman GR, van der Vleuten CP, Newble DI et al. International handbook of research in medical education. Springer: Dordrecht, Netherlands. 2002.

Norman GR, Monteiro SD, Sherbino J et al. The causes of errors in clinical reasoning: cognitive biases, knowledge deficits, and dual process thinking. Acad Med. 2017;92(1):23–30. https://doi.org/10.1097/ACM.0000000000001421

Ohle R, O'Reilly F, O'Brien KK, Fahey T, Dimitrov BD. The alvarado score for predicting acute appendicitis: a systematic review. BMC Med. 2011;9(1):13. https://doi.org/10.1186/1741-7015-9-139

Okafor N, Payne VL, Chathampally Y et al. Using voluntary reports from physicians to learn from diagnostic errors in emergency medicine. Emerg Med J. 2015;33(4):245–252. https://doi.org/10.1136/emermed-2014-204604

Schiff GD, Hasan O, Kim S et al. Diagnostic error in medicine: analysis of 583 physician-reported errors. Arch Intern Med. 2009;169(20):1881–1887. https://doi.org/10.1001/archinternmed.2009.333

Schmidt HG, Rikers RM. How expertise develops in medicine: knowledge encapsulation and illness script formation. Med Educ. 2007;41(12):1133–1139. https://doi.org/10.1111/j.1365-2923.2007.02915.x

Singh H, Giardina TD, Meyer AN et al. Types and origins of diagnostic errors in primary care settings. JAMA Intern Med. 2013;173(6):418–425. https://doi.org/10.1001/jamainternmed.2013.2777

Stone JV. Bayes' rule: a tutorial introduction to Bayesian analysis. Sebtel Press: Sheffield, South Yorkshire, UK. 2013.

Sweller J. Cognitive load during problem solving: effects on learning. Cogn Sci. 1988;12(2):257–285. https://doi.org/10.1207/s15516709cog1202_4

Tversky A, Kahneman D. Judgement under uncertainty: heuristics and biases. Science. 1974;185(4157):1124–1131. https://doi.org/10.1126/science.185.4157.1124

Young M, Thomas A, Gordon D et al. The terminology of clinical reasoning in health professions education: implications and considerations. Med Teach. 2019;41(11):1277–1284. https://doi.org/10.1080/0142159X.2019.1635686

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