**Abstract**

Objective

Overconfidence is an important source of medical error. Here we analyse experimental studies of confidence in medical diagnosis to identify factors affecting clinicians’ confidence in their diagnostic decisions, and how confidence impacts diagnosis and treatment.

Method

A scoping review of both medical and psychological literature was conducted. Articles were categorised according to methodology and clinical speciality. The findings were analysed thematically.

Data Sources

We systematically searched SCOPUS, MEDLINE, PsycINFO and Global Health then performed citation tracking within the references of these initial papers to identify missed articles.

Eligibility criteria

Studies were included if they reported quantitative results from an empirical study in which participants reported their confidence or certainty during a diagnostic decision. Studies comprised a broad set of medical subdisciplines.

Results

79 articles met the inclusion criteria. Across these articles, confidence was not found to be well-calibrated to true diagnostic accuracy regardless of clinician experience. We organised the articles under two main themes: the determinants of confidence, and the uses of confidence later in the patient’s care pathway. Confidence is found to be affected by several factors including patient case complexity, early diagnostic differentials, and context within the healthcare environment. Factors that affect confidence but not accuracy demonstrate how the two can be decoupled, resulting in overconfidence or underconfidence. Confidence is found to affect further patient testing, medication administration and referral rates, among other clinical actions.

Conclusions

Results from this review have implications for medical education and practice around diagnostic uncertainty and considerations of work from cognitive psychology. We propose a theoretical model of factors that affect diagnostic confidence/certainty and diagnostic accuracy. Such a model can inform future work on diagnosis, especially within medical education, on how appropriate confidence can be prompted and communicated amongst clinicians.

Word Count: 293

WHAT IS ALREADY KNOWN ON THIS TOPIC

There is extensive evidence of diagnostic error in most healthcare specialities and it has been suggested that cognitive biases, such as overconfidence, are causally linked with these errors. This study aims to synthesise past work on diagnostic confidence to understand the factors that contribute to clinicians’ confidence in their diagnoses, as well as how confidence informs other parts of patients’ care pathway.

WHAT THIS STUDY ADDS

This scoping review identifies that diagnostic confidence and accuracy have separate contributing factors related to the patient’s condition, the clinician making the diagnosis and the healthcare context. It also identifies pathways by which confidence, and misplaced confidence, can affect diagnosis and patient care. We introduce an integrative model of confidence throughout the patient care process to synthesise current research findings and identify future opportunities.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

This study demonstrates the broad importance of calibrated confidence across medical disciplines in two main respects. Firstly, we show the lack of evidence that clinicians’ confidence is aligned to their diagnostic accuracy, even when using certain cognitive interventions. Secondly, we note that confidence is predictive of many parts of the patient care process, such as further tests, referrals to specialists or prescriptions, which in turn may be carried in a suboptimal manner if confidence is miscalibrated. Our proposed conceptual model highlights our current understanding of diagnostic confidence and how future research can focus on underexplored research areas, particularly on the link between information seeking and confidence.

**INTRODUCTION**

Accurate medical diagnosis is crucial to high quality, safe patient care and is a core part of a doctor’s job. Research on diagnosis has been grounded in the incidence of errors. A report from the US Institute of Medicine1 concluded that most patients will experience a diagnostic error within their lifetime. Around 32% of clinical errors have been found to be caused by clinician assessment, particularly the clinician’s failure to weigh up competing diagnoses2. Studies have also investigated the downstream consequences of diagnostic errors. Unnecessary treatment (or ‘overtreatment’) was estimated to cost the US healthcare system $158-$226 billion in 20113. Diagnostic errors lead to longer hospital stays and increased patient mortality4.

Heuristics are commonly used in diagnostic decisions that are necessarily often based on incomplete, imperfect information and made under time pressure. For example, making a diagnosis may involve considering a hypothesis as likely because the displayed symptoms correspond with a prototypical case of a particular condition5. A clinician may have had a recent experience of a patient with a particular condition and, when seeing another patient exhibit similar symptoms, is more likely to diagnose that patient with the same condition6. Although these heuristics are often effective, associated cognitive biases are thought to be linked to diagnostic error. One cognitive bias that has been posited as a contributor to diagnostic error is overconfidence7, which may cause an individual clinician to fail to consider alternative diagnoses or lead a clinical team to be overly swayed by one individual’s opinion.

Confidence is the subjective assessment of a decision’s quality or accuracy8. We refer to confidence as being ‘calibrated’ if it closely predicts objective accuracy (i.e., such that the individual is neither overconfident nor underconfident). In experimental studies, confidence sometimes exhibits impressive calibration to objective accuracy9, which is thought to reflect people’s ability to evaluate the quality of evidence on which they base their decisions10. But calibration is rarely perfect because confidence also depends on factors that do not directly correlate with accuracy, such as the time spent deliberating and the total amount of evidence considered (independent of the quality or consistency of this evidence)11,12, as well as the mood13, personality14, gender15 and status16 of the decision maker. The resulting under- and overconfidence matters: Overconfident decision makers leap to premature conclusions and ignore useful information or advice, while underconfident decision makers waste time collecting evidence that won’t improve their decisions17. Effective decision making in groups likewise depends on team members sharing calibrated information about their uncertainty: Confident team members tend to be listened to more, which can lead others astray if they are overconfident18. Conversely, underconfident team members may be ignored or may fail to share potentially useful information19.

A diagram of overconfidence and accuracy

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**FIGURE 1: Visual representation of confidence calibration when comparing objective accuracy (x-axis) to subjective confidence (y-axis). Confidence is said to be calibrated when the two are relatively equivalent.**

These features of confidence highlight its potential importance in healthcare, as overconfidence can lead to insufficient consideration of diagnostic alternatives and inadequate care20. In the absence of objective feedback, confidence can be used as a marker of how likely someone is to be correct21. In medicine, a lack of clearly communicated feedback can cause clinicians to proceed as if they have received positive feedback. This means that they do not adequately update their internal model of the patient and then increase their confidence inappropriately, whether working individually or in teams22.

Given growing interest in this topic, we conducted a scoping review to synthesise current work on studying diagnosis as a cognitive process. We aimed to identify key determinants of confidence and characterise how judgements of confidence are utilised within the wider medical decision making process. For the purposes of this review, and in common with practice in the reviewed articles, we treat “confidence” and “certainty” as interchangeable terms, while noting that the psychological literature discusses whether they are subtly different concepts23. Our full research questions can be found in Box 1.

**BOX 1: Scoping Review Research Questions (Preregistered)**

Primary questions:

* **RQ1:** How calibrated are confidence/certainty judgements made during diagnostic decisions by clinicians relative to their actual accuracy?
* **RQ2:** How are confidence/certainty judgements utilised within the wider diagnostic decision process?

Subsidiary questions:

* **RQ3:** What are the prevalent ways in which diagnostic confidence and certainty are measured and operationalised as variables?
* **RQ4:** What strategies, tools or frameworks have been used to prompt better calibration of both confidence and certainty?
* **RQ5:** What types of empirical procedures/tasks are used to study confidence and certainty in diagnostic decisions? Do they come to different conclusions?
* **RQ6:** What are the discrepancies between the concepts/research questions studied in the context of confidence and certainty in the cognitive psychology literature and the medical diagnosis literature?
* **RQ7:** What areas of research are still underexplored within the context of medical diagnosis?

**METHODS**

**Search Strategy**

Our review protocol was preregistered on the Open Science Framework: <https://osf.io/wz5se>. We conducted a systematic scoping review of empirical studies on confidence and certainty in medical diagnosis using JBI’s PRIMSA-ScR Checklist for Scoping Reviews24. The search strategy was designed in cooperation with a subject specialist librarian at the University of Oxford’s Bodleian Libraries group. The search string comprised keywords that captured the intersection of four elements: confidence/certainty, medical diagnoses, decision making and a study population of medical staff/students (i.e., clinicians, physicians, doctors and medics). The full search terms can be found in Box 2. The databases SCOPUS, MEDLINE, PsycINFO and Global Health were searched during February 2024. Finally, we hand-searched the citations of the included articles from these databases for further relevant articles via backward and forward scanning25,26.

**BOX 2: Search Terms**

(clinicians OR physicians OR doctors OR medics)

AND

( confiden\* OR uncertain\* OR certain\*)

AND

( diagnosis AND medical )

AND

( decision OR ( decision AND making ) OR decision-making )

**Study Selection**

The inclusion criteria for studies were as follows: (1) original empirical studies with quantitative results, (2) written in the English language, (3) experimental paradigm uses medical diagnostic decisions, (4) confidence or certainty is measured as a dependent variable. We exclude editorials, review papers and opinion papers, though we do include dissertations. We do not exclude any medical subdisciplines and do not exclude papers based on publication date. Identified articles were uploaded onto Rayyan (<https://rayyan.ai/>), which detects duplicate papers for manual checking and removal.

**Research Synthesis**

Papers selected for review were first categorised by their broad research methodology (e.g., patient vignettes, in situ questionnaires, etc.) and their medical population of study (e.g., medical students, general practitioners/primary care physicians/family doctors, medics etc.). We reviewed the experimental procedures to extract their key manipulations and independent variables (e.g., case complexity, use of a cognitive intervention, level of medical experience). We also extracted dependent variables as they pertain to confidence/certainty and, where relevant, recording of both diagnostic differentials and information seeking. Each of the paper’s key findings were summarised and then all findings were categorised under recurring themes.

**RESULTS**

**Findings of Scoping Review**

The initial search returned a total of 3,332 articles. Applying the inclusion criteria described in the Study Selection section identified 50 eligible articles. 439 further articles were retrieved for review from the included articles’ citations. After applying both exclusions of duplicates and our inclusion criteria, 29 further articles were identified. This produced a total of 79 articles for inclusion and synthesis. The PRISMA diagram for this search process can be found in Figure 2.

A diagram of a flowchart

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**FIGURE 2 – PRISMA Diagram of Literature Review.**

**Study Characteristics**

A summary of the included studies are found in Table 1. As shown in Figure 3, 36 of the 79 studies (46%) were published since 2019, indicating a recent surge of research interest in this field and the timeliness of a scoping review. The studies appeared in 59 different publications, including both medical and psychological journals, with journals related to medical education being most common (19 studies). Other research areas most represented were Primary Care/General Practice, Emergency Medicine and Nursing.

**Research Design**

Before discussing research themes that emerged from the included literature, we first set out the types of research designs. The included studies split roughly evenly between focusing on how confidence varies across individuals (35 studies) and on how confidence varies according to features of the patient case (31 studies), whilst the remaining 13 studies studied the interaction between both. 34 studies (43% of the sample) looked at the level of medical experience or training’s effect on confidence, either measured as a dependent variable or by recruiting participants in ‘novice’ versus ‘experienced’ groups. 19 studies (24%) manipulated the complexity or difficulty of the patient case. Finally, 10 studies (13%) investigated how diagnostic confidence varies with the information presented or the opportunity to seek information.

Most of the studies (44 articles, 56% of the sample) used clinical patient text vignettes. For vignettes, there is an established ground truth in each case (unlike in situ studies involving real patients) to compare the participants’ confidence to in order to gauge calibration. As vignettes are quick and simple to administer, participants can complete several diagnoses during a single study such that both their confidence and accuracy can be averaged across cases. Other experimental methodologies include the use of imaging (e.g., ECG, X-Rays, MRI) for diagnosis, high-fidelity simulations (either using extended reality tools or a patient mannequin), or questionnaires administered in situ to measure confidence during real patient cases as they are happening (Table 1). The preponderance of vignette studies is noteworthy given the finding from one study that nurses were both less accurate and less confident in a high-fidelity simulation compared to a paper-based vignette27, suggesting the need for caution when generalising to how medical professionals behave in their everyday practice.

Studies varied in how confidence and diagnostic accuracy were assessed. Studies mostly used a self-reported scale for confidence (usually 1-10 or 1-100) as opposed to verbal expressions of confidence (e.g., “not sure” to “certain”) or visual analogue scales. The use of self-report numerical scales is common within cognitive psychology and measured confidence values are often found to predict other behavioural variables of uncertainty, such as the tendency to seek further information or to opt out of making a decision28. Twenty-four studies (30%) allowed participants to input multiple diagnostic differentials rather than a single diagnosis. Confidence is then either measured for each differential or in the set of differentials as a whole.

In terms of accuracy, most studies prompt clinicians for a single diagnosis that is marked as correct or incorrect. However, clinicians may consider multiple possible diagnoses in their everyday practice. Hence, 24 studies (30%) allowed participants to record multiple differentials in their diagnosis. This complicates scoring of accuracy and confidence: If accuracy is operationalised as whether a correct diagnosis is included in this set of multiple differentials, clinicians are more likely to correct with more differentials, and it may remain unclear how clinicians weigh up competing differentials. Hence, measures of how calibrated confidence judgements are to true diagnostic accuracy are heavily contingent on how diagnoses are recorded. This then has a bearing on how reliable findings on overconfidence/underconfidence are.

|  |  |  |  |
| --- | --- | --- | --- |
| **Publication Year** | | **Subdiscipline / Population** | |
| 1991-2000 | 10 | Primary Care / General Practice | 26 |
| 2001-2010 | 11 | Medical Students | 15 |
| 2011-2020 | 29 | Emergency Medicine | 10 |
| 2021- | 29 | Nursing | 6 |
|  |  | Pathology | 4 |
| **Study Environment/Context** | | Radiology | 4 |
| Text Vignette | 44 | Other | 14 |
| Imaging Interpretation (e.g. ECG) | 20 |  |  |
| In Situ Questionnaires/Surveys | 13 | **Study Population Sample Size** | |
| High-Fidelity Simulation | 2 | < 100 | 44 |
|  |  | 101-200 | 20 |
| **Participant Experience Levels** | | 201-300 | 9 |
| Fixed Across Participants | 50 | > 300 | 6 |
| Multiple Experience Groups | 29 | **Total** | **79** |

**TABLE 1: Characteristics of Included Studies, including year of publication, study environment used and medical population (recruiting single or multiple levels of participant experience, medical subdiscipline, sample size).**

A graph of a number of years

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**FIGURE 3 – Distribution of Papers by Publication Year**

**Emerging Research Themes**

Miscalibration of Confidence and Certainty Judgements to Objective Accuracy

Calibration is assessed by comparing confidence ratings with objective diagnostic accuracy: When clinicians rate 100% (or 50% or 60%, etc.) certainty in their diagnosis, are they in fact correct 100% (or 50%, 60%, etc.) of the time? Calibration is then an indirect measure that is calculated by comparing two other observed measures: confidence and accuracy. In our study sample, there was limited evidence of calibrated confidence judgements, with some studies reporting underconfidence27,29,30 and others overconfidence31-33. To examine these findings in more detail, we consider factors that impact or promote calibration in diagnoses.

The first major theme of interest is how calibration interacts with experience. A difference in calibration across experience was not always observed in the results34,35. Calibration interacted with case complexity and experience however, with experienced clinicians better able to identify when a case is more complex or difficult, adjusting their confidence accordingly36,37. Looking at the link between calibration and experience alone may be too simplistic, and there are other aspects of experience that influence diagnoses. Experienced clinicians were found to be less likely to ‘distort’ neutral information to be in support of their reported diagnoses, indicating a lower tendency toward confirmation bias38. Past work has also hinted at a distinction between experience (operationalised as years of experience or role seniority) and knowledge (measured using standardised tests of medical knowledge). In medical students, the calibration of confidence judgements were found to improve with years of education but not with medical knowledge39. Information ‘distortion’ was found to affect novice clinicians more38 and lower knowledge was found to be related to higher susceptibility to irrelevant, distracting features of a patient40. However, the latter study found that medical knowledge was not directly associated with calibration.

The second major theme relates to contextual and environmental factors. Studies have found that calibration is affected by the complexity or difficulty of the presented case41-43. When confidence judgements are not sensitive to the difficulty or complexity of the case, confidence stays fairly constant for difficult cases whilst accuracy decreases, leading to increased overconfidence (and decreased calibration)41. In past studies, complexity is manipulated by either presenting patient cases with more comorbid conditions42 or by showing conflicting information about the patient to indicate multiple possible conditions34. Calibration can be improved by the presence of feedback during a training period44,45.

Contextual factors that pertain to the situated medical environment can also affect confidence specifically (rather than calibration), as found using naturalistic paradigms. For example, clinicians may be constantly interrupted by other tasks46, especially during busier shifts where they have to manage more patients47 and may not be present for the sharing of information during handovers48. Studies that simulated these situations found they resulted in lower diagnostic confidence. However, such studies cannot assess the effect of contextual factors on calibration with diagnostic accuracy because they were conducted in-situ, meaning that researchers for these studies are not able to obtain measures of accuracy. At this stage, we can only determine how these contextual factors affect confidence, rather than calibration.

**BOX 3: Papers on Imaging and Confidence**

A subset of papers find an increase in confidence when providing clinicians with specialised imaging for a patient when making diagnoses, be they MRI scans49-50, CT scans51, evacuation proctography52 or photos of wounds53. Another subset of papers use various forms of computer-aided decision support systems with the goal of improving confidence, with mixed results54-57. These results are perhaps not surprising, but do warrant addressing as per our inclusion criteria.

Interventions at the Point of Generating Differentials

The process of generating diagnostic differentials has been subject to experimental manipulations and interventions (such as early diagnostic suggestions) to investigate their effect on accuracy and confidence. This work is applicable, for instance, to understanding how a clinician transitions care of a patient to another clinician and gives a handover of relevant information. A general theme of this work is that there is a tendency toward higher weighting of early information, indicating a primacy effect. Early diagnostic suggestions have been found to be highly influential in the subsequent decision process where clinicians find these suggestions difficult to ignore and have more confidence in them58-59. This also affects the breadth of differentials considered, with fewer differentials considered when provided with early suggestions60 and an underweighting of differentials if they were considered later in the diagnostic process61. Interventions aimed at mitigating this tendency by asking clinicians to explicitly consider alternatives, increased their accuracy and calibration62, or prompting the consideration of the patient’s ‘red flags’ in diagnoses, which increased confidence on simpler cases but not accuracy63. These interventions seem to require explicit instructions: Simply asking clinicians to reflect on their decision without guidance64,65 or participate in an educational training course66-67 does not seem to improve diagnostic accuracy and calibration.

Studies have also investigated how confidence is affected by the manner in which information is presented to clinicians during the diagnostic process. Higher confidence was found when clinicians were presented with redundant patient information68 and when given all available patient information rather than having to gather information themselves69. Clinicians were also found to be more confident when presented with an Electronic Health Record of the patient alongside other information70 and when presented with the patient history first rather than out of order71. This indicates that complete patient history available early on has a positive impact on confidence. However, an erroneous patient history has also been found to cue both novice and experienced clinicians to incorrect diagnoses whilst confidence remained relatively high, resulting in overconfidence72.

Uses of Confidence

With more naturalistic studies, it is possible to isolate ways in which confidence and certainty are utilised within the wider diagnostic process, especially as healthcare involves transitions of care between multiple clinicians and departments. Past work has attempted to establish a link between confidence and further seeking of patient information and tests, with mixed results. US hospitalists with lower confidence were found to be linked to more test orders47 whilst better calibrated pathologists (i.e., who tended to report confidence judgements that were closer to their true accuracy) were found to be more likely to request further tests when they were unsure37. Confidence has also been linked to prescribing medication, though overtreatment with unnecessary medications has been linked to both underconfidence73 and overconfidence33. Higher confidence has also been linked to more referrals to specialists in other departments74 and to a lower willingness to admit mistakes30. One study found that whilst experienced clinicians were not more accurate in their initial diagnoses, they were more willing to change diagnoses and request more information75. Lower confidence has been found to result in less specific diagnoses for patients in situ76. Although psychology research on confidence has examined its role in group decision making (see Introduction), only one included article looked at confidence in group decisions in medicine. This study found that a multidisciplinary panel was more confident and better calibrated than a single clinician77. We return to this later as a theme for future work.

Conceptual Model for Diagnostic Decisions

We synthesise the reviewed findings into a theoretical framework that illustrates how various factors distinctly impact diagnostic confidence and accuracy. This framework (Figure 4) summarises existing research and identifies opportunities for future research that have been relatively untapped to date.

The model starts by mapping out the stages of the diagnostic process (Figure 4, bottom panel). Based on initial patient presentation, clinicians gather and interpret patient information (e.g. history, examinations, tests) to inform their diagnosis of the patient’s condition. The clinician’s confidence in their diagnosis guides their judgment on when they have enough information to begin treatment versus whether further tests or additional information are needed. Once a diagnosis is reached, this guides patient treatment and care, the success of which is evident in the outcome for the patient.

The middle panel of Figure 4 characterises the cognitive processes of the clinician that determine the accuracy of the diagnosis and confidence with which the diagnosis is made. Past research suggests a distinction between medical experience (measured as years of experience) and knowledge (measured using a standardised assessment of medical ability) as they separately interact with confidence and diagnostic accuracy separately38-40. This is especially pertinent given the social influence that experience/seniority can have within a group, reducing the likelihood of more junior clinicians speaking up about potential errors in the presence of more experienced clinicians78. Knowledge is improved through feedback on how a patient case was handled and its outcome, which in turn improves future diagnostic accuracy.

The top panel of Figure 4 highlights factors pertaining to the medical environment/context. In particular, we draw on findings from the literature that provide evidence for lower confidence in the face of time pressures27, interruptions to work46, busy shifts47 and complex patient cases41-43 (either due to conflicting information or comorbidities). We also note however that exposure to complex cases can improve medical knowledge by giving clinicians a more diverse pool of experienced cases to draw upon in the future.

Finally, we note two primary directions for future research. First, given the focus of research to date on diagnosis by individual clinicians, we recommend that future work also studies diagnoses in groups, given that diagnoses are often made by teams rather than single individuals, particularly in primary care settings. Second, we recommend future work investigate the association between the receipt of information and confidence. While included literature found that confidence was predictive of subsequent testing37,47 or referral to specialists74, past work does not look at the decisional process prior to formulating a diagnosis and associated confidence, in particular how information is sought and collated. Cognitive psychology literature has found that higher information seeking is associated with increased confidence12. Individuals have also been shown to have a tendency to sample information that corresponds with a previous decision, with confidence increasing the extent to which information sampling is biased79.

A diagram of a patient's process

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**FIGURE 4: Conceptual model of the various factors that impact the course of a diagnostic process, with links established between concepts based on findings from this systematic scoping review. Factors are categorised in three levels: the level of the diagnostic decision process (bottom box, where the course of the decision proceeds from left to right), the level of the clinician (middle box) and the level of the environmental context within which the clinician operates (top box). Black arrows represent a progression from one concept to another. Green arrows indicate positive impacts between concepts; red arrows indicate the opposite (i.e. a negative relationship). Orange arrows represent links between concepts that we highlight for future research to focus on, as they are currently underexplored in the literature based on the papers included in this review.**

**DISCUSSION**

\*\*This start of the discussion is not well targeted at what’s needed. The discussion should start either with a restatement/reminder of the aims, or with a punchy integrative statement of key findings. Here we’re starting with more tangential points and mentions of future directions that belong later. Take a look at a few papers (from our lab or elsewhere) to see models of what a first paragraph (and following discussion structure) can look like.\*\*

Our forward and backward citation search identified 37% of our sources, which is rather high but reveals a lot about the current state of the literature. We aimed to review studies on confidence during diagnoses and found a large number of studies through citation tracking. This review process reveals the broad applicability of confidence across medical subdisciplines. We also find that several studies measured confidence or certainty across a variety of different research methods (e.g. using ‘assessments’ or ‘interpretations’ as well as diagnostic decisions), but not as a primary variable for study. Future work would benefit from standardisation in terms of measuring confidence, as well as studying confidence itself in more detail. This is particularly important given the broad findings that confidence in diagnostic decisions tend to be miscalibrated. Given that confidence seems to interact with other factors like experience and the complexity of the patient case, future work could, in particular, prompt confidence in a manner that better reflects the individual and case-level factors. This review has also shown how confidence is associated with many aspects of the patient care process, illustrating just how it can influence clinicians’ behaviour and its importance to study, as well as its huge benefits to elucidate through further research.

Whereas previous reviews have focused on mapping instances of cognitive biases within medical errors80-82 or on medical uncertainty more broadly83,84, our review is the first to comprehensively map out the literature that links confidence and certainty to medical diagnoses in such a broad remit across medicine. Our work demonstrates that both errors and confidence are fruitful areas to study within diagnosis, as together they determine how calibrated a clinician is when expressing certainty/uncertainty. The breadth of the literature reviewed here, from a wide variety of medical subdisciplines, demonstrates how important confidence is as an area of study in terms of its broad applicability across healthcare. Given the wide range of subdisciplines that have studied confidence, there is then a need for a wider focus on confidence and metacognition within medical education. Findings from metacognition are already being used to inform educational practices outside medicine to improve students’ memory retention85,86.

**Implications and Future Clinical Research**

This scoping review shows the importance and the (particularly recent) surge in interest in diagnostic confidence. The recent interest in this field of work may be related to the increased focus on artificial intelligence in healthcare, particularly for diagnosis, and how important it is for these tools to convey uncertainty clearly. As such, there is interest in understanding where and how diagnostic uncertainty arises. Whilst confidence has been linked to diagnostic error in the past7, studying it requires insights from cognitive psychology to inform medical education and practice87. How clinicians evaluate their decisions contributes to their effectiveness, as an overconfident clinician may overlook diagnostic possibilities, delay treatment or ignore crucial information. Conversely, an underconfident clinician may be less likely to speak up in a group about potential errors78. Our review finds that confidence and accuracy are rarely aligned during diagnoses. Whilst cognitive interventions such as considering alternative diagnoses and guided reflections have been tested, there is yet to be a standardised cognitive framework to teach non-technical skills such as expressions of uncertainty. Notably from these papers, miscalibration of confidence is not only a function of social and environmental factors, as it was also observed for vignette studies performed by individual participants. Such factors only serve to amplify systematic tendencies toward misaligned confidence/certainty.

Studying errors has tended to be the focus of past work, especially overconfidence as a source of errors. Our review provides evidence in support of this, as the included studies found evidence for overconfidence particularly when dealing with complex cases. Overconfidence was also found to be associated with overlooking differentials, ignoring important patient information and being less willing to admit mistakes. Hence, mitigating overconfidence is an important direction for future research. Underconfidence has received less attention, but is observed more in medical trainees27,29,30 and can lead to negative outcomes such as delayed treatment88. Interventions have been tested to improve confidence calibration (such as considering alternative diagnoses and guided reflection), but these have not been successful in this regard64,65. More work is then needed to design interventions to improve calibration.

Whilst we have reviewed a wide breadth of the available literature on confidence/certainty in diagnoses, there are still many avenues for future work. Namely, the majority of the studies presented here do not study diagnosis as a constantly ongoing and evolving process. This is likely a function of the methodologies used where participants are asked for diagnoses at a particular point in time, usually after reading all the available information on a patient. In reality, diagnoses feature a back and forth between seeking information and evaluating that information in the context of currently considered diagnostic possibilities. Without this consideration in experimental design, researchers cannot study the diagnostic process up until the point of expressing confidence. Past work has viewed confidence insofar as it affects the subsequent diagnostic process (e.g. medications, testing) after this confidence is expressed, rather than what causes this sense of confidence in the first place. One way to study this is using more naturalistic, in situ methodologies that are more analogous to everyday medical practice. However, interrupting clinicians in real time to report their diagnostic thinking can be a distraction and potentially a safety risk. Future research should focus on utilising other methodologies for capturing the diagnostic reasoning of clinicians as it evolves with time and the receipt of new information. This could include getting clinicians to think aloud as they make diagnoses89 or using a visual representation of clinicians’ thought processes to capture paths and sources of diagnoses62. The use of high-fidelity simulations is also useful for emulating the pressure and work environment of the clinician (which may affect decision making), as well as providing an actual ‘patient’ to observe (unlike in textual vignettes). Use of such paradigms would also improve the generalisability of results. Considering the work environment is important given our findings of lower confidence due to environmental factors such as shift busyness and time pressures. This corresponds with other findings of stress being associated with decreased confidence for intermediate levels of uncertainty90 and this stress could be contributed to by the healthcare environment that the clinician operates in.

Most of the reviewed studies investigate confidence in individual clinicians. However, diagnosis and treatment decisions are often made by teams rather than individuals, particularly in secondary care settings. Evidence from organisational psychology indicates that group decisions depend critically on communicated confidence and uncertainty19: Overconfident team members can anchor a group on an incorrect decision91. Conversely, underconfident team members may fail to share important information that is unknown to the rest of the group, exacerbating the problems of ‘hidden information’ and ‘shared information bias’92. In addition, future work can aim to identify how the certainty held by individuals differs from the certainty communicated to others (be they patients or other clinicians). Clinicians may modify how they communicate certainty with others, especially given the collaborative nature of healthcare and the social benefits of communicating opinions with confidence in order to be listened to in a group30. Situational awareness (SA) is also important in a group, and higher stress may be associated with overconfidence in SA93. Taken together, group medical decisions are clearly an important and naturalistic area for future study.

The papers in this review have also not looked at individual differences in expressions of confidence, where past work from cognitive psychology has found individual systematic tendencies toward higher or lower confidence94,95. Hence, whilst task-level or environmental factors affect confidence and calibration, individual clinicians may also have trait-level factors that are predictive too.

**CONCLUSIONS**

This scoping review indicates that confidence is frequently not calibrated to accuracy during diagnostic decisions. We also found across the literature that different factors affect confidence and accuracy separately, which may help to explain why such instances of overconfidence or underconfidence are observed. Finally we identified several papers that underscore how confidence affects the subsequent care pathway of patients and its importance for future study. Taken together, these findings have implications for how diagnostic confidence should be studied in future clinical work, including the role that information gathering and interpretation has on diagnoses.

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**TABLE 2: Full Table of Included Studies (Supplemental)**

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| --- | --- | --- | --- | --- | --- |
| Author(s) | Title | Year | Discipline | Methodology | Measure of Confidence |
| Neugebauer, M.; Ebert, M.; Vogelmann, R. | A clinical decision support system improves antibiotic therapy for upper urinary tract infection in a randomized single-blinded study. | 2020 | Medical Doctors (Internal Medicine) | Fictive Paper Case | Confidence in Diagnosis (%) |
| Sanger, P. C.; Simianu, V. V.; Gaskill, C. E.; Armstrong, C. A. L.; Hartzler, A. L.; Lordon, R. J.; Lober, W. B.; Evans, H. L. | Diagnosing surgical site infection using wound photography: a scenario-based study. | 2017 | Members of Surgical Infection Society | 5 online scenarios | Confidence in diagnosis (1-10) |
| Levin, P. D.; Idrees, S.; Sprung, C. L.; Weissman, C.; Weiss, Y.; Moses, A. E.; Benenson, S. | Antimicrobial use in the ICU: Indications and accuracy - an observational trial. | 2012 | ICU | Observational in ICU | Certainty of presence of infection when starting patients on antimicrobials |
| Fernandez-Aguilar, Carmen; Martin-Martin, Jose Jesus; Minue Lorenzo, Sergio; Fernandez Ajuria, Alberto | Use of heuristics during the clinical decision process from family care physicians in real conditions. | 2022 | Primary Care | Real patients presenting with dyspnoea | 0-100% scale confidence in diagnosis |
| Heller, Rachael F; Saltzstein, Herbert D; Caspe, William B | Heuristics in medical and non-medical decision-making. | 1992 | Paediatric residents | Medical and non-medical problems | 0-100% scale confidence in diagnosis |
| Mackenzie, R; Dixon, A K; Keene, G S; Hollingworth, W; Lomas, D J; Villar, R N | Magnetic resonance imaging of the knee: assessment of effectiveness. | 1996 | Radiology | Observation of knee MRI patients | 5 point visual analogue confidence scale |
| Mamede, S.; Zandbergen, A.; De Carvalho-Filho, M.A.; Choi, G.; Goeijenbier, M.; Van Ginkel, J.; Zwaan, L.; Paas, F.; Schmidt, H.G. | Role of knowledge and reasoning processes as predictors of resident physicians' susceptibility to anchoring bias in diagnostic reasoning: A randomised controlled experiment | 2024 | Internal Medicine | 6 clinical vignettes (with vs without salient distracting features) | Confidence in diagnosis |
| Staal, J.; Speelman, M.; Brand, R.; Alsma, J.; Zwaan, L. | Does a suggested diagnosis in a general practitioners’ referral question impact diagnostic reasoning: an experimental study | 2022 | Internal Medicine | 6 cases formatted as GP referral letters | 0-10 confidence in diagnosis |
| Küper, A.; Lodde, G.; Livingstone, E.; Schadendorf, D.; Krämer, N. | Mitigating cognitive bias with clinical decision support systems: an experimental study | 2023 | Students and physicians | 6 clinical scenarios | 7 point scale confidence as well as likelihood of each differential |
| Oskay, A. | Evaluation of thoracic computed tomography interpretation by emergency medicine residents with regards to accuracy and confidence | 2023 | Emergency Medicine | 30 CT scans | 1-10 Confidence |
| Marx, G.; Koens, S.; Von Dem Knesebeck, O.; Scherer, M. | Age and gender differences in diagnostic decision-making of early heart failure: Results of a mixed-methods interview-study using video vignettes | 2022 | General Practice | Video vignettes | 0-100% certainty |
| Albrechtsen, S.S.; Riis, R.G.C.; Amiri, M.; Tanum, G.; Bergdal, O.; Blaabjerg, M.; Simonsen, C.Z.; Kondziella, D. | Impact of MRI on decision-making in ICU patients with disorders of consciousness | 2022 | ICU | Real patient cases in ICU | 5 point likert scale |
| Fawver, B.; Thomas, J.L.; Drew, T.; Mills, M.K.; Auffermann, W.F.; Lohse, K.R.; Williams, A.M. | Seeing isn’t necessarily believing: Misleading contextual information influences perceptual-cognitive bias in radiologists. | 2020 | Radiology | 16 deidentified musculoskeletal radiographic cases | 5 point likert scale |
| Hausmann, D.; Kiesel, V.; Zimmerli, L.; Schlatter, N.; von Gunten, A.; Wattinger, N.; Rosemann, T. | Sensitivity for multimorbidity: The role of diagnostic uncertainty of physicians when evaluating multimorbid video case-based vignettes | 2019 | General Practice / Emergency Medicine | Video vignettes | 0-100% scale confidence in diagnosis |
| Lambe, K.A.; Hevey, D.; Kelly, B.D. | Guided reflection interventions show no effect on diagnostic accuracy in medical students | 2018 | Medical Students | Fictional patient cases | 1-6 scale of confidence in original differential |
| Cairns, A.W.; Bond, R.R.; Finlay, D.D.; Breen, C.; Guldenring, D.; Gaffney, R.; Gallagher, A.G.; Peace, A.J.; Henn, P. | A computer-human interaction model to improve the diagnostic accuracy and clinical decision-making during 12-lead electrocardiogram interpretation | 2016 | GPs and Undergrads | ECG interpretation | Self-rated confidence 1-10 |
| Ben-Assuli, O.; Sagi, D.; Leshno, M.; Ironi, A.; Ziv, A. | Improving diagnostic accuracy using EHR in emergency departments: A simulation-based study | 2015 | Emergency Medicine | Simulated patient scenarios with actors for presenting complaints | 7 point likert scale of confidence in diagnosis |
| Maserejian, N.N.; Lutfey, K.E.; McKinlay, J.B. | Do physicians attend to base rates? prevalence data and statistical discrimination in the diagnosis of coronary heart disease: Physicians and coronary heart disease | 2009 | Primary Care | Vignettes of CHD | 0-100 scale of certainty |
| Abujudeh, H.H.; Kaewlai, R.; McMahon, P.M.; Binder, W.; Novelline, R.A.; Gazelle, G.S.; Thrall, J.H. | Abdominopelvic CT increases diagnostic certainty and guides management decisions: A prospective investigation of 584 patients in a large academic medical center | 2011 | Emergency Medicine | Real patients presenting with abdomen pain | 0-100% certainty |
| van Hout, H.P.J.; Vernooij-Dassen, M.J.; Stalman, W.A.B. | Diagnosing dementia with confidence by GPs | 2007 | General Practice | Observation of dementia patients | 4 point likert scale |
| Benvenuto-Andrade, C.; Dusza, S.W.; Hay, J.L.; Agero, A.L.C.; Halpern, A.C.; Kopf, A.W.; Marghoob, A.A. | Level of confidence in diagnosis: Clinical examination versus dermoscopy examination | 2006 | Dermatology | 20 pairs of clinical and dermoscopic images of lesions | 7 point likert scale of confidence in diagnosis (whether benign or malignant) |
| Dreiseitl, S.; Binder, M. | Do physicians value decision support? A look at the effect of decision support systems on physician opinion | 2005 | Dermatology | 25 dermoscopic lesions | 1-10 scale of benign to malignant, with higher values interpreted as confident? |
| Davis, D.P.; Campbell, C.J.; Poste, J.C.; Ma, G. | The association between operator confidence and accuracy of ultrasonography performed by novice emergency physicians | 2005 | Emergency Medicine | Ultrasound scanning | 1-10 scale of confidence of correct test identification |
| McKinlay, J.B.; Lin, T.; Freund, K.; Moskowitz, M. | The unexpected influence of physician attributes on clinical decisions: Results of an experiment | 2002 | Primary Care | 2 Video vignettes | Certainty adhering to diagnosis (% likelihood for each differential) |
| Friedman, C.; Gatti, G.; Elstein, A.; Franz, T.; Murphy, G.; Wolf, F. | Are clinicians correct when they believe they are correct? Implications for medical decision support | 2001 | Internal Medicine | 36 clinical cases split into 4 equal groups | Confidence in each diagnosis |
| Harvey, C.J.; Halligan, S.; Bartram, C.I.; Hollings, N.; Sahdev, A.; Kingston, K. | Evacuation proctography: A prospective study of diagnostic and therapeutic effects | 1999 | Radiology | Questionnaires after proctography in 50 patient cases | 1-10 confidence in diagnosis |
| Berner, E.S.; Maisiak, R.S. | Influence of case and physician characteristics on perceptions of decision support systems | 1999 | General Practice / Emergency Medicine | Written cases | 1-5 confidence |
| Hillson, S.D.; Connelly, D.P.; Liu, Y. | The Effects of Computer-assisted Electrocardiographic Interpretation on Physicians' Diagnostic Decisions | 1995 | Primary Care | ECG interpretation + vignettes (10) | 1-10 confidence in diagnosis |
| Calman, N.S.; Hyman, R.B.; Licht, W. | Variability in consultation rates and practitioner level of diagnostic certainty | 1992 | GP / Family practice | Observational of consultations | Confidence scored based on physician notes by coders |
| Sklar, D.P.; Hauswald, M.; Johnson, D.R. | Medical problem solving and uncertainty in the emergency department | 1991 | Emergency Medicine | Real patients, filling in questionnaire | Visual analogue scale for each differential |
| Brannon, Laura A; Carson, Kimi L | Nursing expertise and information structure influence medical decision making | 2003 | Nursing | Patient scenarios, manipulated information | 0-100% scale confidence in diagnosis |
| Clayton, Dayna A.; Eguchi, Megan M.; Kerr, Kathleen F.; Miyoshi, Kiyofumi; Brunyé, Tad T.; Drew, Trafton; Weaver, Donald L.; Elmore, Joann G. | Are Pathologists Self-Aware of Their Diagnostic Accuracy? Metacognition and the Diagnostic Process in Pathology | 2023 | Pathology | Diagnosis based on slides for microscopes | 6 point scale confidence in correct diagnosis |
| Friedman, Charles P.; Gatti, Guido G.; Franz, Timothy M.; Murphy, Gwendolyn C.; Wolf, Fredric M.; Heckerling, Paul S.; Fine, Paul L.; Miller, Thomas M.; Elstein, Arthur S. | Do physicians know when their diagnoses are correct?: Implications for decision support and error reduction | 2005 | Internal Medicine | 2-4 page medical synopses diagnosis | Likelihood to seek assistance to reach a diagnosis |
| Garbayo, Luciana S.; Harris, David M.; Fiore, Stephen M.; Robinson, Matthew; Kibble, Jonathan D. | A metacognitive confidence calibration (MCC) tool to help medical students scaffold diagnostic reasoning in decision-making during high-fidelity patient simulations | 2023 | Medical Students | High Fidelity Sim (Cases: Heart Failure, Respiratory Distress, DKA, heat exhaustion) | 7 point likert scale of confidence |
| Hautz, Wolf E; Schubert, Sebastian; Schauber, Stefan K; Kunina\_Habenicht, Olga; Hautz, Stefanie C; Kämmer, Juliane E; Eva, Kevin W | Accuracy of self\_monitoring: does experience, ability or case difficulty matter? | 2019 | Medical Students | 6 clinical scenarios | 10 point scale (0% to 100%) |
| Kämmer, Juliane E.; Schauber, Stefan K.; Hautz, Stefanie C.; Stroben, Fabian; Hautz, Wolf E. | Differential diagnosis checklists reduce diagnostic error differentially: A randomised experiment | 2021 | Medical Students / Emergency Medicien | 6 clinical scenarios | 10 point scale of confidence |
| Kostopoulou, Olga; Russo, J. Edward; Keenan, Greg; Delaney, Brendan C.; Douiri, Abdel | Information Distortion in Physicians’ Diagnostic Judgments | 2012 | Primary Care | 3 clinical scenarios each with 2 competing diagnoses | 21 point likelihood |
| Kourtidis, Ploutarchos; Nurek, Martine; Delaney, Brendan; Kostopoulou, Olga | Influences of early diagnostic suggestions on clinical reasoning | 2022 | Family Medicine | 2 patient scenarios with or without diagnostic suggestions | 10 point visual analogue scale of certainty |
| Krupat, Edward; Wormwood, Jolie; Schwartzstein, Richard M; Richards, Jeremy B | Avoiding premature closure and reaching diagnostic accuracy: some key predictive factors | 2017 | Internal Medicine | 4 complex vignettes | 1-100 scale of certainty |
| Leblanc, Vicki R.; Norman, Geoffrey R.; Brooks, Lee R. | Effect of a Diagnostic Suggestion on Diagnostic Accuracy and Identification of Clinical Features: | 2001 | Medical Students | Scenarios with photographs with clinical features |  |
| Redelmeier, Donald A.; Shafir, Eldar | The Fallacy of a Single Diagnosis | 2023 | Primary Care | Series of vignettes to diagnosis COVID | % likelhiood |
| Trueblood, Jennifer S.; Eichbaum, Quentin; Seegmiller, Adam C.; Stratton, Charles; O'Daniels, Payton; Holmes, William R. | Disentangling prevalence induced biases in medical image decision-making | 2021 | Medical Students / Imaging | Cell scans (cancer identification) |  |
| Yang, Huiqin; Thompson, Carl; Bland, Martin | The effect of clinical experience, judgment task difficulty and time pressure on nurses’ confidence calibration in a high fidelity clinical simulation | 2012 | Nursing | High Fidelity Sim | 0-100 confidence |
| Yang, Huiqin; Thompson, Carl | Nurses’ risk assessment judgements: a confidence calibration study: Nurses’ risk assessment judgements | 2010 | Nursing | Risk assessment vignettes | 0-100 confidence |
| Eva, Wayne Kevin | The influence of differentially processing evidence on diagnostic decision-making | 2001 | Medical Students | Presenting case histories | Probability ratings |
| Tabak, Nili; Bar-Tal, Yoram; Cohen-Mansfield, Jiska | Clinical decision making of experienced and novice nurses | 1996 | Nursing | Two scenarios | 0-100% scale confidence in diagnosis |
| Brezis, Mayer; Orkin-Bedolach, Yael; Fink, Daniel; Kiderman, Alexander | Does Physician's Training Induce Overconfidence That Hampers Disclosing Errors? | 2019 | Cross Disciplines | Survey with clinical vignette of a girl with urinary infection and penicillin allergy | 5 point likert scale |
| Mann, Doug | The Relationship between Diagnostic Accuracy and Confidence in Medical Students. | 1993 | Medical Students / Cardiac | ECG slides - Classification of cardiac dysrhythmias | 11 point scale, 0-100% |
| Schoenherr, Jordan Richard; Waechter, Jason; Millington, Scott J | Subjective awareness of ultrasound expertise development: individual experience as a determinant of overconfidence | 2018 | Cardiology | Cardiac ultrasound case studies | 6 point scale confidence in correct identification |
| Meyer, Ashley ND; Payne, Velma L; Meeks, Derek W; Rao, Radha; Singh, Hardeep | Physicians’ diagnostic accuracy, confidence, and resource requests: a vignette study | 2013 | Internal Medicine | 4 case vignettes | 0-10 confidence in diagnosis (for each) |
| Wood, Greg; Batt, Jeremy; Appelboam, Andrew; Harris, Adrian; Wilson, Mark R. | Exploring the Impact of Expertise, Clinical History, and Visual Search on Electrocardiogram Interpretation\*\* | 2014 | ED | ECG traces and eye tracking | 1-10 confidence in diagnosis |
| Bergl, P. A.; Shukla, N.; Shah, J.; Khan, M.; Patel, J. J.; Nanchal, R. S. | Factors influencing diagnostic accuracy among intensive care unit clinicians – an observational study\*\* | 2024 | ICU | Surveys during ICU | 5 point likert scale |
| Frey, J.; Braun, L. T.; Handgriff, L.; Kendziora, B.; Fischer, M. R.; Reincke, M.; Zwaan, L.; Schmidmaier, R. | Insights into diagnostic errors in endocrinology: a prospective, case-based, international study\*\* | 2023 | Endocrinology | 5 patient cases | 1-10 confidence in diagnosis |
| van Sassen, C.; Mamede, S.; Bos, M.; van den Broek, W.; Bindels, P.; Zwaan, L. | Do malpractice claim clinical case vignettes enhance diagnostic accuracy and acceptance in clinical reasoning education during GP training?\*\* | 2023 | General Practice | Cases with and without malpractice claim information | 0-100 confidence |
| Gupta, A. B.; Greene, M. T.; Fowler, K. E.; Chopra, V. I. | Associations Between Hospitalist Shift Busyness, Diagnostic Confidence, and Resource Utilization: A Pilot Study\*\* | 2023 | Doctors | Questionnaire during shift | 1-10 Confidence |
| Kuhn, J.; Mamede, S.; van den Berg, P.; Zwaan, L.; van Peet, P.; Bindels, P.; van Gog, T. | Learning deliberate reflection in medical diagnosis: does learning-by-teaching help?\*\* | 2023 | General Practice | 10 written cases | 1-9 confidence |
| Staal, J.; Katarya, K.; Speelman, M.; Brand, R.; Alsma, J.; Sloane, J.; Van den Broek, W. W.; Zwaan, L. | Impact of performance and information feedback on medical interns' confidence–accuracy calibration\*\* | 2023 | Medical Students | X-ray interpretation | 0-10 confidence in diagnosis |
| Keene, T.; Pammer, K.; Lord, B.; Shipp, C. | Dispatch information affects diagnosis in paramedics: an experimental study of applied dual-process theory\*\* | 2022 | Paramedics | Vignettes in two parts with an intuitive impression and then diagnosis, with or wtihout secondary task distraction | 4 point scale |
| Tio, R. A.; Filho, M. A. C.; de Menezes Mota, M. F.; Santanchè, A.; Mamede, S. | The Effect of Information Presentation Order on Residents’ Diagnostic Accuracy of Online Simulated Patients With Chest Pain\*\* | 2022 | Cardiology | 12 clinical cases presented in 2 diagnostic rounds (history and EKG) | 0-100 confidence |
| Kuhn, J.; van den Berg, P.; Mamede, S.; Zwaan, L.; Bindels, P.; van Gog, T. | Improving medical residents’ self-assessment of their diagnostic accuracy: does feedback help?\*\* | 2022 | General Practice | 12 cases | 1-9 confidence |
| Katz, I.; O'Brien, B.; Clark, S.; Thompson, C. T.; Schapiro, B.; Azzi, A.; Lilleyman, A.; Boyle, T.; Espartero, L. J. L.; Yamada, M.; Prow, T. W. | Assessment of a Diagnostic Classification System for Management of Lesions to Exclude Melanoma\*\* | 2021 | Pathology / Dermatology | 217 Lesions prepared and stained from patients | 1-5 confidence |
| Staal, J.; Alsma, J.; Mamede, S.; Olson, A. P. J.; Prins-van Gilst, G.; Geerlings, S. E.; Plesac, M.; Sundberg, M. A.; Frens, M. A.; Schmidt, H. G.; Van den Broek, W. W.; Zwaan, L. | The relationship between time to diagnose and diagnostic accuracy among internal medicine residents: a randomized experiment\*\* | 2021 | Internal Medicine | 8 clinical case | 0-100% scale confidence that diagnosis was correct |
| Thorlacius-Ussing, G.; Bruun, M.; Gjerum, L.; Frederiksen, K. S.; Rhodius-Meester, H. F. M.; Van Der Flier, W. M.; Waldemar, G.; Hasselbalch, S. G.; Nobili, F. | Comparing a Single Clinician Versus a Multidisciplinary Consensus Conference Approach for Dementia Diagnostics\*\* | 2021 | Neurology | Real patient evaluations | 0-100 Visual analogue scale |
| Chen, Y.; Nagendran, M.; Kilic, Y.; Cavlan, D.; Feather, A.; Westwood, M.; Rowland, E.; Gutteridge, C.; Lambiase, P. D. | The diagnostic certainty levels of junior clinicians: A retrospective cohort study\*\* | 2021 | Emergency Medicine | Real patient cases deindentified | Qualitative labels translated into % |
| Li, S.; Zheng, J.; Lajoie, S. P. | The relationship between cognitive engagement and students’ performance in a simulation-based training environment: an information-processing perspective\*\* | 2020 | Medical Students | Two patient cases shown | 0-100% scale confidence in diagnosis |
| Chartan, C.; Singh, H.; Krishnamurthy, P.; Sur, M.; Meyer, A.; Lutfi, R.; Stark, J.; Thammasitboon, S. | Isolating red flags to enhance diagnosis (I-RED): An experimental vignette study\*\* | 2019 | Paediatric residents | Paediatric cases | 1-10 Confidence |
| Cleary, T. J.; Konopasky, A.; La Rochelle, J. S.; Neubauer, B. E.; Durning, S. J.; Artino, A. R. | First-year medical students’ calibration bias and accuracy across clinical reasoning activities\*\* | 2019 | Medical Students | Some of kind of virtual patient sim | Estimations of performance |
| Costa Filho, G. B.; Moura, A. S.; Brandão, P. R.; Schmidt, H. G.; Mamede, S. | Effects of deliberate reflection on diagnostic accuracy, confidence and diagnostic calibration in dermatology\*\* | 2019 | Medical Students / dermatology | 12 dermatological images | 0-100% scale confidence in diagnosis |
| Nederhand, M. L.; Tabbers, H. K.; Splinter, T. A. W.; Rikers, R. M. J. P. | The Effect of Performance Standards and Medical Experience on Diagnostic Calibration Accuracy\*\* | 2018 | General Medicine | 6 clinical cases | Confidence in diagnosis (1-10) |
| Pusic, M. V.; Chiaramonte, R.; Gladding, S.; Andrews, J. S.; Pecaric, M. R.; Boutis, K. | Accuracy of self-monitoring during learning of radiograph interpretation\*\* | 2015 | Radiology / medical students | Ankle radiographs | Qualitative labels |
| Hautz, W. E.; Kämmer, J. E.; Schauber, S. K.; Spies, C. D.; Gaissmaier, W. | Diagnostic performance by medical students working individually or in teams\*\* | 2015 | Medical Students | 6 simulated cases of respiratory distress | 1-10 Confidence |
| Soares, W. E.; Price, L. L.; Prast, B.; Tarbox, E.; Mader, T. J.; Blanchard, R. | Accuracy screening for ST elevation myocardial infarction in a task-switching simulation\*\* | 2019 | Emergency Medicine | ECG interpretation | 1-5 confidence |
| Blissett, S.; Sibbald, M.; Kok, E.; van Merrienboer, J. | Optimizing self-regulation of performance: is mental effort a cue? \*\* | 2018 | Internal Medicine | ECG interpretation | 0-100% certainty |
| Adderley, U. J.; Thompson, C. | Confidence and clinical judgement in community nurses managing venous leg ulceration – A judgement analysis\*\* | 2017 | Nursing | 110 (!) clinical scenarios | 1-10 confidence in diagnosis |
| Feyzi-Behnagh, R.; Azevedo, R.; Legowski, E.; Reitmeyer, K.; Tseytlin, E.; Crowley, R. S. | Metacognitive scaffolds improve self-judgments of accuracy in a medical intelligent tutoring system\*\* | 2014 | Pathology / Dermatology | Dermatoligical slides | 6 point scale confidence in correct diagnosis |
| Hageman, M. G. J. S.; Bossen, J. K. J.; King, J. D.; Ring, D. | Surgeon confidence in an outpatient setting\*\* | 2013 | Surgery | Real patients visiting surgery | 5 point likert scale |
| Crowley, R. S.; Legowski, E.; Medvedeva, O.; Reitmeyer, K.; Tseytlin, E.; Castine, M.; Jukic, D.; Mello-Thoms, C. | Automated detection of heuristics and biases among pathologists in a computer-based system\*\* | 2013 | Pathology / Dermatology | Dermatoligical slides | Scale from -1 to +1 |
| Yang, H.; Thompson, C.; Bland, M. | Effect of improving the realism of simulated clinical judgement tasks on nurses' overconfidence and underconfidence: Evidence from a comparative confidence calibration analysis\*\* | 2012 | Nursing | Both paper and high fidelity sim scenarios | 0-100 confidence |
| Gruppen, L; Wolf, F; Billi, J | Information Gathering and Integration as Sources of Error in Diagnostic Decision Making\*\* | 1991 | Primary Care | Vignettes deciding between two diagnostic alternatives | Probability correct |

Studies marked with \*\* next to their title were included via citation tracking