THE ASIA-PACIFIC SCHOLAR
MEDICAL AND HEALTH PROFESSIONS EDUCATION

REVIEW ARTICLE

Check for updates

Submitted: 7 April 2024
Accepted: 5 February 2025
Published online: 1 April, TAPS 2025, 10(2), 34-45
https://doi.org/10.29060/TAPS.2025-10-2/RA3272

Effective methods of teaching clinical reasoning in paediatrics: A scoping review

Jasmin Oezcan[1], Marcus A. Henning[2] & Craig S. Webster[2]

[1]Pediatric Department, Erlangen University Hospital, Erlangen, Germany; [2]Centre for Medical and Health Sciences Education, School of Medicine, University of Auckland, New Zealand

Abstract

Introduction: Paediatric practice presents unique challenges for clinical reasoning, including the collection of clinical information from multiple individuals during history taking, often in emotionally charged circumstances, and the variable presentation of signs and symptoms due to the developmental stage of the child. Communication skills are clearly important but the most effective methods of teaching clinical reasoning in paediatrics remains unclear. Our review aimed to examine the existing methods of teaching clinical reasoning in paediatrics, and to consider the evidence for the most effective approaches.

Methods: We performed a scoping review and evidence synthesis drawn from reports found during a systematic search in five major databases. We reviewed 211 reports to include 11.

Results: Students who received explicit training in clinical reasoning showed a significant improvement in their experiential learning, diagnostic ability, and reflective clinical judgement. More specifically, key findings demonstrated frequent student-centered interactive strategies increased awareness of the critical role of communication skills and medical history taking. Real case-based exercises, flipped classrooms, workshops, team-based or/and bed-side teaching, and clinical simulation involving multisource feedback were effective in improving student engagement and performance on multiple outcome measures.

Conclusion: This review provides a structured insight into the advantages of different teaching methods, focusing on the multistep decision process involved in teaching clinical reasoning in paediatrics. Our review demonstrated a relatively small number of studies in paediatrics related to clinical reasoning, underlining the need for further research and curricular developments that may better meet the known unique challenges of the care of paediatric patients.

Keywords: *Clinical Reasoning, Paediatrics, Teaching Methods, Medical Students*

Practice Highlights

- Clinical reasoning in paediatrics involves unique challenges including the collection of clinical information from multiple people (child, parents and care givers), symptoms that may present differently due to children's stage of development, and complex pharmacokinetics.
- The efficacy of paediatric training could be increased by combining student-centered methods like flipped-classroom, team-based or bed-side teaching and simulation.
- Low stakes training such as simulation that allows repetition and learning from mistakes is particularly effective and engaging for students.
- Our review demonstrated a relatively small number of studies specifically related to clinical reasoning in paediatrics, underlining the need for further research and curricular developments that may better meet the known unique challenges of the care of paediatric patients.

I. INTRODUCTION

Reflective diagnostic skills, comprising the analyses of symptoms and health issues and the weighing up of alternative explanations, are essential for establishing a correct diagnosis and for successful treatment and patient management. In addition, it is important to acknowledge that conscious and unconscious biases may be associated with human errors underlining clinical decision-making (Croskerry, 2005; Webster, Taylor, et al., 2021). The prevalence of incorrect acute clinical diagnosis has been

estimated at 5-15% and emphasises the importance of understanding and minimising reasoning errors (Scott, 2009). It has been estimated that 75% of diagnostic errors may be associated with problems of clinical reasoning, in particular related to failures to elicit, synthesise, decide, or act on clinical information (Graber et al., 2005; Pennaforte et al., 2016).

Clinical reasoning requires a competent and highly developed cognitive process, which can use experiential and formal knowledge to work through a cluster of symptoms to generate a correct diagnosis (Pinnock & Welch, 2014). A general approach should incorporate comprehensive problem-solving and involves the need for clear questioning to discern a set of viable differential diagnoses while remaining mindful of the potential of bias in the decision-making process (Pinnock et al., 2021).

The practice of paediatric medicine, however, presents particular challenges for a careful, question-based process of differential diagnosis. Taking a medical history typically requires the collection of clinical information from multiple individuals, including parents, caregivers and the child themselves, often in emotionally charged circumstances. In addition, symptoms in children and neonates can be subtle and unclear – children often have limited communication abilities, their symptoms may present differently depending on their stage of development, many diagnostic tools and tests are designed for adults and have limited utility in children, and children may have unexpected sensitivities and responses to medications due to having pharmacokinetics that are very different to those of adults (Webster, Anderson, et al., 2021).

Despite these challenges, the teaching and experience of clinical reasoning for trainees in paediatrics is often informal and occurs in an unstructured way throughout clinical attachments. In addition, there is often a lack of opportunity to review performance with an experienced clinician, which hinders the development of insight regarding common causes of errors (Lee et al., 2010; Schmidt & Mamede, 2015). It is well known that quality supervision and feedback leads to better learning in trainees, however, there is often a shortage of appropriately qualified paediatricians able to provide such supervision and feedback (de Jong & Ferguson-Hessler, 1996; Zhang et al., 2019).

The medical curriculum typically focuses on the acquisition of content knowledge, cultivating both theory and practical skills, which culminates in the ability to develop a treatment strategy for the patient (Norman, 2005). Clinical reasoning can be described as a multistep process consisting of: data gathering; the proposal of a diagnosis from a range of possible different hypotheses, and the reevaluation of that proposal in light of new information.

Early approaches to the teaching of diagnostic reasoning included the hypothetico-deductive procedural method that involved establishing a series of hypotheses, which then required the gathering of selective patient data to confirm or rule out the hypotheses being made (Norman, 2005; Schwartz & Elstein, 2008). This approach was intended to promote an understanding of the physical development of a disease or condition, and is also known as the pathophysiological approach, and relies on hypothetico-deductive reasoning and knowledge acquisition (Page et al., 1995). Hence, this approach may not represent the most efficient way to cultivate clinically relevant skills. An alternative approach involves the explanation of an expert's reasoning as an unconscious and automatic pattern recognition process (Groen & Patel, 1985; Schwartz & Elstein, 2008). This can be linked with the dual-cognition theory (Marcum, 2012). It has been suggested that in 95% of case encounters, expert clinicians use the fast, automatic, and unconscious pattern recognition abilities of system 1, while system 2, which is conscious, slow and effortful, tends to be applied only in unusual and complicated cases (Fabry, 2022; Webster, Taylor, et al., 2021). Studies have underlined that both systems should be used simultaneously to ensure an efficient outcome (Pennaforte et al., 2016). Therefore, the teaching of the awareness of individual unconscious information processing and judgment is a major pedagogical challenge, particularly in potentially difficult practice domains such as paediatrics (Bargh & Chartrand, 1999; Gruppen & Frohna, 2002; Webster et al., 2022).

It takes years to train a qualified paediatrician with accurate perception and judgment, enabling them to work effectively with children and their parents, guardians, or caregivers (Gong et al., 2022). Gathering the medical history appropriately and forming an accurate diagnosis through a reliable clinical reasoning process is a critical professional competency in paediatricians, which may require specific curricular techniques to achieve. Therefore in this review we aimed to examine the existing methods of teaching clinical reasoning and diagnosis in paediatrics, and to consider the evidence for which approaches may be the most effective.

II. METHODS

A. The Search Process

In consideration of the array and typology of available reviews, we choose the scoping review because it is a useful synthesis approach to create an overview of the salient literature and to identify key findings. A preliminary search identified no published review with an equal or comparable research question as the current work, suggesting that our scoping review may allow priorities for future investigations to be outlined, including potentially informing later systematic reviews (Grant & Booth, 2009). The literature search was conducted during the period of March and April 2023, using five major databases (Pubmed, PsychInfo, Scopus, ERIC, and Google Scholar). We aimed to identify studies, without restriction of type or year of publication, reported in English or German, to capture as much of the Western thought on clinical reasoning in paediatrics as possible and to make the most of the language fluency of the authors. The search employed the PICO (Population, Intervention, Comparison and Outcome) framework and the terms listed in Table 1 (Schardt et al., 2007). These search terms were used according to the following structure, for example: "medical-student" AND "clinical-reasoning" AND "paediatrics". The search included MeSH terms, truncations, subject headings, word variants and incorporated both American and British spellings.

Types of participants	**Types of intervention**	**Types of comparison**	**Types of outcomes**
Medical-students, clinic*ians, experts and teachers.	Clinical-reasoning, paediatric setting, clinical-rotation, medicine	Types of educational system, study types and teaching methods.	Depending on the study type the comparison of assessment and efficacy.

Table 1. PICO Framework Components

B. Data Analysis

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) was utilised as an evidence-based guideline for the inclusion and exclusion process, as illustrated in the flow diagram (Figure 1) (Moher et al., 2009). Author JO screened reports initially by title and abstract, with uncertainties being resolved at regular meetings with authors MAH and CSW. Those with suitable titles were placed in a citation management program (Vanhecke, 2008). We included studies that focused on teaching methods in clinical reasoning in paediatrics, in particular approaches that were intended to improve the quality of reasoning and decision making (see Figure 1 for inclusion and exclusion criteria). Author JO subsequently reviewed the references of the publications yielded by the search to identify additional relevant articles. Authors JO, MAH and CSW worked collaboratively to review and categorise each publication in terms of its quality of evidence (Eccles et al., 2001; Moher et al., 2009). The included articles were then summarised with reference to: (1) first study author, year, and country; (2) study design; (3) type of curricula; (4) assessment; and (5) key outcomes related to clinical reasoning (Table 2).

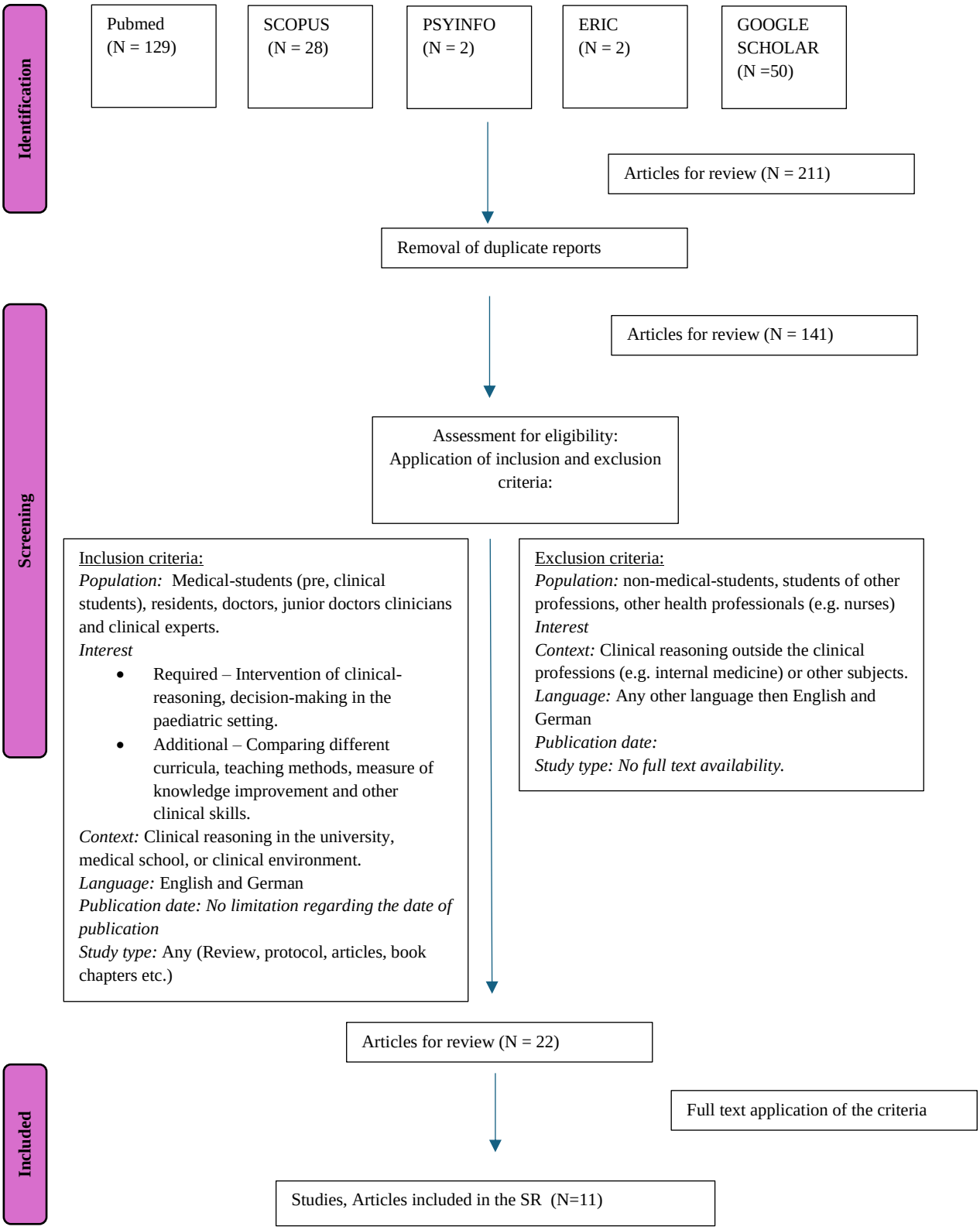

Figure 1. Flow diagram used in search strategy: PRISMA flow chart

III. RESULTS

A. Summary of Search Strategy

The primary literature search generated the most results from Pubmed, Scopus and Google Scholar (Pubmed n=129, Scopus n=28 and Google Scholar n=50). Search results after the first 5 pages on Google Scholar were not considered for inclusion as these pages contained no relevant reports. After the exclusion of duplicates and screening at the title and abstract levels, the application of the inclusion and exclusion criteria upon reading the full text of candidate papers resulted in a further 11 reports being excluded on the basis that they did involve medical students, clinical contexts or had their full texts available. Eleven studies were admitted to the final scoping review (Figure 1).

Table 2 illustrates an overview of each included study. The curriculum was classified based on the teaching methodology described by Fabry et al. (2022), which entailed dividing the typology into group size and didactic principles, i.e., flipped classroom or bed-side teaching. Due to multifaceted teaching concepts, some studies are included under more than one subheading.

First author (year, country)	Study design	Type of Curriculum	Assessment	Key outcome
Gong et al., (2022) China	Randomised-Controlled	Bedside teaching; team-based learning	Computer-based case simulation; Mini-CEX; Questionnaire	Creating a role shift to support and develop awareness of diagnostic steps and team-based mutual critical thinking. Significant improvement of satisfaction, clinical judgement, counseling skills in favor of the intervention group.
Bye et al., (2009) University of Sydney, Australia	Randomised-Crossover	Interactive lecture vs. computerised tutorial.	Expert Observation; Questionnaire	Interactive lecture was perceived as being more enjoyable, more effective in teaching clinical reasoning than observation. Face-to-face teaching considered critical to maximising the value of computer-assisted self-learning.
Yousefichaijan et al., (2016) Amir Kabir Hospital, Iran	Semi-experimental study	Workshop	Clinical-reasoning tests (Diagnostic Thinking Inventory (DTI), Key Features and Clinical Reasoning Problems)	This study emphasises the lack of teaching concepts of medical data acquisition techniques of reasoning steps. Effective example of repeatedly practicing clinical reasoning as a practical skill by working in small groups on illness scenarios of real medical histories.
Konopasek et al., (2014) New York-Presbyterian Hospital, Graduate Medical Education, New York, NY, USA	Experimental study	Group Objective Structured Clinical Experience (OSCE); practice of communication skills and Multi- Source Feedback (MSF)	Questionnaire	Studies emphasise the relationship between efficient communication skills, diagnostic accuracy, patient adherence, and positive health outcomes. Additionally this approach used problem-solving exercises based on dual-process theory. Students were instructed to consciously work through their first pattern recognition and second hypothesis-data driven clinical assumptions. Significant improvements of self-efficacy, confidence and learning motivation in the post-training scores.
Rideout & Raszka (2018) University of Vermont Children's Hospital, USA	Comparative studies	Simulation Case (Hypovolemic Shock in a Child)	Questionnaire and Evaluation	Simulation of rapid critical-illness recognition, diagnostic interpretation, decision-making, management, and procedural skills with the motto: learning from your mistakes. Improvements were noted in clinical judgement in critical situations, procedural and team skills.

Bhardwaj et al., (2022) **University of Florida College of Medicine, USA**	Longitudinal Survey	Script Concordance Test (SCT)	Written Exam: Comparing the SCT to usual clinical assessments	Significant correlations between SCT, as ambiguous evolving clinical case scenario, and improved decision-making competency and valid assessment items. The SCT facilitated feedback and meaningful conversation about problem-solving insecurities
Wright et al., (2019) **University of Western Australia**	Retrospective study	Feedback Learning Opportunities (FLO)	Multi-source feedback	Prescence of FLOs in complex cases underlines one problem: insufficient clinical information related to clinical reasoning. Advantages shown for systematic feedback-related advice to handle diagnostic and treatment inaccuracies and the learning of alternatives
Forbes & Foulds (2023) **Department of Pediatrics, University of Alberta, Edmonton, Canada**	Comparative study	Team-based learning (TBL) with Key Feature Questions (KFQ)	Written and oral exam involving KFQ, OSCE and MCQ. Anonymous evaluation	Significant improvement in KFQ scores. Valuable feedback on team-based approach on KFQ to progress clinical reasoning Ability to experience mistakes and identifying "learning gaps"
Khera et al., (2020) **McGovern Medical School at the University of Texas Health Science Center, USA**	Non-experimental descriptive studies	Skill session on writing patient assessments	Written exam involving Pre- and post-written patient assessments	Introduction and practice of the efficient usage of semantic qualifiers for key problem summaries. Positive effect demonstrated when practicing the formulation, synthesising, and reviewing of potential differential diagnoses and integration of clinical reasoning.
Lissinna et al., (2022) **Department of Pediatrics, University of Alberta, Edmonton Clinic, Canada**	Qualitative Study	Pediatric bootcamp using flipped classroom	Questionnaire and Evaluation	Positive effects of pre-readings and virtual interactive illness approach on efficiency of clinical data collection, critical-thinking and new mental approach to learning strategies in low stakes environment. Showed possible benefits from the preclinical-clinical transition.
Schmidt & Grigull (2018) **Medizinischen Hochschule Hannover (MHH), Germany**	Qualitative Study	Interactive Serious Game: "Pedagotchi," for case-based learning; blended learning	Questionnaire System Usability Scale (SUS) and User Experience Questionnaire (UEQ)	Motivational and digital additions to traditional lectures. Improved dialogue, real-time feedback and practice of clinical-reasoning in a low-stakes environment.

Table 2. Overview of reports included in scoping review

B. Source of Studies and Research Design

Included studies came from 6 countries, in general being conducted at university hospitals. The largest group of included studies (n=4) originated in the USA (Bhardwaj et al., 2022; Khera et al., 2020; Konopasek et al., 2014; Rideout & Raszka, 2018). Two articles came from Australia (Bye et al., 2009; Wright et al., 2019) and Canada (Forbes & Foulds, 2023; Lissinna et al., 2022). Single studies were derived from China (Gong et al., 2022), Germany (Schmidt & Grigull, 2018) and Iran (Yousefichaijan et al., 2016).

We categorised the evidence in each publication based on an established evidence hierarchy (Table 3) (Eccles et al., 2001; Jensen et al., 2004). No reviewed study could be aligned to criterion 1a, i.e., evidence from meta-

analysis of randomised controlled trials. Two studies employed a randomised-control design, with Bye et al. conducting a crossover controlled design (Bye et al., 2009; Gong et al., 2022). The method of employing a quasi-experimental study was conducted by two included studies (Konopasek et al., 2014; Yousefichaijan et al., 2016). The majority of included studies could be aligned with category III, i.e., evidence from non-experimental descriptive methods, or more specifically longitudinal surveys (Bhardwaj et al., 2022), retrospective studies (Wright et al., 2019) and qualitative approaches (Forbes & Foulds, 2023; Khera et al., 2020; Lissinna et al., 2022; Rideout & Raszka, 2018; Schmidt & Grigull, 2018).

Category of evidence	Number of studies identified on each rank
Ia: evidence from meta-analysis of randomised controlled trials	
Ib: evidence from at least one randomised controlled trial	n=2 Gong et al., 2022; Bye et al., 2009
IIa: evidence from at least one controlled study without randomisation	
IIb: evidence from at least one other type of quasi-experimental study	n=2 quasi-experimental Yousefichaijan et al., 2016; Konopasek et al., 2014
III: evidence from non-experimental descriptive studies, such as comparative studies, correlation studies and case-control studies	n=7 Longitudinal survey: Bhardwaj et al., 2022 Qualitative study: Lissinna et al., 2022; Khera et al., 2020; Rideout & Raszka, 2018; Forbes & Foulds, 2023; Schmidt & Grigull, 2018. Retrospective study: Wright et al., 2019
IV: evidence from expert committee reports or opinions and/or clinical experience of respected authorities	

Table 3. Included studies categorised according to levels of evidence defined by Eccles et al. (2001)

C. Summary based on Type of Evidence

The key outcomes derived from the included studies mostly focused on the principle of problem-based learning and can be framed in reference to experiential learning, such as clinical simulation and the acquisition of theoretical reasoning skills (Fabry, 2022; Jensen et al., 2004).

1) Experiential learning: There is evidence, based on the following studies, indicating that a team-based approach of clinical scenarios, with patients or simulated scenarios facilitate the impartation of clinical skills and critical thinking. The role shift towards student-centered learning increases the motivation to actively participate and overcome passive decision-making (Gong et al., 2022). The randomised study by Gong et al. established a division of bedside tasks (i.e., medical history, physical examination, etc.) amongst the case group students. This facilitated knowledge exchange within the team, and enabled both awareness and practice of reasoning steps. Subsequent assessment using computer-based case simulations and the Mini-CEX (Mini Clinical Evaluation Exercise) detected significant improvements in clinical judgment and counselling skills after bedside team-based learning (Gong et al., 2022). In reference to critical thinking, all of the included studies demonstrated a preference for students to encounter and use real cases involving ambiguity, symptom polymorphisms and the possibility of false leads in the context of paediactric practice (Kassirer, 2010).

Forbes and Foulds (Forbes & Foulds, 2023) found that students' evaluations of team-based learning showed that positive feedback on the ability to use the experiences of mistakes were linked with significant improvements in assessment scores using the Observed Structured Clinical Exam (OSCE).

Similarly, a survey by Rideout and Raszka (Rideout & Raszka, 2018) highlighted that increased team skills can result from feedback exchange and lead to the improvement of communication skills learnt during simulation, including working in intensive settings and with distressed parents (Konopasek et al., 2014; Rideout & Raszka, 2018). In addition, improved motivation to learn was related to learning in a low-stakes environment (Lissinna et al., 2022; Rideout & Raszka, 2018; Schmidt & Grigull, 2018). Wright et al. reported that student log entries underlined the advantages of feedback-related advice in handling diagnostic and treatment inaccuracies (Wright et al., 2019).

A technique called the Group Objective Structured Clinical Experience used by Konopasek et al. (Konopasek et al., 2014) showed benefits for the learner-centered method through the practice of communication skills in teams during the process of clinical reasoning. This approach brought together experiential learning, multisource feedback and the perspective of dual-process theory in directing students to begin with their recognition of symptoms, then consider hypotheses based on history taking, and information and feedback from multiple parties (Table 2). In a questionnaire-based evaluation such clinical problem solving demonstrated significant increases in self-efficacy and their motivation to learn data gathering techniques (Konopasek et al., 2014).

A further example, Khera et al. (Khera et al., 2020) focused on written patient information prioritisation by using semantic qualifiers to efficiently summarise key problems. Semantic qualifiers are bipolar descriptions of symptoms linked to distil broad medical histories (Norman, 2005). The comparison of pre- and post-intervention evaluation resulted in statistically significant increases in differential diagnosis assessment scores (Khera et al., 2020).

Furthermore, half of the included studies identified multi-source feedback (student, teacher, patient) as being integral to the development of insight into their reasoning and decision-making processes. Feedback itself can proactively influence students' awareness about their mistakes allowing a meaningful conversation about areas of confusion.

2) Theoretical reasoning skills: Examples of didactic approaches included the use of short-term workshops, flipped classroom teaching, virtual learning experiences, and script-concordance tests. These teaching methods resulted in improved awareness of theory, development of knowledge structures, data prioritisation, and critical thinking (Yousefichaijan et al., 2016). More specifically, half of the studies acknowledged the incorporation of a medical data acquisition technique as being a useful approach to teaching, since diagnostic inaccuracy can be linked with a lack of accurate data gathering (Bye et al., 2009). In reference to these diagnostic techniques, the workshop of Yousefichaijan et al. is an effective example of repeatedly practicing clinical reasoning as a pragmatic skill (Yousefichaijan et al., 2016). Comparing analyses of the Diagnostic Thinking Inventory (DTI) and Clinical Reasoning Problem (CRP) showed significant advantages of working in small groups on illness scenarios (Yousefichaijan et al., 2016). Lissinna et al. (2022) employed a virtual flipped classroom exercise, and then assessed students' experiences of pre-reading and their practice of efficient sorting of clinically relevant data via semi-structured interviews. The concept of Blended-Learning, as a combination of digital and traditional teaching, embodies the Serious Game approach of Schmidt et al. (2018). The complementary results of Bye et al.'s comparative study, which focused on interactive versus computerised methods of pedagogy, underlines the advantages of the digital addition in the practice of interactive case-based learning with real-time feedback (Bye et al., 2009). In consideration of the aforementioned aspects, the implementation of the Script-Concordance Test that assesses case training, can reveal several advantageous measurements, related to pedagogical techniques using case-based and feedback methods and thus can be regarded as a valid assessment tool (Bhardwaj et al., 2022).

IV. DISCUSSION

A. Clinical Reasoning – A Complex Practical Skill

The findings from this scoping review affirm that clinical reasoning can be described as the mediatory link influencing a clinician's cognitive multistep process. This process involves knowledge organisation, efficient data gathering, critical data integration culminating in generating a set of reasonable hypotheses, to finally achieve accurate diagnostic interpretation and reflection (Lissinna et al., 2022; Pennaforte et al., 2016; Pinnock et al., 2021). From a data driven perspective, used by novice learners, teaching these reasoning steps separately would likely impair the effectiveness of the reasoning process (Schmidt & Mamede, 2015). At the moment no peer-reviewed paediatric curricula guidelines focus on active educational experience of clinical reasoning. Additionally, short paediatric rotations only allow limited practice of common paediatric diagnoses (Madduri et al., 2024).

Consistent with Miller's pyramid of clinical competence learning clinical skills effectively, involves promoting practice by doing, along with frequent repetition (Fabry, 2022; Miller, 1990). In reference to the dual-process model, repetition moves much of the cognitive effort involved in understanding the relevant illness presentation from system 2 to the pattern recognition abilities of system 1 (Yazdani et al., 2017). Considering clinical reasoning as a practical skill, student passivity is the reason why it is relatively difficult to attain a high level of competency (Forbes & Foulds, 2023). Ulfa et al. (2021) used a randomised control trial comparing lecture vs. team-based learning of postpartum hemorrhage of midwifery students. The results indicated the superiority of active team-based methods on the development of independent and effective critical-thinking abilities. This suggests substantial benefits for a paediatric curricula

configuration that involves implementation of more active learning experiences starting in the pre-clinical years in the form of mixed teaching strategies (Forbes & Foulds, 2023; Jost et al., 2017; Koenemann et al., 2020). Jost and colleagues observed significantly improved clinical reasoning performance with Team-Based Learning groups in an undergraduate neurology course using key-feature examination (Jost et al., 2017).

B. Mix of Teaching Methods

In reference to this scoping review's aim, we can identify the advantages of combining different teaching styles. Lectures remain the fundamental method used to convey basic scientific knowledge, which can be an essential precondition for using more practical teaching methods. The findings indicated that improvements of the decision-making process were first identified by theory presentation, i.e., teaching dual-process theory and its links to common cognitive pitfalls and the potentially significant adverse consequences for paediatric clinical reasoning (Schmidt & Mamede, 2015). However, lectures also have didactic disadvantages, which include teacher-centered explanations with less activation and linking of previous knowledge and may create cognitive overload in learners (Fabry, 2022). There are different options to overcome this by promoting active pre-class learning and open discussions about information processing ambiguities (Lissinna et al., 2022). For example, the use of the flipped classroom approach can improve clinical understanding and increase the motivation to learn in contrast to lecture-based approaches (Tang et al., 2017). The crossover study of Tan et al. (Tan et al., 2016) also indicated superior problem-solving ability attributed to team-based learning in comparison with interactive lectures. Similarly, Jackson et al. (Jackson et al., 2020) demonstrated a significant increase in satisfaction when using critical thinking and promoting student self-directed learning when attending an online team-based learning module in a family medicine rotation.

C. Clinical Reasoning and Clinical Cases

The simulation of clinical judgment can be enhanced using an evolving clinical scenario (Fabry, 2022). The focus on improvement of clinical judgment in paediatrics can be justified by a unique interaction of fine perception and empathy of the child's clinical problem. In particular, the practice of effective communication plays a critical role in the analyses of symptoms when in discussion with parents and children. Since both are overlaid with anxiety, this adds to the diagnostic challenge. This requires experiential learning, for example by the careful student-centered bedside practice of communication with anxious and vulnerable families. This can increase students' awareness of emotional messages and changes in the patient. The link of promoting empathy by teaching problem-solving plays a critical role in paediatrics (Gong et al., 2022). One example, could be the use of Illness scripts, describing an approach to synthesising patient history into a meaningful flowchart. Levin et al. and Konemann et al. showed students' motivation working on real complex cases embodying a step-by-step information disclosure approach (Koenemann et al., 2020; Levin et al., 2016). Interestingly, Schmidt and Mamede also described these two opposing ways to present clinical cases, calling them "serial-cue" vs. "whole case" methods (Schmidt & Mamede, 2015). The studies included in this review emphasised students' challenges with obtaining the correct collection of critical information for a stepwise disclosure in paediatrics.

Furthermore, the randomised trial protocol of Pennaforte et al., embodies an example of combining real-environment patient simulation and iterative discussions (Pennaforte et al., 2016). These discussion protocols appear as reminders at three key moments in time, namely data gathering, integration, and confirmation. The reminder and task verbalisation provide better insight into the dynamic systems, based on the dual-process theory. Debriefing thoughts, in the form of thinking aloud and self-explanation, could promote higher performance of active understanding, more accurate symptom correlations, deliberate reflection and especially detecting pitfalls in the reasoning process (Chamberland et al., 2015; Pennaforte et al., 2016).

Studies revealed the important role of appropriate and timely feedback on the overall improvement of a clinical skill (DeLeon et al., 2018; Fabry, 2022; Wright et al., 2019). Torre et al., identifies the contribution of bedside teaching and multi-source feedback (supervisor, students, and patients) as an essential part of enhancing students' perceptions and understandings of a meaningful teaching experience (Torre et al., 2005). Feedback allows access to different perspectives, which can promote learning capacity; it is clearly regarded as a positive and proactive influence on the personal development required for successful teamwork (Koenemann et al., 2020).

The constant reference to decision making should not be regarded as relevant only to the clinician's perspective since effective disease management in paediatric care also depends on decisions being made by the patient and the child's parents and care givers. Consequently, we also need to focus on shared decision-making and communication skills as a crucial part of such deliberation (Gay et al., 2013). Patient-centered

communication includes personal factors, like empathy and authenticity, which are essential when building a trusted and authentic clinician-patient relationship. Additionally, these skills can be seen as a tool for efficiently eliciting information and in the communication of treatment information, including medication information, to parents and children (Konopasek et al., 2014; Yousefichaijan et al., 2016). Effective communication skills of this sort increase patient adherence, especially when treatment strategies are planned in consensus with the patient (Amey et al., 2017).

V. CONCLUSION

Our scoping review illustrated a knowledge gap regarding the teaching of clinical reasoning as a practical skill in paediactric practice. The findings indicate that active student-centered repetition involving experiential learning would likely facilitate more effective learning during clinical reasoning in paediatrics as aligned with the following key steps. Firstly, it would facilitate activation of prior knowledge, supporting clinically relevant knowledge structure and ensuring accurate data gathering techniques. Secondly, the simulation of critical thinking is required to improve the process of reflection to reduce cognitive biases and pitfalls. And thirdly, such an approach would promote efficient communication and the development of feedback skills to overcome diagnostic and treatment inaccuracies. Despite our comprehensive search and the international representation present in the evidence-based studies included in our review, the total number of medical education studies in paediatrics related to clinical reasoning was limited, which underlines the need for further research and curricular development in this domain, particularly given the known unique challenges of the care of paediatric patients.

Notes on Contributors

Dr. Jasmin Oezcan was involved in the conceptualisation of the study, review of the literature, analysis of included reports and in the writing and revision of the manuscript.

Associate Professor Marcus A. Henning was involved in the development of the final list of papers considered for the review and in the writing and revision of the manuscript.

Associate Professor Craig S. Webster was involved in the development of the final list of papers considered for the final review, and in the writing and revision of the manuscript.

All authors have read and approved the final version of the manuscript and agree to be accountable for the work and its findings.

Ethical Approval

This manuscript comprises a scoping review of existing published reports and, therefore did not require approval from institutional review boards.

Data Availability

All relevant quantitative data are within the manuscript.

Acknowledgement

This work was conducted by Dr. Jasmin Oezcan as a visiting scholar at the Centre for Medical and Health Science Education, School of Medicine, University of Auckland, New Zealand. The authors also wish to thank Professor Cameron Grant, Head of the Department of Paediatrics, Child and Youth Health, for helpful insights regarding the development of teaching programs for primary care practitioners in child health and paediatrics in New Zealand.

Funding

There is no external funding involved in this study.

Declaration of Interest

Associate Professor Marcus Henning is an Editor of The Asia Pacific Scholar. Other authors have no conflicts of interest.

References

Amey, L., Donald, K. J., & Teodorczuk, A. (2017). Teaching clinical reasoning to medical students. *British Journal of Hospital Medicine*, *78*(7), 399-401. https://doi.org/10.12968/hmed.2017.78.7.399

Bargh, J. A., & Chartrand, T. L. (1999). The unbearable automaticity of being. *American Psychologist*, *54*(7), 462–479. https://doi.org/10.1037/0003-066X.54.7.462

Bhardwaj, P., Black, E. W., Fantone, J. C., Lopez, M., & Kelly, M. (2022). Script concordance tests for formative clinical reasoning and problem-solving assessment in General Pediatrics. *MedEdPORTAL*, *18*, 11274. https://doi.org/10.15766/mep_2374-8265.11274

Bye, A. M., Connolly, A. M., Farrar, M., Lawson, J. A., & Lonergan, A. (2009). Teaching paediatric epilepsy to medical students: A randomised crossover trial. *Journal of Paediatrics and Child Health*, *45*(12), 727-730. https://doi.org/10.1111/j.1440-1754.2009.01602.x

Chamberland, M., Mamede, S., St-Onge, C., Setrakian, J., Bergeron, L., & Schmidt, H. (2015). Self-explanation in learning clinical reasoning: The added value of examples and prompts. *Medical Education*, *49*(2), 193-202. https://doi.org/10.1111/medu.12623

Croskerry, P. (2005). Diagnostic failure: A cognitive and affective approach. In K. Henriksen, J. B. Battles, E. S. Marks, & D. I. Lewin (Eds.), *Advances in Patient Safety: From Research to Implementation* (Vol. 2, pp. 241-254). PsycEXTRA Dataset. https://doi.org/10.1037/e448242006-001

de Jong, T., & Ferguson-Hessler, M. G. M. (1996). Types and qualities of knowledge. *Educational Psychologist, 31*(2), 105-113. https://doi.org/10.1207/s15326985ep3102_2

DeLeon, S., Mothner, B., & Middleman, A. (2018). Improving student documentation using a feedback tool. *The Clinical Teacher, 15(*1), 48-51. https://doi.org/10.1111/tct.12625

Eccles, M., Freemantle, N., & Mason, J. (2001). Using systematic reviews in clinical guideline development. In M. Egger, G. D. Smith, & D. G. Altman (Eds.), Systematic Reviews in Health Care (pp. 400-409). Wiley Online Library. https://doi.org/10.1002/9780470693926.ch21

Fabry, G. (2022). *Medical Didactics- A competence-orientated, practical and scientific-funded education*. Hogrefe.

Forbes, K. L., & Foulds, J. L. (2023). A team-based learning approach during pediatric clerkship to promote clinical reasoning. *Academic Pediatrics*, *23*(7), 1459-1464. https://doi.org/10.1016/j.acap.2023.04.002

Gay, S., Bartlett, M., & McKinley, R. (2013). Teaching clinical reasoning to medical students. *The Clinical Teacher, 10*(5), 308-312. https://doi.org/10.1111/tct.12043

Gong, J., Du, J., Hao, J., & Li, L. (2022). Effects of bedside team-based learning on pediatric clinical practice in Chinese medical students. *BMC Medical Education*, *22*(1), Article 264. https://doi.org/10.1186/s12909-022-03328-4

Graber, M. L., Franklin, N., & Gordon, R. (2005). Diagnostic error in internal medicine. *Archives of Internal Medicine*, *165*(13), 1493-1499. https://doi.org/10.1001/archinte.165.13.1493

Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information & Libraries Journal, 26*(2), 91-108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Groen, G. J., & Patel, V. L. (1985). Medical problem-solving: Some questionable assumptions. *Medical Education*, *19*(2), 95-100. https://doi.org/10.1111/j.1365-2923.1985.tb01148.x

Gruppen, L. D., & Frohna, A. Z. (2002). Clinical Reasoning. In G. R. Norman, C. P. M. van der Vleuten, D. I. Newble, D. H. J. M. Dolmans, K. V. Mann, A. Rothman, & L. Curry (Eds.), *International Handbook of Research in Medical Education* (pp. 205-230). Springer. https://doi.org/10.1007/978-94-010-0462-6_8

Jackson, L., Otaki, F., Powell, L., Ghiglione, E., & Zary, N. (2020). Study of a COVID-19 induced transition from face-to-face to online team-based learning in undergraduate family medicine. *MedEdPublish*, *9*(1), 232. https://doi.org/10.15694/mep.2020.000232.1

Jensen, L. S., Merry, A. F., Webster, C. S., Weller, J., & Larsson, L. (2004). Evidence-based strategies for preventing drug administration error during anaesthesia. *Anaesthesia, 59*(5), *493-504*. https://doi.org/10.1111/j.1365-2044.2004.03670.x

Jost, M., Brüstle, P., Giesler, M., Rijntjes, M., & Brich, J. (2017). Effects of additional team-based learning on students' clinical reasoning skills: A pilot study. *BMC Research Notes, 10*(1), Article 282. https://doi.org/10.1186/s13104-017-2614-9

Kassirer, J. P. (2010). Teaching clinical reasoning: Case-based and coached. *Academic Medicine*, *85*(7), 1118-1124. https://doi.org/10.1097/acm.0b013e3181d5dd0d

Khera, S., Gavvala, S., Parlar-Chun, R., Huh, H., Hsu, J., & Ford, C. (2020). Skill session on writing patient assessments for pediatric clerkship students. *MedEdPORTAL, 16*. https://doi.org/10.15766/mep_2374-8265.11029

Koenemann, N., Lenzer, B., Zottmann, J. M., Fischer, M. R., & Weidenbusch, M. (2020). Clinical case discussions - A novel, supervised peer-teaching format to promote clinical reasoning in medical students. *GMS Journal for Medical Education*, *37*(5), Doc48. https://doi.org/10.3205/zma001341

Konopasek, L., Kelly, K. V., Bylund, C. L., Wenderoth, S., & Storey-Johnson, C. (2014). The group objective structured clinical experience: building communication skills in the clinical reasoning context. *Patient Education and Counseling*, *96*(1), 79-85. https://doi.org/10.1016/j.pec.2014.04.003

Lee, A., Joynt, G. M., Lee, A. K., Ho, A. M., Groves, M., Vlantis, A. C., Ma, R. C., Fung, C. S., & Aun, C. S. (2010). Using illness scripts to teach clinical reasoning skills to medical students. *Family Medicine*, *42*(4), 255-261.

Levin, M., Cennimo, D., Chen, S., & Lamba, S. (2016). Teaching clinical reasoning to medical students: A case-based illness script worksheet approach. *MedEdPORTAL, 12*, Article 10445. https://doi.org/10.15766/mep_2374-8265.10445

Lissinna, B., Rashid, M., Foulds, J. L., & Forbes, K. L. (2022). Embracing uncertainty: Medical student perceptions of a pediatric bootcamp developed in response to mandated changes during the pandemic. *BMC Medical Education*, *22*(1), Article 390. https://doi.org/10.1186/s12909-022-03471-y

Madduri, G. B., Torwekar, E. L., Demirel, S., Durham, M., Hauff, K. I., Kaul, R., Nichols, T., Ravid, N. L., Shaner, M. A., & Rassbach, C. E. (2024). CRISP: An inpatient pediatric curriculum for family medicine residents using clinical reasoning and iIllness scripts. *MedEdPORTAL*, *20*, Article 11393. https://doi.org/10.15766/mep_2374-8265.11393

Marcum, J. A. (2012). An integrated model of clinical reasoning: Dual-process theory of cognition and metacognition. *Journal of Evaluation in Clinical Practice*, *18*(5), 954-961. https://doi.org/10.1111/j.1365-2753.2012.01900.x

Miller, G. E. (1990). The assessment of clinical skills/competence/performance. *Academic Medicine, 65*(9), S63-S67. https://doi.org/10.1097/00001888-199009000-00045

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Medicine, 6*(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Norman, G. (2005). Research in clinical reasoning: Past history and current trends. *Medical Education*, *39*(4), 418-427. https://doi.org/10.1111/j.1365-2929.2005.02127.x

Page, G., Bordage, G., & Allen, T. (1995). Developing key-feature problems and examinations to assess clinical decision-making skills. *Academic Medicine*, *70*(3), 194-201. https://doi.org/10.1097/00001888-199503000-00009

Pennaforte, T., Moussa, A., Loye, N., Charlin, B., & Audétat, M. C. (2016). Exploring a new simulation approach to improve clinical reasoning teaching and assessment: Randomised trial protocol. *MIR Research Protocols*, *5*(1), e26. https://doi.org/10.2196/resprot.4938

Pinnock, R., Ritchie, D., Gallagher, S., Henning, M. A., & Webster, C. S. (2021). The efficacy of mindful practice in improving diagnosis in healthcare: A systematic review and evidence synthesis. *Advances in Health Sciences Education*, *26*(3), 785-809. https://doi.org/10.1007/s10459-020-10022-x

Pinnock, R., & Welch, P. (2014). Learning clinical reasoning. *Journal of Paediatrics and Child Health*, *50*(4), 253-257. https://doi.org/10.1111/jpc.12455

Rideout, M., & Raszka, W. (2018). Hypovolemic shock in a child: A pediatric simulation case. *MedEdPORTAL, 14,* Article 10694. https://doi.org/10.15766/mep_2374-8265.10694

Schardt, C., Adams, M. B., Owens, T., Keitz, S., & Fontelo, P. (2007). Utilisation of the PICO framework to improve searching PubMed for clinical questions. *BMC Medical Informatics and Decision Making, 7*(1), Article 16. https://doi.org/10.1186/1472-6947-7-1

Schmidt, H. G., & Mamede, S. (2015). How to improve the teaching of clinical reasoning: A narrative review and a proposal. *Medical Education*, *49*(10), 961-973. https://doi.org/10.1111/medu.12775

Schmidt, R., & Grigull, L. (2018). Pedagotchi: Entwicklung einer neuartigen Lernanwendung für die Pädiatrie. *Monatsschrift Kinderheilkunde, 166(3), 228-235*. https://doi.org/10.1007/s00112-017-0253-9

Schwartz, A., & Elstein, A. (2008). Clinical reasoning in medicine. In J. Higgs, M. Jones, S. Loftus, & N. Christensen (Eds.), *Clinical Reasoning in the Health Professions* (pp. 223-234). Elsevier.

Scott, I. A. (2009). Errors in clinical reasoning: causes and remedial strategies. *BMJ, 338*, b1860. https://doi.org/10.1136/bmj.b1860

Tan, N., Tan, K., & Ng, C. (2016). Does team-based learning improve clinical reasoning in neurology? *Neurology, 86*(16_supplement). https://doi.org/10.1212/wnl.86.16_supplement.p2.373

Tang, F., Chen, C., Zhu, Y., Zuo, C., Zhong, Y., Wang, N., Zhou, L., Zou, Y., & Liang, D. (2017). Comparison between flipped classroom and lecture-based classroom in ophthalmology clerkship. *Medical Education Online*, *22*(1), Article 1395679. https://doi.org/10.1080/10872981.2017.1395679

Torre, D. M., Simpson, D., Sebastian, J. L., & Elnicki, D. M. (2005). Learning/feedback activities and high-quality teaching: Perceptions of third-year medical students during an inpatient rotation. *Academic Medicine*, *80*(10), 950-954. https://doi.org/10.1097/00001888-200510000-00016

Ulfa, Y., Igarashi, Y., Takahata, K., Shishido, E., & Horiuchi, S. (2021). A comparison of team-based learning and lecture-based learning on clinical reasoning and classroom engagement: A cluster randomised controlled trial. *BMC Medical Education*, *21*(1), Article 444. https://doi.org/10.1186/s12909-021-02881-8

Vanhecke, T. E. (2008). Zotero. *Journal of the Medical Library Association*, *96*(3), 275.

Webster, C. S., Anderson, B. J., Stabile, M. J., Mitchell, S., Harris, R., & Merry, A. F. (2021). Improving the safety of pediatric sedation: Human error, technology, and clinical microsystems. In K. P. Mason (Ed.), *Pediatric Sedation Outside of the Operating Room*, 721–752. https://doi.org/10.1007/978-3-030-58406-1_38

Webster, C. S., Taylor, S., Thomas, C., & Weller, J. M. (2022). Social bias, discrimination and inequity in healthcare: Mechanisms, implications and recommendations. *BJA Education*, *22*(4), 131-137. https://doi.org/10.1016/j.bjae.2021.11.011

Webster, C. S., Taylor, S., & Weller, J. M. (2021). Cognitive biases in diagnosis and decision making during anaesthesia and intensive care. *BJA Education*, *21*(11), 420-425. https://doi.org/10.1016/j.bjae.2021.07.004

Wright, H. M., Maley, M. A. L., Playford, D. E., Nicol, P., & Evans, S. F. (2019). Feedback learning opportunities from medical student logs of paediatric patients. *BMC Medical Education, 19*(1), Article 107. https://doi.org/10.1186/s12909-019-1533-y

Yazdani, S., Hosseinzadeh, M., & Hosseini, F. (2017). Models of clinical reasoning with a focus on general practice: A critical review. *Journal of Advances in Medical Education & Professionalism*, *5*(4), 177-184.

Yousefichaijan, P., Jafari, F., Kahbazi, M., Rafiei, M., & Pakniyat, A. (2016). The effect of short-term workshop on improving clinical reasoning skill of medical students. *Medical Journal of the Islamic Republic of Iran*, *30*, 396.

Zhang, Y., Huang, L., Zhou, X., Zhang, X., Ke, Z., Wang, Z., Chen, Q., Dong, X., Du, L., Fang, J., Feng, X., Fu, J., He, Z., Huang, G., Huang, S., Ju, X., Gao, L., Li, L., Li, T., … Sun, K. (2019). Characteristics and workload of pediatricians in China. *Pediatrics*, *144*(1), e20183532. https://doi.org/10.1542/peds.2018-3532

*Dr. Jasmin Oezcan
Department of Pediatrics Erlangen
University Hospital Erlangen,
Loschgestraße 15, 91054 Erlangen, Germany
Email: oezcanj@yahoo.de