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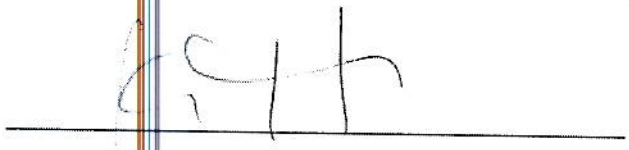

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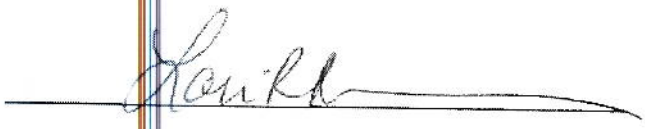

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THINKING ABOUT THINKING: DEVELOPING A FORMAL CURRICULUM ON CRITICAL THINKING FOR PEDIATRIC RESIDENTS

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A Thesis Submitted to the Faculty of

The Harvard Medical School

in Partial Fulfillment of the Requirements

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Abstract

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Thinking about thinking: Developing a formal curriculum on critical thinking for pediatric residents

Introduction: Critical thinking is a fundamental skill for a pediatrician and deficiencies in critical thinking can have a negative impact on patient care. Until recently, critical thinking was presumed to be learned indirectly throughout clinical training. Reduced duty hours and increased standardization of care have threatened the development of critical thinking skills. Research and consensus guidelines now recommend formal critical thinking training. A gap in the literature exists with respect to how to incorporate critical thinking education in a pediatric training environment.

Objectives: This study was a targeted needs assessment for developing a formal curriculum on critical thinking for pediatric residents. The objectives of this study include: 1) to explore physicians' experiences developing critical thinking skills as both learners and educators during post-graduate training; 2) to explore physicians' attitudes towards developing a critical thinking curriculum; and 3) to explore physicians' proposed strategies for content, delivery, and evaluation of a formal curriculum in critical thinking skills for pediatric residents.

Methods: A qualitative approach, using a semi-structured interview guide, was used to explore the research objectives. A total of 14 faculty physicians, across five different pediatric subspecialties, were interviewed. A conventional content analysis approach was used for data analysis.

Results: The key factors in developing critical thinking for pediatric residents that were identified include clinical experience, the preceptor-learner relationship, psychological safety, probing, the role of emotion, and seeing oneself as a lifelong learner. Threats to the development of critical thinking were identified both in general training environments and within pediatrics. Distinct challenges associated with the use of critical thinking skills in a community pediatric setting were identified. There was a positive attitude towards the development of a formal curriculum, particularly the potential positive impact on patient care. Participants suggested educational strategies, including content and delivery methods, identifying both in-person and multimedia modalities. Potential barriers to implementing the curriculum were explored. The challenges in assessing critical thinking skills and broader benefits were acknowledged, and strategies for evaluation at the individual and program level were recommended.

Conclusions: The results of the targeted needs assessment will inform the development of a pilot curriculum on critical thinking for pediatric residents. Further work is needed regarding evaluation methods and the broader implementation of a critical thinking curriculum.

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Background

What is critical thinking and why is it important?

Critical thinking is one of the foundational and fundamental skills of a clinician, playing an essential role in decision making. It is considered a 'metacompetency', or overarching skill, given that it is applied in numerous CanMed roles, including medical expert, scholar, health advocate, leader, and collaborator[1,2].

The approach to teaching critical thinking in medical settings continues to evolve. Historically, there has been an assumption that medical students and residents would learn critical thinking through experience and observation in the clinical environment, and that no targeted training was needed[3]. In addition, there was a deliberate emphasis on rote memorization and recall as part of medical training—both in the classroom and in the clinical setting. Both aspects have adjusted with the rapid expansion of medical knowledge and information, and the changing clinical environment (i.e. shortened length of stay, a shift of healthcare from the inpatient environment to the community setting[4], and decreased time spent at the patient beside[5]). Intentionally thinking about how to proactively teach critical thinking, rather than relying on osmosis through clinical experience and observation, is increasingly being considered a necessary training feature. Rather than emphasizing recall and memorization skills, there is a greater focus on the ability of physicians to gather and utilize information to treat patients.

A working definition of the competency in these settings has been a challenge until recently. In 2011, at the Millennium Conference on Critical Thinking, physician and nurse educators who are considered experts in the field of critical thinking gathered to explore the teaching, assessment, and faculty development of this competency. This group defined critical

thinking as 'the application of higher cognitive skills (e.g., conceptualization, analysis, evaluation) to information (gathered from medical history, records, physical exam, or diagnostic investigation) in a way that leads to action that is precise, consistent, logical and appropriate'[3].

Critical thinking is no longer simply considered a valued attribute or skillset. The consequences of a physician being deficient in critical thinking directly affects patient care. Errors in how a physician makes decisions can lead to misdiagnosis [6], delayed diagnosis [7], treatment errors [8,9] and failure to recognize a change in a patient's clinical status[10]. As an illustrative example, diagnostic error may be a factor in up to 70% of medical errors[6,11–13]. Analysis of 23,000 malpractice claims in Massachusetts revealed that 20% of successful claims were due to diagnostic error[14]. Lapses in clinical reasoning were identified in 73% of those cases. In only 3% of those cases was a knowledge deficit identified as the reason for diagnostic error[14]. Similarly, diagnostic error was a factor in 72.1% of malpractice claims in the primary care setting[6].

What restricts critical thinking in medical environments?

There are many threats to critical thinking in the clinical realm. Like most sectors, healthcare is becoming increasingly complex and costly, which can lead to an emphasis on efficiency, potentially at the detriment to the learning environment. Medical learners often spend the majority of their training in a tertiary care setting, where patients often arrive prelabelled with their diagnosis. While this approach can contribute to treatment efficiency, it can lead to a missed opportunity for learners to develop and receive feedback on their critical thinking skills. Furthermore, the hierarchical nature of a medical team can make it difficult for a junior learner to question a working diagnosis. Medical residents who question the diagnosis of a more senior

team member may be seen to be delaying diagnosis or treatment or be evaluated as difficult or confrontational learners. Therefore, the astute medical learner recognizes early on that assimilating with the status quo may be the best way to guarantee a positive evaluation. Generally, the educational system places more value in reaching the correct answer or diagnosis – an easily measured criteria – rather than evaluating a learner's diagnostic process[3].

As medical knowledge and research expands, it is no longer realistic to expect a clinician to consume and memorize evidence as it becomes available. Moving forward, an increased emphasis is expected to be on clinical reasoning—how we make decisions. All decision making is prone to cognitive bias and physicians under appreciate the influence of cognitive biases on their medical decision making[15].

An additional negative influence on critical thinking is the ongoing trend in healthcare to pursue standardization, including the use of guidelines and order sets. This has a positive impact on patient care and reduces healthcare costs, but may detract from the development of critical thinking skills[16–23]. Order sets, used in most tertiary care settings, allow a learner to manage a patient without necessarily understanding the indications, contraindications and potential complications of medications they are ordering. A study completed at the Children's Hospital of Eastern Ontario (CHEO) explored residents' perceptions on the impact of order sets on their learning. There was consensus among the residents that order sets, while good for efficiency and patient care, had a negative influence on the development of critical thinking skills[24].

Current best practices in teaching critical thinking in medicine

In the context of the 2011 Millennium Conference, the consensus among experts in critical thinking was that in order to teach critical thinking, learners must learn about both

metacognition* and cognitive skills. The field of metacognition includes neurobiology, cognitive bias, and probabilistic thinking. Ideally this teaching would be woven through the core curriculum for medical learners in a longitudinal manner. Further, the shared view was that teaching critical thinking would ideally begin early in medical training to establish strong foundations in this essential skill and prevent the development of bad habits, including inappropriately using heuristics or relying on rote memorization[3].

Practitioners at the Millennium Conference identified the that teaching critical thinking should have the following goals:

- To provide a common language for students with respect to problem solving;
- To provide an understanding of the neurobiology of learning and thinking, principles underlying logical reasoning and metacognition, and familiarity with common cognitive biases;
- To provide knowledge and skills in a developmentally appropriate way such that the learner can readily apply the principles to work at hand, whether in the classroom or clinical setting; and
- To promote habits of mind and a culture among students that will reinforce the notion that how one gets to the answer is as important as the answer itself [3].

In addition, educational strategies to teach critical thinking skills identified at the Millennium Conference include actively involving learners in problem solving, asking them to

* Also commonly referred to as neurocognition

justify how they arrived at a decision (questioning)[25], making thinking explicit, self reflection[25], case based teaching[25], 'just in time' learning, team based learning, simulation, or concept maps [3].

A key part of teaching a learner how to think critically is educating learners on metacognition, cognitive bias and heuristics. This provides shared language to use among clinicians and develops a shared conceptual framework for learners to develop their critical thinking skills[25]. Training in probabilistic reasoning and Bayesian reasoning allows individuals to overcome their cognitive biases[26,27].

The role of a supervising physician in modeling critical thinking cannot be understated. Simply by explaining the rationale behind how they linked a patient's symptoms, clinical findings, investigations, and knowledge of pathophysiology is one of the best ways to flex and demonstrate an experts critical thinking skills[3].

Physician self-reflection on their own practice and cognitive process also helps to develop critical thinking skills and may lead to better patient outcomes. For example, Yee et al, found that obstetricians who scored higher on reflective capacity tests had higher rates of successful attempts of vaginal birth after caesarean delivery[28].

What has been done before and has it been effective?

Dalhousie University, led by Dr. Patrick Croskerry, has developed a Critical Thinking Program. The focus is on dual process theory, cognitive debiasing, and clinical decision making. It is incorporated in the undergraduate, postgraduate, and as faculty development workshops[29–32].

While the effectiveness of Dalhousie University's program has yet to be formally assessed, other similar initiatives are yielding positive results. A curriculum developed for

pediatric and combined pediatric-internal medicine residents on metacognitive skills and debiasing strategies, resulted in an increased awareness of cognitive biases. When researchers surveyed residents one year after the curriculum was developed, it was found that the increased awareness of cognitive biases persisted[33]. Another workshop developed for psychiatry and internal medicine residents showed an improvement in diagnostic accuracy of clinical vignettes after they received instruction on cognitive bias[34].

In a separate study, researchers evaluated the impact of a clinical reasoning curriculum on medical students during their internal medicine clerkship. A pseudo-randomized control trial was conducted, with students divided equally between the intervention group and the control group. The intervention group completed six interactive modules including content on diagnostic error, cognitive psychology, clinical reasoning skills, cognitive bias and heuristics. The intervention group also received a workshop on clinical reasoning. The intervention was evaluated using a 20 item quiz that assessed concepts and terminology learned in the online modules and using the IDEA assessment tool. The IDEA assessment tool is designed to assess clinical reasoning skills in written documentation[35]. Those students in the intervention group scored higher on the clinical reasoning knowledge quiz (67% vs. 54%) and better clinical reasoning demonstrated in their written documentation in the domains of data synthesis and diagnostic reasoning. The students in the intervention group also reported increased recognition of the use of clinical reasoning by their preceptors in the clinical setting[36].

Unique threats to critical thinking in pediatric training programs

Specialty-specific challenges exist with respect to residents developing critical thinking skills. For example, within pediatrics, residents spend the majority of their training in a tertiary

or quaternary care center, surrounded by pediatric subspecialists. A large portion of their clinical experience is admitting patients from regional hospitals or from the emergency department, which is often staffed by pediatric emergency medicine specialists. Unless on an emergency medicine or community pediatrics rotation, they are rarely the first point of contact for a truly undifferentiated patient. This means they do not benefit from the educational opportunity of assessing an undifferentiated patient complaint.

Pediatrics is a specialty with unique pathophysiology and diagnoses, which can be significantly influenced by the seasonal nature of many illnesses. As an example, in many pediatric clinical settings, most eight months old babies who present with wheeze have bronchiolitis. However, while this may be generally accurate, the use and modelling of this heuristic is problematic for a medical learner, since the differential for wheeze in this age group is rarely fully explored. Failure to explore the differential diagnosis could lead to a diagnostic error in the future. The physician may be subject to a premature closure bias and the consequences for that patient may be dire.

Although training for pediatric residents usually occurs in academic centers, many residents do not practice in the same setting as their training. In Canada, approximately half of pediatric residents go on to be general pediatricians, many working in a community or rural settings[*]. Residents spend their formative years in a unique, and well-resourced setting, with a high rate of pre-diagnosed patients and easy access to pediatric subspecialists. For many, the clinical experience of working as a general pediatrician is vastly different than their experience as a pediatric resident. By encouraging residents to develop and apply their critical thinking

[*] Based on personal communication with CHEO's pediatric residency program director

skills while still in training may result in a smoother, and safer, transition to practice and a more effective practice thereafter.

Study purpose, research question, and research objectives

Previous studies have broadly explored how critical thinking is taught to medical learners; however, there is a gap in current literature as it relates to critical thinking education in the unique pediatric training environment. This study will inform the development of a curriculum on critical thinking specifically for Canadian pediatric residents. The curriculum will be developed and piloted at the Children's Hospital of Eastern Ontario (CHEO).

Kern's six step approach to curriculum development was followed. This includes the following stages: 1) Problem identification and general needs assessment; 2) targeted needs assessment; 3) identification of goals and objectives; 4) development of educational strategies; 5) implementation; and 6) evaluation and feedback[37].

Regarding the first phase, a previous study conducted at CHEO explored residents' perceptions of the impact of order sets on their learning, and has identified a problem and a need within the pediatrics residency curriculum. Specifically, residents reported feeling that order sets have a negative influence on their ability to think critically while working clinically.

To complete the targeted needs assessment phase, a qualitative approach was used to explore the research question of 'How can critical thinking be implemented into the formal curriculum for pediatric residents?' Specific research objectives are as follows:

Research Objectives

1) To explore physicians' experiences developing critical thinking skills as both learners and educators during post graduate training;
2) To explore physicians' attitudes towards developing a critical thinking curriculum; and
3) To explore physicians' proposed strategies for content, delivery and evaluation of a formal curriculum in critical thinking skills for pediatric residents.

Methods

Sampling

In this study, faculty pediatricians who are responsible for teaching pediatric residents were interviewed. Represented subspecialties included hospitalist general pediatrics, community general pediatrics, neonatology, pediatric intensive care, and pediatric emergency medicine.

The community pediatricians that were interviewed practice in communities that are more than 100 kilometers from a tertiary care center. These community pediatricians regularly supervise pediatrics residents on rotation from CHEO (Ottawa), the Hospital for Sick Children (Toronto) and the Northern Ontario School of Medicine (Sudbury & Thunder Bay).

In order to target physicians who were passionate about education and critical thinking, we used a purposive sampling technique. Potential interview candidates were discussed between two investigators who were familiar with the physicians at our institution (VB and DC). Some participants identified other physicians who would be interested in participating

in an interview (snowball sampling). To better ensure that key stakeholders were involved in this curriculum development project, both the current and incoming pediatric program directors of the CHEO training program were included in the study sample.

Qualitative interviews

An interview guide was created to explore the research objectives. It was developed collaboratively after a review of the critical thinking literature with two co-investigators (AS and DC). The project was presented to a panel of medical educators in the context of the Harvard Macy Program for Educators in Health Professions and feedback was incorporated into the final interview guide. It was then reviewed by three thesis committee members, who are experienced medical education researchers.

The interview guide asked participants about their experiences developing their critical thinking skills and teaching critical thinking to pediatric residents. Participants were also asked, based on their experience and expertise, to describe, effective and ineffective strategies for developing a learner's critical thinking skills and how to apply these skills. The interview guide also included questions to investigate participants' attitudes towards developing a critical thinking curriculum, including its proposed content, potential educational strategies, the anticipated impact of a targeted curriculum, and evaluation methods. Potential barriers to implementing a critical thinking curriculum were also investigated. Please see Appendix A for the full interview guide.

The interviews were conducted by the principle investigator (VB), in person or by phone. The duration of interviews ranged from 17 - 55 minutes. Participants were made aware that the interviews would be professionally transcribed and deidentified prior to analysis.

Participants were aware that they could withdraw from the study at any time. The interviewer (VB) was not in a direct supervisory role to any of the participants. There was no compensation or honorarium given for participation in an interview.

Qualitative Analysis

An in-depth analysis of the data was performed using a conventional content analysis approach using Dedoose software[38]. Conventional content analysis is used when existing research on a topic is limited. The codes and categories are derived directly from the data, rather than developing categories prior to analysis in a directed content analysis approach[39].

An iterative approach to data analysis was initiated once the sixth interview was collected. The transcripts were reviewed in full and open coding was performed ('level 1 codes') The goal of open coding was to keep the codes as close to the original data as possible. Relationships were then identified between codes and were used to develop level 2 codes. Next, a codebook was developed and directed coding was performed for the remainder of the interview data, altering the codebook as new concepts and ideas were identified[40–42]. Categories were then developed that reflected the relationships between our level 2 codes and our research objectives. The full codebook in presented in Appendix B.

To ensure rigor of the analysis, 36% (5/14) of the interviews were independently coded by a co-investigator (AS). Throughout the analysis process, working codes were repeatedly compared, clarified and refined to develop consensus, allowing intercoder reliability to be established and maintained. A third co-investigator (DC) reviewed a sample (5/14) of the interviews and the codebook to verify that the analysis accurately reflected the data and to confirm the reliability of the codes and categories.

Ethics approval

Ethics approval was sought from the Children's Hospital of Eastern Ontario's Research Ethics Board (REB). As this project is a curriculum development project, the board deemed it exempt from ethics approval.

Ethics approval was received from Harvard University's Institutional Review Board (IRB).

Results

Summary statistics of study participants

A total of 14 physicians were interviewed for this study. At the time of the interviews, the physicians operated in the following five clinical settings: hospitalist pediatrics (3), community pediatrics (2), pediatric emergency medicine (3), pediatric intensive care (3) and neonatology (3). The majority of participants were female (12/14). Most participants reported a single subspecialty, with one participant dually trained (pediatric intensive care and pediatric emergency medicine). The years of independent practice, including post residency and fellowship training, ranged from 1-16 years. Of the physicians interviewed, 85% (12/14) had completed their medical school in Canada and only one individual completed their postgraduate training (residency) outside of Canada.

The teaching settings included: inpatient; outpatient; ED; community outreach; and teaching of allied health professionals. Community outreach included continuing medical education for community physicians or teaching in developing countries (i.e. Médecins Sans

Frontières). Allied healthcare education consisted of dedicated teaching of nurse practitioners and paramedics. The sample group is summarized in Table 1.

Table 1: Demographics of participants, based on gender, specialty, years of practice, location of medical school and postgraduate training, and teaching setting.

Interview	Gender	Specialty	Practice Years	Medical School	Postgraduate Training	Teaching settings
CT1	F	Community Pediatrics	1	Canada	Canada	Inpatient, outpatient
CT2	F	PEM	15	Canada	Canada	ED, Community outreach
CT3	M	PEM/PICU	6	International	Canada	Inpatient, Allied health
CT4	F	PICU	13	Canada	Canada	Inpatient
CT5	F	PEM	3	Canada	Canada	ED
CT6	F	Hospitalist Pediatrics	4	Canada	Canada	Inpatient, outpatient
CT7	F	Community Pediatrics	4	Canada	Canada	Inpatient, outpatient
CT8	F	NICU	5	Canada	Canada	Inpatient
CT9	F	PEM	6	Canada	Canada	ED, Allied health, Community outreach
CT10	F	PICU	16	Canada	Canada	Inpatient, Community outreach
CT11	F	Hospitalist Pediatrics	3	Canada	Canada	Inpatient, Outpatient
CT12	M	NICU	16	International	International/ Canada	Inpatient
CT13	F	NICU	10	International	Canada	Inpatient
CT14	F	Hospitalist Pediatrics	11	Canada	Canada	Inpatient, Community outreach

Qualitative Analysis

Objective 1: To explore physicians' experiences developing critical thinking skills as both learners and educators during post graduate training

a) Developing critical thinking skills

The experience of developing critical thinking skills as both a learner and an educator was explored. Subcategories included clinical experience, approaches, relationships, power of questions, importance of psychological safety, emotion, and lifelong learning. Results related to each of these elements is summarized in the sections that follow. Illustrative remarks from study participants are also featured.

Clinical experience

Broad clinical experience, over a number of years, is a key feature in in developing a learner's critical thinking skills. In addition to clinical experience, critical thinking skills development also benefits from extensive background knowledge about disease pathophysiology, often gained through and independent learning. This foundational knowledge allows the teacher to help guide them in developing an approach to clinical problems.

You can also see a difference between residents who've had, for example, a lot of broad range of experiences versus a very narrow range of experiences. CT6

Approaches

A variety of approaches exist in thinking through clinical problems and developing critical thinking skills. Building a toolkit of different approaches and mental frameworks that are adaptable helps in the approach to a clinical scenario.

> *I think it's different where it pertains to different problems, but I think I was trying to learn mental models to approach different things and if you have enough mental models, you'll probably be able to address most problems. CT3*

Relationships

The learner-teacher relationship can have a direct impact on the development of critical thinking skills. Developing this skill set depends on the preceptor modelling critical thinking when making clinical decisions and being intellectually honest about misconceptions and errors in clinical reasoning they have experienced themselves.

> *It's all about normalizing it, right? "You guys have made mistakes that they make on the ward all the time and that's why we're going to solve this problem." Or "I didn't know that answer either at your stage". CT4*

> *Yeah. I think, honestly, the onus—a lot of the onus does fall on the teachers, the clinician teachers, the role models. I think if we model those skills, our residents will feel inspired to do those things, too. CT6*

The power of questions

Study participants highlighted the value in questioning and probing a learner's clinical reasoning to diagnose and develop their critical thinking skills. This approach requires that a preceptor allows for silence while the learner considers their own reasoning, rather than jumping

in with the answers. Under this approach, the emphasis should be placed on the process of thinking through a problem rather than the correct answer.

> *I think questioning is the best way. It's to try and make people get to an answer on their own because most of the time people know what to do and knowledge, I don't think it's a good idea to spoon feed people. I think it's a good idea to give them a little bit of knowledge to intrigue them a little bit. CT3*

> *I think it begins with curiosity and asking those probing questions of learners. A lot of times when we're busy and we don't have time and a learner sees the patient and they give you a plan and you think that plan is reasonable, then you say, "Okay, sounds good" and the conversation's over. I think having the time to be curious about the answers that they're giving you, and to ask those probing questions, "Oh, that's interesting. Can you tell me why you decided to use this medication? Are there other medications that we could be using instead? What about this patient made you make this choice, and in what other patient populations would that not be an appropriate choice to make" and really asking those probing questions is where it begins. CT7*

Importance of psychological safety

Learner autonomy and an environment of psychological safety are key success factors for developing critical thinking skills. This creates an atmosphere where a learner is comfortable acknowledging when they are unsure. This also helps teachers in the identification of knowledge gaps or errors in clinical reasoning. Study participants highlighted that it is important for a preceptor to demonstrate that patients rarely conform to a single diagnosis or algorithm, and that

different approaches to the seemingly identical clinical scenario may be required depending different factors specific to that patient.

> *With an early learner, who has no expertise or no experience, then that can be, often that's just how you do it because you have to get on with things, but I think once the learner has a good basis in terms of just his basic knowledge and understanding of the particular problem or chief complaint, then helping them to walk the path is much more effective than just giving it to them, and then I guess that's part of the—you're sort of helping them to develop their critical thinking around a particular problem rather than just giving them the answer. Cause actually the process of getting to the answer is very important, and that can be used like across the board, that skillset can be used really across the board with lots of different problems. So, I guess the impatient teacher who just tells the answer—it's much less about getting to the right answers and developing the process. So, I always even tell the residents, them trying to decide what they think is going on even when they're incorrect is actually very important. And so to get away from that notion of it has to be correct and I'm not comfortable saying what I think unless I'm really sure it's correct versus gather your information, do your physical exam, do you problem synthesis in your head, considers differentials, and "tell me what you think is the most likely" and even when you're incorrect, we can talk about why, what made me think it's something else, and that actually is very valuable. CT2*

Emotion

Emotion was identified as a powerful factor in the development of critical thinking skills. While shaming a learner is considered detrimental, there is value in exposing a learner to tension

or stress in the learning environment. This is often achieved in acute clinical settings, through the use of probing and questioning. Further, simulation can help create an environment of clinical stress, which helps push a learner's thought process and imprint knowledge.

> *There's something to be said about negative emotion learning, and I don't know what it is there, but I feel like when I was a resident or a medical student or a fellow, the times that I really imprinted knowledge was when I either didn't know and was very scared… Or you make a mistake, and you imprint the "Oh my God!" CT4*

Lifelong learning

The development of critical thinking skills does not end at the completion of residency. Participants saw themselves as life-long learners who actively challenge their clinical reasoning processes. They continue to probe their clinical knowledge and critically appraise the most recent literature to ensure their knowledge is current. They often discuss their clinical reasoning with colleagues to confirm their approach and to receive feedback. Self-reflection regarding clinical cases, through both formal and informal means, is seen as essential to maintaining and further developing their critical thinking skills. Some participants had independently studied critical thinking and how to effectively teach it through workshops, professional development courses, or independent reading.

> *I think, too, just by virtue of being a curious person, sort of always reading, always looking things up, trying to learn—the more you learn, obviously, the bigger knowledge base you have, I think the greater ability you're going to have to critical think about things because you actually need knowledge to be able to do that, too. So I think just*

trying to keep myself as current as I can, and going home and reading about patients and presentations has allowed me to maintain some of those skills.CT6

I think I'm always figuring out ways to improve, both how I think about things and also how I try and teach others to think about things. CT12

I'm actually myself, interested in clinical reasoning, diagnostic error, critical thinking and so from my own perspective, if I go to a medical education conference and I see workshops, seminars, whatever that are kind of dedicated to biases, avoiding biases, critical thinking, clinical reasoning…I would seek those out because I think it's interesting, myself.CT10

b) Threats to the development of critical thinking

Participants highlighted that in developing critical thinking skills being aware of the threats that challenge critical thinking is essential. This includes the current clinical environment, the hidden curriculum, and hubris.

Current training environment

The high patient load and the emphasis on efficiency in the clinical setting limits opportunities for an individual to develop their critical thinking. Most residency programs occur in tertiary care centers, where patients have often already received a diagnosis prior to the resident's initial assessment. In addition, the implementation of a policy to reduce residency duty hours results in less clinical exposure and therefore less time to develop their critical thinking skills in the clinical environment. Finally, the increasing use of clinical guidelines or order sets,

while improving patient care, means that residents may not consider the rationale behind their management plans.

You know what it's like - Emerg is get them through, get them through, get them through, and yeah you've seen a hundred bronchiolitics that the 101th has got to be a bronchiolitic versus maybe they get a foreign body and you just don't sit and think about it because there is such a pressure on, there's other pressures on your clinical performance. CT4

And I think that as there's a change in duty hours and supervision and all those things, which have been positive, but I think they do have an impact in the fact that residents may not have the exposure of depth and breadth of things as much as in the past, and in the past, it was often a bit of trial and error, which is not right either.CT2

Hidden curriculum

Medicine's 'hidden curriculum' demonstrates to a learner that maintaining the status quo and not questioning a management plan or diagnosis is the easiest way to ensure a positive evaluation. Participants noted that learners will often mimic the practice pattern they observe from their preceptor, rather than thinking through a clinical scenario independently. This process is then reinforced by positive feedback from their supervisor based solely on final 'correct answers' rather than feedback informed on the basis of their clinical reasoning abilities.

I think that if your relationship is purely that as evaluation, like preceptor learner and you don't really have that relationship behind it, then I think sometimes learners just say what they think you want to hear, so I feel like that maybe gets in the way of teaching,

modeling and, ironically enough, actually assessing it because I don't think that you're getting true responses. CT7

Hubris

Working with preceptors who are considered closeminded or dogmatic in their clinical reasoning can inhibit the development of critical thinking in a learner. Similarly, arrogance or hubris does not foster an environment of intellectual honesty and psychological safety which is required in order to develop critical thinkers.

I think people have big egos and lots of people don't want to admit when they're wrong or when they don't know, and that stops critical thinking. CT4

c) Critical thinking in pediatrics

Participants highlighted that there are unique challenges to the development of critical thinking within the field of pediatrics relating to both clinical content and the culture within the specialty.

Clinical content

High acuity events occur infrequently in the pediatric population, though the consequence of poor clinical reasoning in those rare scenarios weighs heavily on clinicians. Therefore, pediatric residents have few opportunities to apply critical thinking skills during moments of high acuity, under supervision, as part of their training. Rather, these scenarios are often taught by proxy in didactic teaching or through simulation.

The big issue with peds I find we all struggle with whether it's in residency or in the ICU is the low frequency of events, which makes it a lot harder to teach because people don't see those events ever, or see them very, very rarely.CT3

General pediatrics, like most general specialties, sees typical or 'bread and butter' patients. More complex or undifferentiated patients often have subspecialists involved at an early stage. As a results, pediatric residents may not further develop their clinical reasoning if they are not given the opportunity develop a differential diagnosis and explore a management plan for a complex or undifferentiated patient.

But I do think we're a bit paralysed in some of the general peds, or even what I see in Emerg where you don't have to do a lot of critical thinking, right? For the bronchiolitics and the DKAs and all the things that we see routinely and so that's where I think it gets a bit lost because that's our bread and butter. And, yeah, the weird and wonderful stuff is just not that common and the sub-specialties I think just do a better job because their job is to come in when there's weird and wonderful stuff. CT4

Culture

There is a cultural expectation that pediatricians are seen as friendly and nice individuals. This can result in questioning or probing of a learner being perceived as bullying or creating an unsafe learning environment, when in fact the preceptor's intention was to promote critical thinking.

My experience with a lot of pediatric learners is pediatricians by and large are nice people and I think we're not great at challenging one another or effectively disagreeing

with one another as pediatricians and I think that our learners are the same. We honour in pediatrics being kind and being nice and working together, but I think that also leads to a challenge which is, we don't model the ability to have conflict with one another and to come to resolutions in effective ways.CT7

d) Critical thinking in the community setting

There is a discordance between the training of a pediatric resident within a tertiary care center and their potential future practice in the community pediatrics setting. Physicians practicing outside tertiary care centers reported that they found their critical thinking skills were uniquely challenged in the community setting. The experience of training in a tertiary care setting with differentiated patients and subspecialty support impedes the development of the critical thinking skills required for practicing general pediatrics in a community setting.

At a tertiary center during residency you get the patient to be admitted and you know that they've already been seen and reviewed by a pediatrician; whereas, I get here, especially for kids that are sicker, just a much more unsubstantiated story. An emerg doc calls me with like, "This kid is sick and I don't know why. Please come help" which is good in some ways because that leaves a lot more of the thinking to you as opposed to somebody giving you the story over the phone and being, like, "I've already figured this out. This kid is an asthma exacerbation or whatever." And you could go down and do that admission and not really think too much about it; whereas, here, for better or for worse I

do feel like I'm the first pediatrician seeing them and so it's my responsibility to definitely go back and double-check [the diagnosis] with the emerg doc. CT1

Objective 2: To explore physicians' attitudes towards developing a critical thinking curriculum

a) Gap in the curriculum

There was a positive attitude towards the development of a formal critical thinking curriculum for pediatric residents. Critical thinking is considered to be an important skillset within pediatrics, and one that needs to be strengthened within the specialty. It was noted that important concepts in critical thinking such as heuristics and cognitive bias were not included in the current pediatric residency curriculum.

I don't necessarily feel like we talked a lot directly about it in residency… I feel like after talking about it a fair bit both in undergrad and in med school—although not necessarily as part of the formal curriculum of med school, but some kind of something I did on the side, I don't know that we necessarily talked about it a lot in residency. CT1

b) Impact

Potential impacts of introducing a formal curriculum on critical thinking that were identified included the increased use of evidence-based medicine, reduced diagnostic error, and overall

improved patient care. It was noted that the promotion of critical thinking at all levels of training could improve engagement in the learning process and clinical care.

> C*ritical thinking is fun, I think. I get a lot more satisfaction out of my job when I am critically thinking about patients and not just stamping [a patient] with bronchiolitis for the 15th time that day. That is what I find fun about our jobs and my job satisfaction is way better when I'm seeing interesting cases that I need to use my brain for, quite honestly.CT6*

> *I would do it. If that was offered, I would sit in. I would love to do that. I think it would be very valuable, and I think it would also make me a better teacher, too, if I were to go through something like that. I can't say I've ever been through something like that, so I would be very interested. CT12*

> *If people are not exercising sound critical thinking and you have flawed clinical reasoning they will, I think more often, arrive at the wrong diagnosis, which could prolong the time to get to appropriate treatment and can also increase the cost of medicine because of a more expanded diagnostic odyssey. CT8*

c) Barriers

In developing a critical thinking curriculum, participants noted that challenges in prioritizing time for such a curriculum was a barrier, as well as resistance to change.

Time

A barrier to the implementation of the critical thinking curriculum is the difficulty in reprioritizing other elements to accommodate a new curriculum within the academic schedule.

As soon as somebody says, "I want to do something new and it's going to create a time commitment for you" ... you've become the most unpopular person in the room ... but anytime you add something to someone's workload is never well received. CT6

Resistance

It was identified that there may be initial resistance to a new or novel idea within the pediatric curriculum that was not previously seen as an essential skill to be explicitly taught to learners. Further, not all residents have the same learning style, suggesting that curriculum implementation will need to accommodate different learning styles.

I think there's a bit of inertia in terms of the way things are done, and so people are very comfortable with the methodologies that have been used forever so they may not—so it's always a little bit difficult to get people to look at, or change their teaching methods, so that could be hard, but done right, I think people would see the value. CT2

d) Buy in

One of the strategies suggested to overcome potential barriers was to demonstrate the value of a critical thinking curriculum. However, it was also noted that significant challenges exist in directly attributing and quantifying the value of this type of curriculum. Another strategy suggested was to initially implement the curriculum to a small group of learners. The learners would hopefully express their interest in, and the educational value of, such a curriculum, which could help generate support for the importance of explicitly teaching critical thinking skills.

> *I think the biggest thing is interest, or how do you show value to people, because they need to be invested. There should be a reflection and if people don't reflect, it's not going to work out, because you have to apply what you're learning, that confirmation of bias, for example, and how that makes you approach different problems… So maybe starting with a small group of middle years, and then a believer's going to convince the other people that this is important*. CT3

Objective 3: To explore physicians' proposed strategies for content, delivery and evaluation of a formal curriculum in critical thinking skills for pediatric residents

a) Train the trainer

Although there was agreement from participants that critical thinking should be explicitly taught, there was a concern expressed that not all preceptors may have common background knowledge, familiarity with terminology, and awareness of a framework to teach residents to

apply critical thinking in a clinical setting. It was proposed that there could be a 'train the trainer' workshop to streamline the teaching of critical thinking across the institution.

> *And then you have the heterogeneity of the teachers, right? So you need to be probably, I guess if you were going to sort of pilot something, you'd want to choose very engaged, interested highly skilled teachers to do a few modules on common things or whatever and then that could grow. CT2*

b) Content

Suggestions for content to include in the critical thinking curriculum included metacognition, cognitive bias, heuristics and critical appraisal skills.

Cognitive psychology

Teaching of cognitive psychology was felt to be important, including cognitive biases and how they can influence medical decision making.

> *I was lucky because I did psychology as an undergrad and I was interested in cognitive psychology which is that thinking about thinking. Learning about a lot of heuristics and biases that we have and I wrote a paper with an internal medicine doctor in med school about cognitive biases and how they play into medical decision making. I think I'm lucky in that way to have had that background that a lot of other people wouldn't have had just because of chance and what I did before medicine. I think that that's contributed a fair bit to how I think about thinking. CT1*

Critical appraisal

Participants suggested that critical appraisal could be used as a tool to frame a discussion about critical thinking. The learner could then be probed and evaluated on their rationale and reasoning behind their appraisal of literature.

> *I think we do use critical thinking in one section is research. We do force that resident to read an article and then critically appraise it, and then come out and say if this was a valid article or not a valid article.CT5*

There was an acknowledgement among participants that they did not feel they had sufficient background knowledge to recommend other content.

c) Delivery

Delivery was discussed both in terms of embedding critical thinking teaching within broader medical education in the clinical setting, as well as the various teaching methods that could be used.

Embedded curriculum

It was recommended that the curriculum not be delivered exclusively in the classroom setting, and that the content needed to be reinforced in the clinical setting. It was proposed that the curriculum be integrated throughout the pediatrics curriculum, and ideally, early in medical school. One physician suggested developing a 'top ten tips for promoting critical thinking in the clinical setting' that could be posted in areas where clinical teaching occurs.

I do think it needs to start in medical school. This isn't something that should start day one of residency. This needs to go way back to clerkship and even before where these people need these skills, then, when it's actually not that impor—it is important, I guess what I'm saying is that in residency, they have so many other demands of time. In clerkship, I really feel like it's just, "here I am being a clerk", and then you could hone those skills then, then you could carry them to residency, that would be super helpful. It's just a question of if you could do it earlier. CT4

I caution you about bringing it to the classroom setting because I do think there is something lost in that, though there may be a place for introducing the concepts of critical thinking so that when people are actually applying it at the bedside, they are able to be a little bit more mindful about the process and really work on their various pieces of trying to apply critical thinking. So, there's probably a place for it in the half-day curriculum to introduce some of the ways to go about doing it, but the actual applying it and practicing it, I think, yes, we should have a formal curriculum, but that curriculum should be applied in clinical context. CT8

Teaching methods

Multiple educational strategies for delivering critical thinking content were suggested. Several participants highlighted the potential benefit of a flipped classroom design. The exclusive use of didactic teaching was not considered to be an effective technique for teaching critical thinking. In was proposed that the in-person experience could be used to deliver content using clinical cases as exemplars. Reflection was considered fundamental to the teaching of critical thinking.

I like flipped classroom a lot. I think that that is the nice way of allowing the learner to think about those few steps we talked about off the top, like if you allow the learner to get their baseline level of knowledge, up by reading or even if that's attending a more didactic kind of lecture, that sort of thing. CT2

There should be a reflection and if people don't reflect, it's not going to work out, because you have to apply what you're learning, that confirmation of bias, for example, and how that makes you approach different problems. If you don't think of an episode where you actually identify bias by having a conversation about bias, then you really can't apply it. CT3

You know what's always helpful in a curriculum or when you learn anything is examples. I'll never forget having the examples, even just during lectures, diagnosis was thought to be this, but it ended up being this. And so I think it's really interesting when you go through an example like that and if you interview the person who made the decision, and explicitly told the residents or whoever you're teaching what bias was at play that—I think that those are really powerful tools to know the theory of what's going on and then actually see it in action.CT6

Multimedia delivery methods were suggested, including online modules or podcasts to deliver the content.

You [could] do some e-learning with, say, a scenario that kind of unfolds and the learner has to make certain decisions and then a different scenario unfolds according to how the learn makes decisions—I think that would be an excellent complement to what residents are learning just from their patients. CT10

Many participants recommended simulation as a powerful educational tool to not only teach but evaluate a learner's critical thinking.

> *I might ask a question, if someone doesn't know, I don't go, "Why did you think that?" Whereas I think in simulation we do that a lot better because often just uncovering people's reasons for their answer wrong or right is really interesting, and I think that educators should do that more. There's a reason why people aren't getting the answer, and if they just tell you, "I either, a, didn't know, or I did know and I made it up." There's lots of reasons people say stuff, and that might uncover some knowledge gaps. CT4*

d) Evaluation

The challenge of evaluating a critical thinking curriculum was acknowledged by all participants, and proposed methods were suggested at both the program and individual level.

Program level

Under ideal circumstances, patient outcomes could be compared before and after the curriculum was introduced. However, it was noted that it would be unlikely that significant changes would be observed in the short-term, and that it may be challenging to directly attribute any changes in patient outcomes to a single factor. One participant suggested performing a contribution analysis of the curriculum to evaluate its intended and unintended impacts.

That would be a very hard thing to evaluate. You could do it on a very macro level and really look at patient outcomes pre- and post-implementation of the curriculum, but I don't ever think you'd get enough, I don't think you'd have enough impact to probably see that. CT1

One new thing called contribution analysis, which is a different way of looking at program evaluation, which comes more from the federal government because they do lots of programming, looking at can you attribute changes (ie: residents, the care being more effective, or the residents being more confident, or they do better on their exam, or whatever measure you want), and then can you attribute to a change—So if the only change that happened was this new program, then you can kind of attribute it in hindsight. CT2

Individual level

At the individual level, multiple methods for evaluating a learner's critical thinking skills were recommended. These included self-assessment, preceptor assessment, or an Observed Structured Clinical Examination (OSCE). One participant recommended using written documentation to evaluate a learner's clinical reasoning.

OSCEs are really great. Yeah. I think that could help in terms of at least having a measurable outcome that you could use every single year. CT5

You could do assessment from—assessing what the supervisors think in terms of a performance for the trainees on shift or on service kind of assessments. Comparing those to—I guess if you really wanted to, you could have some residents have this new curriculum, and some residents not and see the difference between them that way.CT2

You really get a window into their understanding and their thought processes based on their written documentation. CT8

Given that Canadian residency programs have adopted a Competence by Design (CBD) curriculum, many participants suggested that the assessment of critical thinking skills be embedded more explicitly within development milestones and Entrustable Professional Activities (EPAs).

So I think your best bet would probably be to go through the EPAs,

identify which ones have a critical thinking component and that would be how you would

evaluate it because we're going to have to do it anyways, right? But then you have to do some teaching to the people who are evaluating the EPAs. So you could identify which domains are those EPA most likely to be evaluated in, and target those physicians to say, "We think that this has a strong critical thinking component. This is how we suggest that you assess the critical thinking, and we'd like you to include that as part of your evaluation of this EPA. CT11

Discussion

The analysis of the semi-structured interviews from pediatric educators across multiple clinical settings helps inform how critical thinking could best be implemented into the formal curriculum for pediatric residents. This study explored the experience of learning and teaching critical thinking within pediatrics, with an emphasis on the identification of success factors, barriers, and potential approaches to deliver curriculum and subsequently evaluate its effectiveness for both individual learners and more broadly.

A key result of this study is that the development of critical thinking skills is grounded in a learner's clinical experience and background knowledge. Further, it was revealed that an effective way to teach critical thinking in the clinical setting is to probe a learner's clinical reasoning and diagnostic processes. In addition, developing a longitudinal relationship between a preceptor and learner was seen to be a key element in evaluating, teaching, and modelling the use of critical thinking. Finally, findings highlighted that critical thinking should be considered a skill that is developed over a lifetime, rather than a competency to be completed during training.

This study contributes to the literature and previous research that has explored whether, and how, critical thinking should be explicitly taught to medical learners. Huang et al. previously conducted a qualitative study exploring educational strategies for teaching critical thinking[25]. They interviewed 44 faculty members within eight institutions across North America to explore the explicit teaching of critical thinking. This included a specific emphasis on content, educational strategies, and the motivations for teaching critical thinking. The findings of this study confirmed and aligned with many of the findings of Huang et al, particularly as it relates to educational content; teaching of metacognition and cognitive bias grounded in clinical context. Both studies also highlighted the value of self-reflection, probing, psychological safety, and the use of small group learning. The close alignment of both studies helps to confirm results and supports theory convergence in this area of research.

The importance of a culture of psychological safety was also highlighted in this study. Creating a culture of psychological safety in the clinical environment where learners are both being taught and evaluated, is challenging, but important. Previous research done by Edmondson et al, emphasizes the importance of leaders demonstrating fallibility, breaking down hierarchy, and seeking input and feedback from all members of the team[43]. Prior studies done in

the neonatal intensive care setting, show that physicians who acknowledge fallibility and proactively seeking input from their team have increased psychological safety[44].

Benefits of a critical thinking curriculum for pediatric learners

Participants emphasized that the development of critical thinking skills was essential for pediatric learners, and represented a gap in current training programs. It was noted by participants that the potential impact of a critical thinking curriculum could include improved patient care, through increased use of evidence-based medicine and reduced diagnostic error.

Challenges

Participants were keen to explore threats and barriers to the development of critical thinking skills that arise from challenges in our current training environment. Barriers included time, resistance to change, and the different learning styles of residents. Although time will always be a constraint within post-graduate education, viewing critical thinking as a foundational skill that is central to multiple CanMeds roles could help to prioritize a formal curriculum on this issue. Ideally, the value of the curriculum could be demonstrated through qualitative or quantitative assessments which could help overcome this barrier. In order to accommodate various learning styles, different educational strategies could be used to deliver the content, embedding these throughout the curriculum. This will allow critical thinking to be taught with by different facilitators through a a variety of delivery methods (e.g., small group sessions, clinical applications, guided reflection).

It was noted that there is often discordance between the environment where pediatric training occurs and the challenges to critical thinking in the community pediatric setting. With

approximately half of the pediatric residents within Canada eventually practicing in community settings, this is a issue that requires attention moving forward.

Best practices to deliver the curriculum

In order to successfully embed the curriculum into pediatric training, it was suggested that there should be faculty development to improve critical thinking teaching. This would allow preceptors to have a shared framework and terminology for teaching critical thinking. Bonifacino et al, published a study regarding their experience implementing a clinical reasoning curriculum for clerkship students. They found that students who had undergone the curriculum intervention were better able to identify the use of clinical reasoning and terminology related to metacognition, cognitive bias and heuristics by their supervising physician[36]. If a learner is better able to identify a supervisor's critical thinking, they are able to learn from it and use that modelling to develop their own critical thinking skills.

In developing a critical thinking curriculum for Canadian pediatric residents, participants suggested that content include metacognition, cognitive bias, heuristics and critical appraisal skills. Participants offered a variety of teaching methods to deliver the curriculum, including both in-person and online modalities. Multi-media sources, such as podcasts, were suggested as ways to augment learning critical thinking in the clinical environment. Recommended educational strategies included the flipped classroom method, small group discussion, clinical case examples, and reflection. This is consistent with the educational literature that active learning styles are more effective than exclusive didactic teaching[45].

Reflection on clinical practice is a key tool for developing critical thinking. Many participants commented that as faculty physicians they continue to actively reflect on their

clinical practice. This suggests that more formal methods for promoting reflection could be implemented into pediatric residency curriculum. This is aligned with Huang et al's recommendations for the explicit teaching of critical thinking.

There have been recent concerns about the confidentially of learner reflections, after a trainee's reflection on medical error was used as evidence against her in a criminal trial in the United Kingdom[46]. A negative consequence of this case may be that learners fear retribution from admitting errors in critical thinking. Ensuring residents feel safe and supported in the healthcare environment to reflect on their critical thinking and clinical practice is essential. This requires programs to instill a culture where psychological safety is prioritized.

Evaluation

Simulation can be used to both teach and evaluate a learner's critical thinking skills. Bond et al used simulation debriefing to teach emergency medicine residents about cognitive debiasing or forcing strategies. They then sought resident feedback on the debriefing using both a survey tool and a one on one interview. Senior residents reported increased knowledge and awareness of cognitive strategies and heuristics, whereas junior residents commented more on acquisition of medical expert knowledge[47]. This suggests that simulation can be an effective environment for teaching heuristics and cognitive bias.

An individual's critical thinking skills could be assessed using OSCE stations, preceptor assessments, or learner self-assessment (i.e. self-assessment of confidence in identifying cognitive bias). The use of clinical vignettes to test a learner's knowledge of cognitive biases was recommended by a number of participants. Zwaan et al used clinical vignettes to evaluate physicians' knowledge of cognitive bias, after an educational intervention on cognitive bias.

Although many cognitive biases were recognized in the cases, as a part of that study, there was no agreement among the physicians on identifying individual cognitive biases[48]. This suggests that solely using clinical vignettes to teach and evaluate about cognitive bias may not be effective.

In Canada, the Royal College of Physicians and Surgeons' ongoing transition to the Competence by Design (CBD) framework was seen an opportunity to improve our evaluation of learner's critical thinking skills. The transition process of pediatrics to the CBD has begun and Competency Committees are currently developing Entrustable Professional Activities (EPAs) and milestones for the pediatric residency curriculum. The results of this study will be brought to the key stakeholders of CBD within our institution to see how critical thinking can best be evaluated within this framework.

Potential methods to evaluate a critical thinking curriculum at a programmatic level could be done through patient outcomes and conducting a contribution analysis. There are challenges in demonstrating a causal relationship between an educational interventions and patient outcomes. Contribution analysis is an evaluation tool used to make connections between an educational intervention and a desired outcome. This approach attempts to view the identified problem as a system, considering the impact of other factors, interventions and influences on the whole system[49]. In this case, the lack of critical thinking would be the identified problem, and introducing a formal curriculum on critical thinking would be just one intervention that acts on the whole system, which ultimately affects patient care.

Using a learner's written documentation was identified as a method of evaluating critical thinking. The IDEA assessment tool has been validated in medical students to assess clinical

reasoning through written documentation. This tool includes the domains of interpretive summary, differential diagnosis, explanation of reasoning and alternative diagnosis[35], and could be expanded for use in the post-graduate medical education setting as mechanism to evaluate pediatric residents' clinical reasoning.

Major strengths of the study

A key strength of this study was the targeted focus on teaching critical thinking in the pediatric setting, and the specific challenges within this specialty. The inclusion of pediatricians across a range of clinical settings and years in practice (ranging from one to 16 years) added to the depth and richness of the data collected.

Another strength of the study was level of existing knowledge and engagement on this topic by participants. Physicians were asked to participate in the study if they were known to be passionate about postgraduate education or were considered particularly skilled critical thinkers and clinician educators. The involvement of a program's outgoing and incoming pediatric program director added valuable insight on potential gaps and opportunities in the pediatric resident curriculum. Two of the participants were also fellowship program directors in their respective subspecialties.

In addition, a valuable insight from this study came from the perspective of community-based pediatrics, and the comparison between training environments and final clinical settings. This highlighted that pediatric training programs may not be adequately preparing residents to apply critical thinking when they transition to independent practice, outside a tertiary care setting.

Weaknesses, cautions and limitations

Qualitative methods were used to explore the study's research question. Quantitative methods were considered, such as a survey or validated scale assessment. These were not pursued on the basis that these approaches would not reflect the complexities of teaching critical thinking in the clinical environment. The reliance on qualitative methods is a limitation of the current study; however, future work that builds on these findings, could include quantitative components.

Although participants had a broad range of clinical experience across many different subspecialties, the sample size was small. The institution used for this study is a medium tertiary care centre and therefore, the sample is representative of this particular center and setting so the results may not be transferable to all teaching settings.

Implications and future directions

The results of this study will be used as a foundation to implement a formal curriculum on critical thinking for pediatric residents. A number of methods for evaluating the curriculum have been identified. Once the curriculum has been implemented, it will be evaluated at both the individual and program level to explore the impact of formally teaching critical thinking skills.

As this study was conducted at one institution, further needs assessments should be conducted at pediatric training centers across Canada and/or abroad. This will help to confirm and validate results, and will assist in the design of a more broadly applicable curriculum.

Curriculum development

The Kern' Curriculum Development Cycle was used to develop the 'Critical Thinking for Pediatric Residents' curriculum[37]. The results of this study, together with a review of the literature, supported the development of an evidence-based curriculum that is amenable to feedback and continuous quality improvement. Rather than approaching Kern's Cycle in a step by step process, the curriculum was developed in an iterative fashion.

a. Problem identification and general needs assessment

The problem identification and needs assessment phase was completed as part of previous study focused on the impact of order sets on resident learning. The results of that study highlighted a general need and gap in the existing curriculum for pediatric residents as it relates to critical thinking.

b. Targeted needs assessment

A targeted needs assessment was conducted through this study, which explored educational strategies, and implementation and assessment approaches.

c. Learning Goals

Learning Goals for the critical thinking curriculum for pediatric residents build on the recommendations identified in the context of the 2011 Millennium Conference:

- To provide a common language for students with respect to problem solving;
- To provide an understanding of the neurobiology of learning and thinking, principles underlying logical reasoning and metacognition, and familiarity with common cognitive biases;

- To provide knowledge and skills in a developmentally appropriate way such that the learner can readily apply the principles to work at hand, whether in the classroom or clinical setting; and
- To promote habits of mind and a culture among students that will reinforce the notion that how one gets to the answer is as important as the answer itself.

d. Educational strategies

The targeted need assessment and review of the literature made it evident that using a single educational strategy to teach and evaluate critical thinking would likely be ineffective. Therefore, different educational strategies and evaluation methods have been selected for the curriculum, though individual modules may have a single evaluation method.

Educational content of the curriculum was identified after a review of the literature and from the targeted needs assessment. Recommended content includes metacognition, cognitive biases, heuristics and critical appraisal. As critical appraisal is taught elsewhere in the pediatric residency curriculum, individuals responsible for teaching critical appraisal will be engaged to explore whether critical thinking can be embedded into their existing curriculum or if a module on critical appraisal should be taught within the curriculum.

Simulation was considered an important method to both teach and evaluate a learner's critical thinking skills. As there is currently a simulation curriculum for pediatric residents at the pilot institution, it may be possible to explicitly teach and evaluate critical thinking during simulation.

e. Implementation

A finding of the study was the need to embed the proposed curriculum throughout the pediatric residency training program. A faculty development workshop to 'train the trainer' will be planned to provide all faculty with unified terminology and framework for the teaching and evaluation of critical thinking in the clinical setting. Based on the feedback from that workshop, and the first resident module, a tip sheet will be developed to support embedding critical thinking in clinical practice.

f. Evaluation and feedback

There are two distinct challenges in selecting a method to effectively evaluate the proposed curriculum: first, how to evaluate an individual learner's critical thinking skills; and second, how to demonstrate the impact of the critical thinking curriculum on a learner's critical thinking skills. Key stakeholders will need to be engaged to embed the assessment of critical thinking within the CBD framework which will be used to evaluate pediatric residents. Simulation was seen as the ideal tool for evaluating critical thinking, though the culture of CHEO's simulation program as a psychologically safe environment that is purely formative, makes its use as an evaluation tool challenging. In addition, an evaluative simulated case could potentially be included in the biannual pediatric resident OSCE. The use of a validated tool, such as the IDEA Assessment Tool, could also be used to evaluate residents' written clinical reasoning.

To evaluate the effectiveness of the curriculum, residents will be surveyed after its completion. A second survey will follow six months after the implementation of the curriculum to evaluate concept retention. The use of a contribution analysis to evaluate the impact of the proposed curriculum will be further explored.

MODULE 1: METACOGNITION, HEURISTICS AND COGNITIVE BIAS

A module on metacognition, heuristics and cognitive bias has been developed in response to the targeted needs assessment. The module will be delivered over two sessions at least one week apart, in order to allow time for reflection.

Session 1

In the first session, a flipped classroom approach will be used, meaning the learner will be expected to have background knowledge prior to the in classroom experience. The content will be delivered with case examples, to ensure the clinical context is emphasized. The learner will then be asked to self-reflect on their own experience and cognitive process prior to the second session.

Session 2

The second session will consist of small and large group discussions on cognitive bias and debiasing strategies. The small group will consist of up to three residents and a faculty facilitator. Potential facilitators were identified during the targeted needs assessment. Additional facilitators may be identified during the faculty development workshop.

As some residents may miss a session due to clinical obligations, summary materials will be provided. This will help enable their participation in the second session even, regardless of first session attendance.

Learning Goals & Objectives

Learning Goals:

At the completion of 'Module 1: metacognition, heuristics and cognitive bias' of the Critical Thinking for Pediatrics Curriculum residents will be able to:

i. Understand and apply knowledge of metacognition, heuristics and cognitive biases to their clinical practice;
ii. Demonstrate an understanding of debiasing techniques and develop their own strategies to counteract cognitive errors; and
iii. Reflect on their own cognitive process and clinical experience for examples of cognitive errors.

Learning Objectives:

At the completion of 'Module 1: metacognition, heuristics and cognitive bias' of the Critical Thinking for Pediatrics Curriculum residents will be able to:

i. Describe dual process theory and the impact it has on the clinical decision making process;
ii. Explain and contrast different cognitive biases and to be able to detect them in clinical cases in the small group setting. The cognitive biases will include: premature closure, anchoring, search satisficing, diagnostic momentum, confirmation bias, availability bias, gambler's fallacy and hindsight bias;
iii. Demonstrate an understanding of debiasing techniques and their application to clinical cases in both a small and large group setting; and

iv. Design and share their own strategies for debiasing and counteracting cognitive errors in a small and large group setting.

Content

Session 1

Topics:

- Baseline knowledge of metacognition
  - Dual process theory
- Heuristics
- Cognitive bias and debiasing techniques
  - Premature closure
  - Anchoring
  - Search Satisficing
  - Diagnostic Momentum
  - Confirmation Bias
  - Availability Bias
  - Gambler's Fallacy
  - Hindsight Bias

Pre-Reading

- The Atlantic: The Cognitive Biases Tricking Your Brain (2018)[50]
- The New Yorker: What's the trouble? (2007)[51]
- NEJM: From Mindless to Mindful Practice (2013)[15]

Educational Strategies:

- Interactive lecture
  - Pre-Survey (5 minutes)
  - Cognitive reflection test (10 minutes)
  - Why is critical thinking important? (5 minutes)
  - Metacognition (10 minutes)
  - Heuristics and cognitive bias (35 minutes)
    - Embedded clinical examples
      - Staff facilitators could provide these examples (encourages intellectual honesty) or pulled from morbidity and mortality rounds. If staff facilitators are not available, senior residents may be asked in advance to provide examples.
- Group discussion (15 minutes)
  - What do you feel are barriers to developing critical thinking skills in residency? How can we overcome them?
- Wrap up and explanation of self-reflection activity (10 minutes)

Take home activity: At the end of the session, residents will be asked to reflect on their own experience and when they have been subjected to cognitive bias. It is important that they return with a case that they were directly involved in, identifying an error they made rather than identifying another's error.

Session 2
Topics: Reflection on cognitive bias and debiasing strategies

Educational Strategies:
• Recap of previous session (10 minutes)
• **Small Group activity** (45 minutes): sharing in small groups (max 4 including facilitator) about clinical experience making cognitive errors. The group will be given a shuffled deck of cards, with a cognitive bias listed on each card. They will be randomly distributed among the group (including the facilitator) and the individual will share with the group an example of when they were subjected to that cognitive bias. The group will then trouble shoot potential debiasing techniques for that case.
  • Important features:
  o Psychological safety (what's said in the room stays in the room)
  o Ice breaker: Such as two truths and a lie. This will be done to break down hierarchical barriers of having staff facilitator
• **Large Group Activity** (20 minutes): The participants will then return to the large group and share effective debiasing techniques
• Wrap up (10 minutes)
• Evaluation (5 minutes)

Evaluation

These survey tools were developed using the principles outlined in AMEE Guide No. 87: Developing questionnaires for educational research[52]. In order to avoid survey fatigue, the surveys were limited to 10 questions or fewer.

Pre-Survey

To be completed by residents before beginning the first session of the module.

1. I have received previous training in metacognition/cognitive psychology/dual process theory in my medical training
    a. Yes/No
        i. If yes, please specify:
2. I have received previous training on cognitive bias
    a. Yes/No
        i. If yes, please specify:
3. I have received previous training on clinical reasoning
    a. Yes/No
        i. If yes, please specify:
4. I feel confident in my ability to think critically in the clinical realm
    a. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
5. How confident are you in your ability to recognize cognitive bias?
    a. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
6. How confident are you in your ability to recognize heuristics?
    a. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
7. I apply my knowledge of cognitive bias to my clinical practice
    a. Almost never/ Once in while/ Sometimes/Often/Almost always

Post Session 1

To be delivered immediately after the first session of the module.

At the completion of the session on critical thinking skills:

1. How confident are you in your understanding of metacognition, dual process theory and how we make decisions?
    i. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
2. How confident are you in your ability to recognize cognitive bias?
    i. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
3. How confident are you in your ability to recognize heuristics?
    i. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
4. I feel confident in my ability to think critically in the clinical realm
    i. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
5. Do you feel knowledge of metacognition is important for a clinician?
    i. Not important /Slightly important/Moderately important/Quite important/Essential
6. Do you feel knowledge of cognitive bias is important for a clinician?
    i. Not important /Slightly important/Moderately important/Quite important/Essential
7. Do you feel knowledge of heuristics is important for a clinician?

        i. Not important /Slightly important/Moderately important/Quite important/Essential

8. Did the group discussion increase your understanding of cognitive bias, heuristics, metacognition and their application to the clinical environment?
        i. Disagree/Somewhat disagree/Neutral/Somewhat agree/Strongly agree
9. The group discussion was a psychological safe environment
        i. Disagree/Somewhat disagree/Neutral/Somewhat agree/Strongly agree
10. Suggested areas of improvement:

Post Session 2

At the completion of the second session:

1. Have you applied content learned in the last session (metacognition, cognitive bias and heuristics) to your clinical practice?
    a. Never/A few times/Often/Many times/Daily
    b. If yes, please specify
2. How confident are you in your understanding of metacognition, dual process theory and how we make decisions?
        i. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
3. How confident are you in your ability to recognize cognitive bias?
    a. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
4. How confident are you in your ability to recognize heuristics?

    a. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident

5. I feel confident in my ability to think critically in the clinical realm
    a. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
6. Did the small group activity increase your understanding of cognitive bias, heuristics, metacognition and their application to the clinical environment?
        i. Disagree/Somewhat disagree/Neutral/Somewhat agree/Strongly agree
7. The small group discussion was a psychological safe environment
        i. Disagree/Somewhat disagree/Neutral/Somewhat agree/Strongly agree
8. Did the large group discussion increase your understanding of cognitive bias, heuristics, metacognition and their application to the clinical environment?
        i. Disagree/Somewhat disagree/Neutral/Somewhat agree/Strongly agree
9. The large group discussion was a psychological safe environment
        i. Disagree/Somewhat disagree/Neutral/Somewhat agree/Strongly agree
10. Suggested areas for improvement:

Retention Survey

The retention survey is designed to measure the impact and behavior change of the curriculum on pediatric residents. In order to evaluate if any behavior change is sustained, residents will be asked to complete this survey six months after the module has been completed.

1. Did you participate in the critical thinking for pediatric residents module on metacognition, cognitive bias and heuristics?

    a. Session 1/ Session 2/ Session 1&2/ Neither
2. Have you applied content learned in the last session (metacognition, cognitive bias and heuristics) to your clinical practice?
    a. Never/A few times/Often/Many times/Daily
3. How confident are you in your understanding of metacognition, dual process theory and how we make decisions?
    a. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
4. How confident are you in your ability to recognize cognitive bias?
    a. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
5. How confident are you in your ability to recognize heuristics?
    a. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
6. I feel confident in my ability to think critically in the clinical realm
    a. Not at all confident/Slight confident/Moderately confident/Quite confident/Extremely confident
7. Should this academic half say session be repeated?
    a. Yes – annually/Yes – every 2 years/No

Conclusion

A targeted needs assessment was performed to inform the development of a critical thinking curriculum for pediatric residents. As part of this assessment, physicians' experiences

developing critical thinking skills as learners and educators, their attitudes towards developing a formal curriculum for critical thinking, and their proposed strategies for content, delivery and evaluation of a formal curriculum for critical thinking were explored.

The results of this study suggest that the development of critical thinking skills in pediatric residents is dependent on broad clinical experience over time. The relationship between a preceptor and learner, built around an environment of psychological safety is also a key component. This allows a learner to share their clinical reasoning process, experience stress, and make mistakes in a safe environment. In addition, preceptors see critical thinking not as a competency to be acquired, but as a skill to be developed and refined by probing their own clinical reasoning.

The study suggests that the current emphasis on efficacy, reduced duty hours, and standardization of care in clinical settings is a threat to the development of critical thinking. This hidden curriculum teaches students to be acquiescent and mimic their preceptors practice pattern. Working with those preceptors who are considered arrogant or closeminded is detrimental to the development of critical thinking and represents the antithesis of a psychologically safe environment.

Specific to the field of pediatrics, this study highlighted the challenges that exist when residents are exposed to a low frequency of high acuity events. Residents miss out on the opportunity to manage complex cases, and therefore the ability to benefit from the learning power of stress, while in a safe and supportive environment.

This study identified a gap in the current pediatric resident curriculum and has proposed an implementation strategy and pilot program to address critical thinking needs within a pilot

institution. An in-depth understanding of the barriers and success factors to critical thinking education in a pediatric training environment was explored. These findings can be incorporated by learners and educators in a variety of clinical settings.

While the results of this study, and its underlying targeted needs assessment, will be used to inform a formal curriculum on critical thinking for pediatric residents, this study contributes to broader research on critical thinking skills development in clinical settings. Although this study focused on a specific institution, and is expected to be representative of similar training programs in Canada, further research is needed to explore the development of critical thinking skills in other pediatric settings nationally. The need for further research to effectively evaluate critical thinking in a pediatric training environment was identified. Based on this study's results, implementing a curriculum for critical thinking, using effective educational strategies, should be a priority for pediatric training programs.

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Appendices

Appendix A – Interview guide

Interview Guide

Thinking About Thinking: Developing A Formal Curriculum on Critical Thinking for Pediatric Residents

DATE: _____

TIME: _____

PARTICIPANT ID: _____

INTERVIEWER: _____

Thank you for participating in this interview. This interview is part of a targeted needs assessment for the development of a formal curriculum on critical thinking for paediatric residents.

Specialty: _____

Hospital: _____

Years of practice: _____

Teaching settings: _____

There are many definitions of critical thinking, for our purposes of the rest of this discussion, we are using the definition: 'the ability to apply higher cognitive skills (e.g., analysis, synthesis, self-reflection, perspective taking) and the disposition to be deliberate about thinking (e.g., being open minded or intellectually honest) that leads to action that is logical and appropriate'. [25]

1. What are your thoughts on critical thinking skills in paediatric residents?
2. How did you develop your critical thinking skills?
3. When did you feel confident in your critical thinking skills?
4. What are some challenges to critical thinking specific to pediatrics?
5. How do you think critical thinking skills can be developed in learners?

a. How do you teach your learners to be critical thinkers?

b. What are some effective strategies you have observed other clinicians using to develop critical thinking skills?

c. What are some ineffective strategies you have observed?

6. What are your thoughts on developing a formal curriculum for critical thinking?

    a. What are the important features of critical thinking that should be explicitly taught? (i.e. content)

7. What are some strategies that educators could use to develop critical thinking skills?

    Probe for examples if required

    Structured content?
    ii. Reflection?
    iii. Discussion?

8. What do you think the impact of a formal curriculum would be?
    a. Positive
    b. Negative

9. What barriers do you foresee to implementation of a critical thinking curriculum?

10. How can effectiveness/impact of this curriculum be measured/proven?

Appendix B – Codebook

Category	Level II Code	Level I Code	Definition	Illustrative Quotes
Objective 1: To explore physicians' experiences developing critical thinking skills as both learners and educators during post graduate training				
Developing Critical Thinking			The experience of developing critical thinking skills as both a learner and an educator.	
	Clinical Experience		The value of broad clinical experience spanning over time in developing a learner's critical thinking skills. This includes background knowledge about disease pathophysiology and independent learning by the resident. This allows the teacher to help guide them in developing an approach to clinical problems.	
		Clinical Experience	The importance of a broad clinical experience in developing critical thinking skills	I*t's important that you can be very theoretical about things that actually, it can't replace the clinical experience for sure, and I think it could very much complement it. And I think that as there's a change in duty hours and supervision and all those things, which have been positive, but I think they do have an impact in the fact that residents may not have the exposure of depth and breadth of things as much as in the past, and in the past, it was often a bit of trial and error, which is not right, either.CT2* *You can also see a difference between residents who've had, for example, a lot of broad range of experiences versus a very narrow range of experiences.CT6*
		Time	The development of critical thinking as a skill as one progresses through training	Usually things get better as they move from the clerkship months to fourth years. I think—trying to look at the teaching setting that I work in because the two clerkship systems that we've got clerks from McMaster so they're second half of second year, nearly brand new to clinical rotations to 4th year ped residents as soon as they get to this rotation as part of their fourth year because they want to do Gen Peds. So there's a big spectrum of ability and a big spectrum of how you see their critical thinking skills improve. – CT1

		Foundation Knowledge	The importance of foundation knowledge before probing to teach critical thinking	*You need a good base there because you can't build on nothing especially if you want to teach them higher mental functions and critical thinking on a higher level, so that's why I think we were talking before we started this about how do we teach different people at different levels because I can't teach a student about fontan physiology, but I can teach a fellow about fontan physiology. They can teach the residents on a smaller scale. So they need to know a little bit more about effective positive pressure, negative pressure on after load and these concepts are a bit higher, so I find that making sure you give them a lead through the problem, think through it, read a little bit more and then come back and build on that, it's like building blocks, building blocks, and it's easier for fellows, or for people to spend more time with us.CT2*
	Approaches		Recognizing that a variety of approaches exist in thinking through problems	
		Problem solver	The experience of learning how to think through problems	*but I always tell them med school is meant to teach people how to approach things, and you don't really have a lot of knowledge coming out of med school apart from getting how to think through 24 problems. I think that's the best part of coming to med school. And our job is to know all that as teachers, and really help people evolve and mature in the way they think through more complex problems and overcome their obstacles, whether they're knowledge obstacles or even at a higher level, admin, work-related problems, or people's issues and trying to address all that in a comprehensive manner as possible, but there's no size-fits-all for everything.CT3* *—one of the things I think that I was lucky in, is that my undergrad's in math and so, and math, you don't just memorize stuff and get away with it, right? You really have to problem solve, and I think that helps with critical thinking. So I think that this unfortunately when you go into medical school, the majority of people come out with biology degrees and whatever and they're memorizing stuff. I mean, physiology's not memorizing, it's understanding, but I do think there's that innate, just feed me the information; whereas in math no one's feeding you anything. You're constantly having to problem solve and figure things out yourself and so I think that there's just that being—that level of self-direction is important for critical thinking.CT4*
		Algorithms	The use of previously developed algorithms to approach a clinical scenario	*one helpful tool was developing some branch logic in terms of working almost through an algorithm. When I was studying for my exam, I think I found that to be a very helpful way of really honing down exactly how to approach*

				by chief complaint, and there was a good resource that I used that was just essentially a text that goes along with Nelson's), it's just all algorithms for chief complaints. So I think that probably, if I was going to think about a resource, like how that sort of taught me about, "if this then this" and sort of walking through what are the things that are really important on histories and physicals that are going to send you down X or Y path, kind of thing. So that's in my head, that sort of a formal way of looking—or a more, yeah, a formal nice way of what was happening in my head, and distilled down to what the important things were. CT2
		Mental frameworks	The use of an adaptable frameworks to approach a clinical scenario	*I think it's different where it pertains to different problems, but I think I was trying to learn mental models to approach different things and if you have enough mental models you'll probably be able to address most problems. The knowledge, per se, in addressing, for example sceptic shock in paediatrics, for example we had an adult emerge resident just last week who was being taught about paediatric sceptic shock and he's like, "In adults, it's always cold shock' and he was very close minded and our job is to try and teach them how to step back and say, "It doesn't matter whether it's an adult or paediatrics as long as you have an approach to this" and thinking through a problem whether it's warm or cold spot for example, and address that by using different medications, different strategies to treat—it doesn't really matter.CT3*
	The Relationship		The impact the learner – preceptor relationship has on the development of critical thinking skills	
		Relationship	The importance of the learner-preceptor relationship in developing critical thinking skills	*during my weeks in Sioux Lookout residents, I do feel like I think at a little bit deeper into it, and I think it's because it's such an immersive learning experience. So rather than just meeting them in clinic in the morning, doing our day, and parting ways, in Sioux Lookout, we're often having breakfast together, going through our day, eating lunch together. Sometimes we have dinner together at the end of the day or we're in the office for sometimes 10, 11, 12 hours total during our dictations together at the end, and having more of a chance to reflect on our day. And when I have that time with residents and get to ask some of these bigger questions, then I do see that there's more there in terms of the way they're making their decision, but in my day-to-day practice, I don't see that CT7*
		Modelling	The experience of learning critical thinking through modelling your preceptors	*He just is constantly asking questions. He forces his learners to constantly ask questions. And so I think working with him trained me to think that way, and also trained me to think that this is my job. This is how I need to be thinking about my patients all the time. And I certainly had mentors*

				like that at CHEO as well. So I think the modeling from day one learning to think that way and not falling into patterns right away in terms of what you see, in terms of how you manage patients and sort of getting that breadth of experience early on and learning to think about patients in this sort of very—and I think, too, honestly, working up north where it seems like there's less straightforward patients, and the patient who comes in with what you think is pneumonia ends up having blastomycosis. CT6 *Yeah. I think, honestly, the onus—a lot of the onus does fall on the teachers, the clinician teachers, the role models. I think if we model those skills, our residents will feel inspired to do those things, too.CT6*
		The Lightbulb	The moment when resident suddenly understands a difficult concept	*I was talking to the residents about mixed venous saturations, and you have to think through the problem, think of why do I need to do a mixed venous sats in a sceptic shock or post op cardiac, and then a couple residents, you can see the light turn on. One of them was like, "Wow! Wow! Wow!" He sounded so excited, which is nice to see, but it's unusual to see that bulb turn on that strongly. That's awesome. It's good to see that strong reaction, but people have all these things in their heads, but sometimes you need that match that'll just bring them all together and now it's making sense.*CT3
		Honesty	The practice of a preceptor being honest with the learner when they had critical thinking errors or uncertainty to encourage growth mindset in a safe environment	*It's all about normalizing it, right? "You guys have made mistakes that they make on the ward all the time and that's why we're going to solve this problem." Or "I didn't know that answer either at your stage." It's debriefing that sim that we did in Toronto for National ICU Fellows, and no one in this entire sim got this one specific issue, and we all said, "Did anyone think about this?" But when you ask those questions in simulation, there's a way that we do it. So I feel like at the bedside people go, "Oh, what do you think about this?" or "Why did you do that?" and in the simulation people call those dirty questions, where say, "I'm curious why no one did A." "No one did a dynamic compliance measurement." And then you state your path, which I think helps people feel comfortable. So then I would say, "Listen, guys, when I was a fellow, I didn't know how to do a dynamic compliance measurement, either. What do you think?" And then they all go, "Yeah, we didn't know. No one taught us this." And there's that safety to it, and I think educators could do a lot more to provide safety in their questions, and that might pull out some of the reasons why people are making the decisions that they're making, right, and it shares their critical thinking skills.* *CT4*
	The Power of Questions		The use of questioning and probing a learner's clinical reasoning to	

			diagnose and develop their critical thinking skills. This depends on a preceptor allowing for silence and resisting jumping in with the answers.	
		Probing	The use of questioning and probing a learner to explore how they made a decision	*I know why I'm giving them medication, then I know when to apply that medication, as opposed to just giving them medication for the sake of giving them medication or doing a treatment for the sake of doing a treatment. I like to know why I'm doing it and why that medication works, and I think a lot of learners right now when you ask them "Why are you giving magnesium sulfate in an asthmatic?" they'll be like, "It's the next step" as opposed to "because it's a smooth muscle relaxant and that's why I'm giving it." CT5* *I think it begins with curiosity and asking those probing questions of learners. A lot of times when we're busy and we don't have time and a learner sees the patient and they give you a plan and they give you a plan and you think that plan is reasonable, then you say, "Okay, sounds good" and the conversation's over. I think having the time to be curious about the answers that they're giving you, and to ask those probing questions, "Oh, that's interesting. Can you tell me why you decided to use this medication? Are there other medications that we could be using instead? What about this patient made you make this choice, and in what other patient populations would that not be an appropriate choice to make" and really asking those probing questions is where it begins.CT7*
		What if?	Teaching critical thinking by presenting alternative variables/factors in a clinical case and exploring a learner's clinical reasoning	*Well, if the heart rate had been this, or if you were seeing this, what else would you have thought about that?" Or "If you had felt a big liver when you assessed it, what's the differential diagnosis you should have considered more." "If this is a stable myocarditis you're seeing, but you were seeing this…" ….. I love that idea of using what is run-of-the-mill stuff and "if I change this and this variable, how would that impact what you would do, and what would you do differently. CT9*
		Spoon-feeding	The experience of passively transferring knowledge to a learner	*I think questioning is the best way. It's to try and make people get to an answer on their own because most of the time people know what to do and knowledge* ***, I don't think it's a good idea to spoon feed people. I think it's a good idea to give them a little bit of knowledge to intrigue them a little bit.*** *CT3*
		Silence	The power of silence and allowing a learner to explore their clinical	*. I think one of the best ways physicians can force critical thinking is by being quiet and giving the resident a safe space to actually think things out, or talk things out with*

			reasoning without jumping in with the answer	*you, and I've seen this modeled in a few of my colleagues, and I've tried to do this more and I've gotten feedback from some residents that they really appreciate having this safe space, too. Because critical thinking, you're basically talking out loud. You're thinking through your thoughts. Half the things you say are probably just words that get you to the end point in a collaborative way. So I think just being supportive allowing our residents to have that space and encouraging it through whatever means we have, whether it's questions, whether it's – I'll often give them articles to read on presentations and say, "Okay, review this and let me know what you think." But I think giving them the opportunity to do that from what I've seen in my colleagues and in my mentors has been the most helpful. CT6*
	Psychological safety		The culture of intellectual and psychological safety, to allow a learner to be unsure and to explore their knowledge gaps. The value is placed on the clinical reasoning process, rather than the correct answer. The modelling of a preceptor that patients rarely fit neat algorithms and different approaches to the same clinical scenarios may be appropriate. This includes encouraging learners to slow down and be thoughtful through their clinical reasoning.	
		Permission to be unsure	The practice of encouraging a learner to read around a case prior to presenting it. Putting an emphasis on quality of cases seen, rather than quantity	*Give them a couple of websites that I think are useful and quick and easy, like Trek.ca, for example. It's a very concise evidence-based one-pager on the pathology that allowed that learner to try to figure out which category of pathology the patient might be in.CT3*
		The Journey	Placing value on a learners thought process, rather than the correct answer	*With an early learner, who has no expertise or no experience, then that can be, often that's just how you do it because you have to get on with things, but I think once the learner has a good basis in terms of just his basic knowledge and understanding of the particular problem or chief complaint, then helping them to walk the path is much more effective than just giving it to them, and then I guess that's part of the—you're sort of helping them to develop their critical thinking around a particular problem rather than just giving them the answer. Cause actually the process of getting to the answer is very important, and that can be used like across the board, that skillset can be used really*

				across the board with lots of different problems. So, I guess the impatient teacher who just tells the answer—it's much less about getting to the right answers and developing the process. So I always even tell the residents, them trying to decide what they think is going on even when they're incorrect is actually very important. And so to get away from that notion of it has to be correct and I'm not comfortable saying what I think unless I'm really sure it's correct versus gather your information, do your physical exam, do you problem synthesis in your head, considers differentials, and "tell me what you think is the most likely" and even when you're incorrect, we can talk about why, what made me think it's something else, and that actually is very valuable. CT2
		Exploring Grey Areas	Demonstrating that patients rarely present exactly like the textbook or fit algorithms perfecting	*going at it from a more case-based perspective in terms of showing the idiosyncrasies and showing the challenges and the things that are a little bit more in the grey area can be quite helpful. CT2*
		Autonomy	The importance of resident autonomy in the development of critical thinking skills	*I do think that there's a certain amount of independence that's required in order to really develop the skill. So there's something about you being the decision maker that really makes this 89 happen. CT2*
		Mistakes	The value of making mistakes in developing your critical thinking skills	*Trial and error, was really the honest truth. I would look things up and would try to apply it. Sometimes it worked, sometimes it didn't. Sometimes I looked the wrong thing up because I wasn't looking the right diagnosis for XYZ patient and being quite fixated, and then tried to reflect back in terms of why was I fixated for the one patient, or that one diagnosis. But am I the best critical thinking, I don't think so. I think people who are in practice longer than me, are definitely much more, but that's my personal experience mainly because they're less bogged down by PPOs[order sets] because they're more reflective of their experience versus the new grads, I would say are more about that PPOs[order sets] than the older grads. But I think my critical thinking came more from just the mistakes that I made. CT5*
		Knowledge Gaps	A resident knowing what they know and what they don't know as a result of teaching critical thinking	*you have to know what you don't know, and then if you pretend that you know something that you don't, it's like a massive pitfall. CT4*
		Slowing down	The process of deliberately slowing down and being thoughtful during case based discussions including assessment and management plans.	*You have to really slow down the thinking and process a little bit and reflect on what they're planning and what they're proposing rather than just blurting out the first thing that comes to mind. And part of the teaching of clinical reasoning and critical thinking is to allow them to show us what their thought processes are and to teach them that*

				slowing down, the reflecting before they come to their final decision of what the diagnosis is or what their management plan is going to be. CT8
	Emotion		The role of emotion in the development of a learner's critical thinking skills.	
		Shame	The ineffective use of shaming to attempt to teach critical thinking	*berating or shaming people for having thought something isn't an effective teaching strategy in general, but also is an ineffective way to teach critical thinking. If you say, or if you imply, "Oh that's ridiculous that you have ever thought that about a patient" that's not going to help either you or the learner understand where they're coming from because clearly they're not an idiot. They're coming from somewhere. They had some reason to think whatever they told you, and making them ashamed of that is not going to help either of you figure out where they went wrong CT1*
		Stress	The value of stress in the learning experience	*There's something to be said about negative emotion learning, and I don't know what it is there, but I feel like when I was a resident or a medical student or a fellow, the times that I really imprinted knowledge was when I either didn't know and was very scared, and that scared emotion comes though as "I'm not sure what to do, so now I'm going to learn as much as I can." Or you make a mistake, and you imprint the "Oh my God!" And there's something about simulation that when people make mistakes, I feel like they somehow get it better the next time and then there's that reflection and the debriefing that really helps them. CT4* *Yeah, for sure. It's almost like pimping,, right? When you ask a learner "Tell me 10 things that can cause this particular presentation" they could feel like it's pimping and a lot of learners won't learn very well that way. They don't learn very well being put on the spot. But the reality of medicine is that you're always put on the spot. If you're not being put on the spot by your teacher, then you're being put on the spot by your patient, and if you're not being put on the spot by your patient, then you're being put on the spot by your colleague. And so people don't realize that. You're always being put on the spot. Always being asked to perform. It may not be a performance in terms of evaluative, but you're always being asked to perform. Just to introduce that in a non-negative way early on might be the best way. Whereas I don't think we do enough of that. CT5*
	Lifelong learning		An individual seeing themselves as a lifelong learner. They continue to probe their clinical knowledge and	

			reasoning through discussions with colleagues, self reflection and reviews of the literature.	
		Life long learning	Identifying as a life long learner in order to grow and develop your critical thinking skills	*I don't see medicine as like a job that just sort of stops when you finish your training. It has to be life-long and for me I feel good about that in the sense that it's okay when I don't know because I can just look it up and I can look up the new resources and the new literature and things are always happening, so if you take an approach that this is a long journey and every day I'm learning, then I think the critical skills develop over time and they get better over time, but they're always in process. CT4*
		Self Reflection	The use of self reflection to analyzed your own critical thinking skills as a practicing physician	*Where I have a really busy week on ward for example, and I'll get to the end of the week and it's when I take a breather that I look back on that week and think, I wasn't really great, this week, at that. So I think it comes in waves and there's times where things are going well in that regard for me, and there are other times where I really have to take a step back and start again. CT7*
		Challenging your thinking	The active engagement of critical thinking skills and challenging your own thought process in order to maintain competence	I feel like it is something that you have to keep reminding yourself about all the time, because it is kind of an active process to be like "Yes, it's bronchiolitis season, this kid probably has bronchiolitis, but what if they don't." Maybe they don't, and I need to keep thinking about it because, just because it's available, because I've seen 20 other kids with bronchiolitis does not mean that I shouldn't still think critically about what is the evidence pointing to and, again, the fact that this kids has bronchiolitis. CT1 *Some areas I find I'm comfortable, but some areas always challenging, and I think it's always good to stay at the edges of your comfort zone where you have to push yourself a little bit more and learn more because even—another example is, you know, thinking critically through talking to families, which we don't sometimes address that as a problem, but it's a problem, an approach to have difficult conversation. And so I try and think about problems, if I have time to go through them, and I think what I should do more of or struggle with is really doing the thinking after the problem is done and that reflection where I don't always go back and reflect. CT3* *I think, too, just by virtue of being a curious person, sort of always reading, always looking things up, trying to learn—the more you learn, obviously, the bigger knowledge base you have, I think the greater ability you're going to have to critical think about things because you actually need knowledge to be able to do that, too. So I think just trying to*

				keep myself as current as I can, and going home and reading about patients and presentations has allowed me to maintain some of those skills also.CT6
		Review of Literature	Regular literature reviews to make sure patient care approach is evidence based	*I think we're just going to have ever more and more treatment options, and there's going to be more and more evidence maybe that some of the things that we used to do didn't work and things that continue to evolve quickly so that, you know that old joke about half of what you learned in med school will be obsolete, the trick is knowing which half? but that it's probably 90% of the stuff that 1we learned in med school were obsolete by the time we finish practicing, and so we're going to have to keep learning what is actually relevant, and we're going to have to do that by critically appraising literature, probably. CT1* *Like I said, as long as the kid is stable, then it's amazing—and I always say on the fellows to, really, focus 10 or 15 minutes of just having a quick re-read or a quick pull of the literature can make all the difference and so I think people get overwhelmed by thinking, "I have to read every source on hypotonia.... It's going to take forever." You don't. This sounds kind of crazy, but I go to PubMed. I might put in—let's just say I was using that case, I might put, "hypotonia" and "neonate" and "review" or "management", or whatever, and then "differential", see what comes up that's kind of new, got to up-to-date and have a quick look at the quick algorithm, but then if there's anything new that comes in the literature then at least I've got that. That doesn't take long to do that, right? And then, to be honest, I knew metabolic stuff for a week after my peds exam and then I left. And so every time a case like this comes in I have to go back and what are metabolic defects that are going to give me a problem, and I think it's important to do that.* CT4
		Colleagues	The practice of discussing cases with colleagues to promote critical thinking	*Asking help. Like we all talk constantly about difficult cases. Knowing when to ask for help, knowing when to use the literature. I mean, I feel like they all do that and I think being in the environment where it's okay to ask each other, promotes critical thinking because you're constantly asking each other questions and not being nervous about that. C2*
Threats to Developing CT			The treats to the development of critical thinking skills.	
	Current training environment		The threats to the development of critical thinking in our current training environment.	
		High Volume	The high volume of clinical work that detracts from the development of critical thinking	*You know what it's like Emerg is get them through, get them through, get them through, and yeah you've seen a hundred 5bronchiolitics that the 101th has got to be a bronchiolitic versus maybe they get a foreign body and you*

				just don't sit and think about it because there is such a pressure on, there's other pressures on your clinical performance, and I feel like—I remember being a senior and feeling that way on the ward that on a slow night when you've admitted 5 patients, you could sit down and critically think about a patient. But on nights that you didn't, you're just moving them ahead. Even on rounds, its more just getting the work done and writing the notes and sending Dear Doctor letters and all these things that take away from the ability to sit and think, which I think you're right, and then the consultant comes in, maybe they only have one consult that day, and so can really sit and think about the problem. Yeah, I don't know. I don't know if it's part of us being wrapped up in the patient or just the other demands that are placed on clinicians CT4
		Reduced Duty Hours	The negative effect reduced work hours has on the development of critical thinking	*I think that as there's a change in duty hours and supervision and all those things, which have been positive, but I think they do have an impact in the fact that residents may not have the exposure of depth and breadth of things as much as in the past, and in the past, it was often a bit of trial and error,* *which is not right, either. CT2*
		Differentiated Patients	The challenge of teaching critical thinking in a tertiary care centre where patients are already diagnosed prior to admission	*So I think, especially in the tertiary center, where you see a lot of the same thing and, again, children often come to you differentiated, so I think it's a really important skill, but—as of now, as a teacher—I am a little bit stuck sometimes knowing how to give feedback about it, how to teach it. CT6*
		Standardization	The negative impact order sets, guidelines and electronic health records have on developing a learner's critical thinking. Both in terms overdependence, automaticity and practicing mindlessly.	*Peds I think is moving more and more to a guidelines-based—a lot of conditions have guidelines, and I think it's important to be aware of the guidelines, but there's this sort of rote, persistence in the guidelines without really a lot of thought about whether or not those guidelines are appropriate for a particular population. Maybe that's just one thing to say. I think that there are ways to use guidelines, but I think this sort of "Well, this is not how we do it" is not really effective and it doesn't model good critical thinking for our learners CT7* *when I came to CHEO and there [were] a lot of these pre-printed orders which took a lot of the cognitive load away, of not forgetting things. So I think they're really helpful from a process standpoint where you standardize practice, there's a lot less variability from a team standpoint, that's good because essentially someone has done the thinking to look at what the evidence is and try to put it together, and said, "Okay, well, this is the best evidence and this is how we should all function," but on the flip side, what it does do is saying why do this? Because I tick the tick boxes. And so, in going through the tick boxes sometimes you've shown*

				someone how to go through the tick boxes, but you haven't actually led them to think about why would you ever flip it over and go to status asthmaticus. You always tick that and you always have a pramof 8, so you know you always do this, but what is your sensitive factor to saying, how are you going to decide someone is in status asthmaticus versus they're not. And then how are you going to troubleshoot someone who's in status asthmaticus aside from knowing that there's a bunch of tick boxes that you have to tick. So they're standardized and they're helpful, but looking at the residents doing their admission orders and so on, it just felt like a lot of it was very rote.CT9
	Hidden Curriculum		The hidden curriculum that encourages a learner to not disagree or challenge a supervisors decision in order to achieve a positive evaluation. Residents will often model a preceptors practice, rather than critically thinking through a clinical scenario.	
		Pattern Recognition	The use of modelling preceptor's practice pattern to approach a problem, rather than going through the clinical reasoning process	*Yeah, I wonder if it gets in the way a bit. I think that if your relationship is purely that as evaluation, like preceptor learner and you don't really have that relationship behind it, then I think sometimes learners just say what they think you want to hear, so I feel like that maybe gets in the way of teaching, modeling and, ironically enough, actually assessing it because I don't think that you're getting true responses. CT7* *do I think they have it or that they don't have it? I think at this moment at CHEO at lot of the pediatric residents are very protocolized and their thinking is "This is happening, so this has to happen." I see a difference between the pediatric residents that are training just at CHEO versus the pediatric residents that train outside of CHEO and then come back to CHEO in terms of their being able to look at the nuances of the situation. Yeah. That's what I think CT5* *I do think it's something that is very difficult to teach, and sometimes I feel like residents, when you dig down deep into their knowledge, it's more just pattern recognition and what they've seen before, what they've seen other people do versus their own critical thinking. I feel like there are some specialties that are better at critical thinking than maybe peds are, and I don't know why that is. I don't know if there's something about the way they teach it, or there's something about the modeling that they have. Something*

				about the time they have to invest in that ability to sit and think.CT4
		Status Quo	The experience of not disagreeing or challenging another's clinical reasoning in order to maintain status quo	*Because my fear is that a resident is going to get poorly evaluated on critical thinking because they just differ from what the staff thinks. They don't think the same ways. "They don't know what they're talking about, so they obviously don't know how to critically think because they're not getting to the same place." You don't want that, either. I think we need to learn how to evaluate this and what are we really trying to teach them. CT6*
	Hubris		The negative effect that hubris and arrogance can have on the development of critical thinking skills.	
		Hubris	The negative impact of hubris that has on fostering critical thinking	*I think there's clinicians that we work with that you can probably think about too that are very dogmatic and very closeminded in their opinion, and so it's either not this, or it's not that, or they withhold information. People withhold information or the deny things that they've done or haven't done—all of that does not help with critical thinking.* ***I think people have big egos and lots of people don't want to admit when they're wrong or when they don't know, and that stops critical thinking.*** *CT4*
		Closeminded	The negative impact of being closed minded has on developing critical thinking skills	*I think there's clinicians that we work with that you can probably think about too that are very dogmatic and very closeminded in their opinion, and so it's either not this, or it's not that, or they withhold information. People withhold information or the deny things that they've done or haven't done—all of that does not help with critical thinking. I think people have big egos and 206 lots of people don't want to admit when they're wrong or when they don't know, and that stops critical thinking. CT4* *I think that having someone who doesn't allow you to explore ideas, kind of cuts you down in terms of your thoughts or your ideas or more specifically your differential, your management plans, because they're not what you thought as a staff would work. I think that's probably one of the number one killers of any sort of creative or critical thinking. So I think we need to be a bit more supportive and open to other possibilities.*
Barriers in pediatrics			The unique challenges in pediatrics to the development of critical thinking skills.	
	Clinical content		The type of events and cases that occur in pediatrics	

		Low frequency events	The impact that the low frequency of high acuity events in pediatric and it's threat to the development of critical thinking	*The big issue with paeds I find we all struggle with whether it's in residency or in the ICU is the low frequency of events, which makes it a lot harder to teach because people don't see those events ever, or see them very, very rarely.CT3*
		Bread and butter	The challenge of pediatric residents seeing bread and butter cases and subspecialists seeing more uncommon presentation, resulting in a lack of development of critical thinking skills in residents	*I think the challenge in peds is we see a lot of the same thing a lot of the time, and so we don't almost have to use our critical thinking skills that well, and so when you do get a consultant involved, you get them involved because there's something weird and wonderful and that's where they sort of step back and give that much more broader view. But I do think we're a bit paralysed in some of the general peds, or even what I see in Emerg where you don't have to do a lot of critical thinking, right? For the bronchiolitics and the DKAs and all the things that we see routinely and so that's where I think it gets a bit lost because that's our bread and butter. And, yeah, the weird and wonderful stuff is just not that common and the sub-specialties I think just do a better job because their job is come in when there's weird and wonderful stuff. CT5*
	Culture		The perception of pediatricians and their culture	
		Nice people	The perception of pediatricians being pleasant and non threatening	*I don't know. This may be simplistic or an assumption that isn't fully accurate, but my experience with a lot of pediatric learners is pediatricians by and large are nice people and I think we're not great at challenging one another or effectively disagreeing with one another as pediatricians and I think that our learners are the same. We honour in pediatrics being kind and being nice and working together, but I think that also leads to a challenge which is, we don't model the ability to have conflict with one another and to come to resolutions in effective ways. That's just one thing that comes to mind. CT7*
		Coddling the learner	The perception of the culture in pediatrics to not push a learner	*Yeah. I'm going to be honest with you. I think pediatrics residents are not pushed enough in terms of being asked questions. A lot of the academic half-days are very passive learning as opposed to active learning. So, if we take examples from our surgical subspecialties where it's a lot of active learning, where the learner is expected to have read a specific section of the book or certain articles or something, and then they're asked about questions regarding that meeting, I think that helps in terms of trying to synthesize that information that person's read; whereas in peds academic half-day for the most part it's a lot of passive learning where an expert is just talking at you. CT5*
CT in the community			The unique challenges of critical thinking in the community pediatrics setting	In some ways, I think maybe less, just because of the way the system works. Like at a tertiary center during residency you get the patient to be admitted and you know that they've already been seen and

				reviewed by a pediatrician; whereas, I get here, especially for kids that are sicker, just a much more unsubstantiated story. As an emerg doc calls me with like, "This kid is sick and I don't know why. Please come help" which is good in some ways because that leaves a lot more of the thinking to you as opposed to somebody giving you the story over the phone and being, like, "I've already figured this out. This kid is an asthma exacerbation or whatever." And you could go down and do that admission and not really think too much about it; whereas, here, for better or for worse I do feel like I'm the first pediatrician seeing them and so it's my responsibility to definitely go back and double-check with the emerg doc. Q: That's very interesting. So you feel that you are more challenged now outside of the tertiary care center than when you were in it? Resp: I think so, and I know not that it's not easy to call someone on the phone, because it is, but it's also, I feel, a bit more of a responsibility to think hard about what might be going—if I feel like I need help to have thought hard about what's going on and what workup I can do by myself before calling that consultant on the phone, just because I want to have kind of a story and have thought through what may be going on, and you just have a bit less easy access to help. CT1 *Not every graduate is going to be working in a tertiary care centre. A lot of our graduates are working independently in clinics, or in smaller centres where they may not have the capability of having a colleague there to potentially bounce ideas off. So I think it's good to start teaching them early on on where to find information and how to synthesize that information on their own while they still have support CT5*
Objective 2: To explore physicians' attitudes towards developing a critical thinking curriculum				
Gap in the curriculum			The gap in the current pediatric residency curriculum for explicitly teaching critical thinking.	
		Room for improvement	The deficiency of critical thinking skills in physicians	*In general, I think we could probably all do a little bit better. In all medicine, not just pediatricians. About thinking about our thinking and addressing some of our own biases. - CT1* *I think some of it comes naturally through your progression through training, but I think there's a component that we could probably do better actively teaching because it is*

				really important to say what is the evidence behind whether it be your diagnosis or your management plan or whatever, and it's a skill that has to be learned to do that and not just to increasingly rely on heuristics and your initial impression which is a skill that, something that also can easily happen as you progress through training, as you get more comfortable with presentations and you're just like, "Yep. It's a breather. Got it. Seen it." It behooves us to teach the residents to stop and think and make sure that that's what we're dealing with and it is an active process to have to do that. CT1
		Gap in Residency	The gap in residency curriculum about critical thinking	*I don't necessarily feel like we talked a lot directly about it in residency… I feel like after talking about it a fair bit both in undergrad and in med school—although not necessarily as part of the formal curriculum of med school, but some kind of something I did on the side, I don't know that we necessarily talked about it a lot in residency. – CT1*
Impact			The potential impact of implementing a critical thinking curriculum.	
		Evidence Based Practice	Improved use of evidence based practice as a consequence of teaching critical thinking	E*valuating the literature better and using fewer treatments that were not evidence based. I would hope it would make things better. CT1*
		Reduced diagnostic error	The reduction in diagnostic error as a positive impact of teaching critical thinking	*You would hope that it would lead to people making fewer diagnostic errors CT1*
		Engagement	Improved resident and faculty engaged as a positive impact of a critical thinking curriculum	*Critical thinking is fun, I think. I get a lot more satisfaction out of my job when I am critically thinking about patients and not just stamping [a patient] with bronchiolitis for the 15th time that day. That is what I find fun about our jobs and my job satisfaction is way better when I'm seeing interesting cases that I need to use my brain for, quite honestly.CT6*
		Patient care	The positive impact improved critical thinking would have on patient care	*I think that it would make better clinicians, there's no questions…I think it would make better clinicians completely and more engaged residents and probably interested faculty, and yeah it might engage people a lot more.* CT4
Barriers			Potential barriers to implementing a formal curriculum on critical thinking.	
	Time	Time	Lack of time and competing demands within pediatric residency curriculum	*As soon as somebody says, "I want to do something new and it's going to create a time commitment for you" everybody tells you, you've become the most unpopular*

				person in the room … but anytime you add something to 258 someone's workload is never well received. CT6
	Resistance		Resistance to the development of a critical thinking curriculum	*I think there's a bit of inertia in terms of the way things are done, and so people are very comfortable with the methodologies that have been used forever so they may not—so it's always a little bit difficult to get people to look at, or change their teaching methods, so that could be hard, but done right, I think people would see the value. CT2*
		One size fits all	The perception that not all learners can be taught critical thinking in the same way, and that a formal approach may not be effective for all learners	*think that, for me, this concept has been something that I've thought about a lot informally and, as a result, I found these strategies that work for me in the way that I talk about things, in the way I like to reflect upon things and it is more informal. So I wonder if we start putting people into a box in terms of the way that we teach this and the way that we ask them to reflect upon their thinking skills if some learners won't respond well to that. Maybe for some people it has to be more of an informal thing and that they would do better with an informal approach. So I wonder if the way that we try to formulate this process that is quite reflective and is unique to each individual, just as a person and as a practitioner would be too restrictive. CT7*
		Educational Inertia	Resistance of a program or a preceptor to developing new knowledge, skills or changing their educational approach.	*I think there's a bit of inertia in terms of the way things are done, and so people are very comfortable with the methodologies that have been used forever so they may not—so it's always a little bit difficult to get people to look at, or change their teaching methods, so that could be hard, but done right, I think people would see the value. CT2*
Getting Buy In			The need to get stakeholders aligned with your vision of a critical thinking curriculum.	
		Preaching to the converted	Starting with a small group of learners who have some foundation knowledge/interest and then expanding curriculum	*think the biggest thing is interest, or how do you show value to people, because they need to be invested. There should be a reflection and if people don't reflect, it's not going to work out, because you have to apply what you're learning, that confirmation of bias, for example, and how that makes you approach different problems. If you don't think of an episode where you actually insert bias by conversion about bias, then you really can't apply it. So maybe starting with a small group of middle years, and then a believer's going to convince the other people that this is important* CT3
		Value	The importance of demonstrating value of a critical thinking curriculum	*think the biggest thing is interest, or how do you show value to people, because they need to be invested. There should be a reflection and if people don't reflect, it's not going to work out, because you have to apply what you're learning, that confirmation of bias, for example, and how that makes*

				you approach different problems. If you don't think of an episode where you actually insert bias by conversion about bias, then you really can't apply it. So maybe starting with a small group of middle years, and then a believer's going to convince the other people that this is important CT3
Objective 3: To explore physicians' proposed strategies for content, delivery and evaluation of a formal curriculum in critical thinking skills for pediatric residents				
Train the trainer			The need to develop a shared language and framework on the teaching of critical thinking skills.	
		Training the trainer	The need to teach preceptors how to teach critical thinking.	*And then you have the heterogeneity of the teachers, right? So you need to be probably, I guess if you were going to sort of pilot something, you'd want to choose very engaged, interested highly skilled teachers to do a few modules on common things or whatever and then that could grow, but that would be very—you would be very direct in terms of exactly how you want to be—I think it's always a little bit dangerous to be, like, "This is what we're going to do". So this is going to be like you have endocrine doing the—applying, embedding this type of teaching into their teaching, and cardiology and because you're still going to be reliant on your sub-specialists to do the teaching, but you might actually be training them to do their teaching differently. I don't know if that's what you're envisioning, but you're still going to lead a whole load of teachers to do this because it'll be particular to each sub-specialty if you're working general pediatrics and so you have a lot of heterogeneity there. So that might be a little bit hard to control or to—yeah, just a handle on, but I think that if you pilot it, you would know what kind of direction that the teachers need and I think you could get people on board if they're motivated teachers and that's their academic bent, but they would I think see that—and some of them may be doing a bit of this anyway. CT2* *Yeah, I think teachers are going to be the barriers. I: Can you expand on that? CT5: Well, because as you asked before, do I think I'm there in terms of my critical thinking skills, and my answer was no. I would feel almost—I can't find the word—as a fake. I: The imposter syndrome. CT5: Yeah. Right. To say to the learner, "Oh this is what you should do for critical thinking" and I, myself, feeling like I'm not there yet. And so, I think that would be the main barrier because I don't think we have the tools. I don't think we know we have the tools to be able to teach critical thinking. You said this was a common theme that all of us say that we're not there yet. Maybe if you show us a first-*

				year resident to now, we'll be, like, "You know what, actually we do have some skills, and we can teach things." But I think the main barrier would be us, not the learner.CT5
Content			Proposed content to include in the critical thinking curriculum.	
	Cognitive psychology	Cognitive Psychology	The teaching of cognitive psychology including bias, heuristics and metacognition	*I was lucky because I did psychology as an undergrad and I was interested in cognitive psychology which is that thinking about thinking. Learning about a lot of heuristics and biases that we have and I wrote a paper with an internal medicine doctor in med school about cognitive biases and how they play into medical decision making. I think I'm lucky in that way to have had that background that a lot of other people wouldn't have had just because of chance and what I did before medicine. I think that that's contributed a fair bit to how I think about thinking. – CT1*
	Critical appraisal	Critical Appraisal	Learning how to critically appraise evidence and apply to your practice	*I think we do use critical thinking in one section is research. We do force that resident to read an article and then critically appraise it, and then come out and say if this was a valid article or not a valid article.CT5*
Delivery			Proposed educational strategies for delivering a curriculum on critical thinking.	
	Embedded Curriculum			
		Embedded in Curriculum	The teaching of critical thinking embedded throughout medical education	*I do think it needs to start in medical school. This isn't something that should start day one of residency. This needs to go way back to clerkship and even before where these people need these skills, then, when it's actually not that impor—it is important, I guess what I'm saying is that in residency, they have so many other demands of time. In clerkship, I really feel like it's just, "here I am being a clerk", and then you could hone those skills then, then you could carry them to residency, that would be super helpful. It's just a question of if you could do it earlier. CT4*
		Clinical Setting	The teaching of critical thinking in the clinical setting.	*I caution you about bringing it to the classroom setting because I do think there is something lost in that, though there may be a place for introducing the concepts of critical thinking so that when people are actually applying it at the bedside, they are able to be a little bit more mindful about the process and really work on their various pieces of trying to apply critical thinking. So there's probably a place for it in the half-day curriculum to introduce some of the ways to go about doing it, but the actual applying it and practicing it, I think, yes, we should have a formal curriculum, but that*

				curriculum should be applied in clinical context, would be my thoughts. CT8
		Tip sheets	The use of tip sheets to help remind preceptors on how to teach critical thinking in the clinical setting	*…and then similarly for people who are supervising residents clinically, that they should be either 10 tips for how to absolutely embed this into your teaching. You know what I mean? CT2*
	Teaching Methods			
		Case Based	Focusing teaching of critical thinking around a clinical vignette	*The last half-day we all went down to the presentation of one of the other pediatricians gave was kind of, it was actually almost like the paper that I had. It was some of her interesting cases that she highlighted, and she highlighted was in which cognitive biases for different diagnoses and the way that the bad case of her gone, which I thought was really interesting. - CT1* *then really keeping something very case-based in terms of almost like a choose-your-own-adventure, so you have the classic presentations, but you also have things that are weird or the wonderful, or the pitfalls or the difficult ones, or the ones where people really tend to have trouble around the decision making, and you allow the learner to walk that path with the patient and making decisions all the way and it's guided or facilitated by an expert, and that actually understanding that they've already done all the background reading, but now it's really application and interpretation of lab results or radiological investigations or physical findings on the patient.CT2*
		Small groups	The use of small group sessions to teach critical thinking	*Probably a different way might be, like, small groups where you give people those case examples and ask them to point out what might have happened, and what people were thinking or come up with their own examples of times that they've seen things happen in their own training, small group discussion piece, because that is often not in teaching other people are often the things that get—materials that stick fast. CT1*
		Flipped classroom	Having learners prepare for a teaching session ahead of time	*I like flipped classroom a lot. I think that that is the nice way of allowing the learner to think about those few steps we talked about off the top, like if you allow the learner to get their baseline level of knowledge, up by reading or even if that's attending a more didactic kind of lecture, that sort of thing, CT2*
		Reflection	The use of self reflection on clinical experience to teach critical thinking	*There should be a reflection and if people don't reflect, it's not going to work out, because you have to apply what you're learning, that confirmation of bias, for example, and how that makes you approach different problems. If you don't think of an episode where you actually insert bias by*

				having a conversation about bias, then you really can't apply it. CT3
		Simulation	The use of simulated clinical scenarios and debriefing to teach critical thinking	*simulation is a very good way in paediatrics because of the low frequency of events, but we struggle, as you know, right. I think the biggest struggle is acute situations where talking to, for example, other people that do 5 mock codes(?for residents. It's a big, big struggle to have them just follow the A, B, C, Ds, right, and just learn some CRM skills, and I would like to think that as fellows, they do a lot more of that and that what really helps them think through things, but also I think there's interest, so we do mock codes once a month for residents and every time, it's frustrating. CT3* *It's a lot more challenging, a lot more reflective practice with the learners. A lot more, sort of understanding why they made decisions versus just saying they were wrong. So we're teaching the background, I might ask a question, if someone doesn't know, I don't go, "Why did you think that?" Whereas I think in simulation we do that a lot better because often just uncovering people's reasons for their answer wrong or right is really interesting, and I think that educators should do that more. There's a reason why people aren't getting the answer, and if they just tell you, "I either, a, didn't know, or I did know and I made it up." There's lots of reasons people say stuff, and that might uncover some misconceptions. CT4*
		Podcasts	The use of podcasts to teach about critical thinking	*you can deliver that in a podcast, I think, which I think is a really, really good idea. I'm not sure there's any healthcare related critical thinking or bias teaching approach in there. I don't know. Do you know of any podcasts? CT3*
		Online modules	The use of online content to deliver curriculum	*modules online, but find there needs to be some interest to absorb that, right? CT3*
		Didactic lectures	The use of didactic lectures to teach about critical thinking	*Didactic teaching's often helpful to give people the background, but I think you need to include a lot of work with respect to self-directed work and how to improve critical thinking that way versus just talking about it CT4* *that I also saw my colleague give a didactic lecture on cognitive biases which I thought was interesting, and good because I don't feel like that's something that we got. CT1*
Evaluation			Proposed methods of evaluation of a critical thinking curriculum at both the program and individual level.	
	Program level			

		Patient Outcomes	Using patient outcomes to evaluate critical thinking skills	*That would be a very hard thing to evaluate. You could do it on a very macro level and really look at patient outcomes pre- and post-implementation of the curriculum, but I don't ever think you'd get enough, I don't think you'd have enough impact to probably see that.* CT1
		Contribution analysis	The use of statistical modelling to identify the impact of a curriculum on an outcome	*One new thing called contribution analysis, which is a different way of looking at program evaluation, which comes more from the federal government because they do lots of programming, looking at can you attribute changes (ie: residents, the care being more effective, or the residents being more confident, or they do better on their exam, or whatever measure you want), and then can you attribute to a change—So if the only change that happened was this new program, then you can kind of attribute it in hindsight, but there's a way of—I'd talked to ____ about that one time just trying to think of novel ways of evaluating programs, because it's actually really tough. You can do the usual stuff, that we talked about at the beginning, but there may be more novel ways of trying to see if this is the change that happens in the curriculum and there's not a lot else that changes about the curriculum and then there's particular outputs that you identify in terms of, well, CT 2*
	Individual level			
		Learner Self Assessment	The use of learner self assessment of perceived confidence or satisfation with critical thinking skills	*So then you're back to the thought that's like, yeah, the confidence and the—which I think is not like completely, I think those are actually important measures. I wonder if it's a more formalized critical thinking piece would actually improve residents' self-advocacy which allows them to do more decision making, you know what I mean? Less reliance on staff and more independent, which is what you need to be doing in an R3/R4. They need to be—I think they probably need to be better at that, and so this type of change might help them to do that, help them to get there. They're confidence is higher so they feel like they can make the decision, I think you could do things like self-advocacy, or confidence from the learner, right?*
		Competence By Design	Including an evaluation of critical thinking in the competence by design framework	*It'd be interesting to know what happens with CBD over time and the frequent assessments that you guys are going to have, with the EPAs and milestones. Whether you could somehow embed critical thinking—I think the milestones are already made, but you could easily embed some critical thinking-type questions in those milestones like when people are filling them out because the assessments are now more frequent, right? And so if you have a case and you're PGY1 and your milestone is to go assess a kid in Emerge and do a proper admission and diagnosis, there needs to be a critical thinking aspect. So did this person think about all*

				possible differential diagnoses, were they able to remove fixation error. Did they have—you could actually think about that every time you have an assessment. Then the question is, could you look at your EPAs before, or half the group gets this thing and then half the group doesn't, follow peoples EPAs and milestones. I don't know. Because you're going to have frequent assessments in the future. CT4
		OSCE	The use of observed, structured clinical examinations to evaluation critical thinking	*OSCEs are really great. Yeah. I think that could help in terms of at least having a measurable outcome that you could use every single year. CT5*
		Clinical vignettes	The use of clinical vignettes to explore a learner's clinical reasoning and to evaluate their knowledge and recognition of cognitive bias	*the cognitive biases - you can design scenarios that highlight those and you can put people through them and see how they respond to them before and after, something like that. So you could do an intervention like that that would test it to see, what are people's thought processes and can I measure how that is [done]. CT9*
		Assessment	Placing value on the learner's assessment or impression of a patient through bedside teaching or documentation to evaluate their critical thinking	*I use that as an evaluative tool for my trainees, as well, is their charting, especially at the higher level. The NICU is overwhelming for more junior trainees, but as that familiarity is acquired after repeat rotations, especially the senior residents and the fellows, you really get a window into their understanding and their thought processes based on their written documentation, especially when, at the beginning of the rotation, you've helped them to understand what you're looking for with the progress notes and the documentation, and then you really get an idea of where some extra education needs to happen.CT8*
		Preceptor assessment		*You could do assessment from—assessing what the supervisors think in terms of a performance for the trainees on shift or on service kind of assessments. Comparing those to—I guess if you really wanted to, you could have some residents have this new curriculum, and some residents not and see the difference between them that way.CT2*

Appendix C – IDEA assessment tool

Baker et al's IDEA assessment tool for written documentation[35].

Tell me your IDEAs ASSESSMENT TOOL

A tool for assessing clinical reasoning based on documentation in comprehensive new patient notes

Student Name:	Rater Name:	Date:

Rate the quality of each section of the written note based on the extent to which defined elements are present
1 = minimal to no elements
2 = some to many elements
3= most or all elements

WRITTEN HISTORY

Detailed history of presenting illness
Defined as including a complete description of the complaint(s) such as location, quality, severity, duration, timing, radiation, factors that aggravate or alleviate symptoms
1 2 3

Descriptive history of presenting illness
Defined by use of semantic and descriptive vocabulary such as acute or chronic, sharp or dull, continuous or intermittent
1 2 3

Chronologic history of presenting illness
Defined as telling a clear story that flows logically
1 2 3

Contextualized history of presenting illness
Defined by identification and inclusion of key findings from past, family and social history and relevant other symptoms that might otherwise belong in later portions of the comprehensive history
1 2 3

Complete comprehensive history
Defined as a complete past, family, and social histories and complete review of systems 1 2 3

WRITTEN PHYSICAL EXAMINATION FINDINGS

Complete physical examination 1 2 3
Defined as documenting a comprehensive examination

Key physical examination findings 1 2 3
Defined as including an exam that highlights the absence and presence of key exam findings, as suggested by the diagnostic possibilities

WRITTEN ASSESSMENT

Interpretive summary
Defined as providing a concise summary statement that uses semantic vocabulary to highlight the most important elements from the history, exam, and testing and to interpret and represent the patient's main problem(s).
1 2 3

Differential Diagnosis
Defined as offering more than one relevant diagnostic possibility, committing to what is most likely and considering what is less likely or unlikely yet important to consider.
1 2 3

Explained well
Defined as explaining the reasoning behind the lead diagnosis, including the epidemiology and key features and how these compare/contrast with the patient's presentation.
1 2 3

Alternatives well considered
Defined as explaining the reasoning behind alternative diagnoses, including the epidemiology and key features and how these compare/contrast with the patient's presentation and the lead diagnosis.
1 2 3

WRITTEN PLAN

Well reasoned plan 1 2 3
Defined as including reasons for diagnostic testing and treatments and summarizing the evidence used to support decisions

IDEA ASSESSMENT TOOL

Please rate the skills this student documented in this patient note:

Reporting skills (based on Written History and Physical Exam Findings)

- ☐ Early: includes *some* important elements of history, exam, and test findings (1 point)
- ☐ Good: includes *many* important elements of history, exam, and test findings (2 points)
- ☐ Excellent: includes *nearly all or all* important elements of history, exam, and test findings (3 points)

Diagnostic reasoning skills (based on Written Assessment)

- ☐ Early: *errors* in diagnostic accuracy OR *limited explanation* of reasoning OR *errors* in reasoning (1 point)
- ☐ Good: *commits* to *at least one* pertinent diagnosis, accurately defines *epidemiology* and *key features* of diagnosis and compares to the patient's history, exam, and test findings (2 points)
- ☐ Excellent: includes *complete, pertinent* differential diagnosis, commits to most likely diagnosis, *accurately* defines epidemiology and key features of most likely diagnosis and alternative diagnoses, and compares/contrasts with the patient's history, exam, and test findings (3 points)

Decision making skills (based on Written Plan)

- ☐ Early: *lists* diagnostic testing and treatment plans (1point)
- ☐ Good: *uses sound reasoning* to support *some* diagnostic testing and treatment plans (2 points)
- ☐ Excellent: *uses evidence* to support most important diagnostic testing and treatment plans, considers patient preferences (if applicable) (3 points)

Total Points = (9 possible)

IDEA Assessment Tool 2014
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