PEDIATRIC ENDOSCOPY TRAINING AND ASESSMENT

UNDERSTANDING THE CHALLENGES IN PEDIATRIC ENDOSCOPY TRAINING:

PATHWAYS TOWARDS COMPETENCE

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Lay Abstract

Performing endoscopy – a procedure that lets doctors look inside the gastrointestinal tract – is an important part of being a pediatric gastroenterologist. Because of this, it is important to explore how to teach endoscopy skills to doctors in. This thesis includes two parts. First a scoping review looking at the research currently available was done to map out and summarize how endoscopy is taught. This helped to explore which teaching strategies exist, the skills they target and what gaps remain. Second, a qualitative study interviewing pediatric gastroenterologists in training and in practice was completed to explore which skills are needed to perform endoscopy. This study looked at what parts of endoscopy are hard for learners and how the teaching strategies can be improved in pediatrics. Together these findings can serve as a guideline for a structured training program that might help better teach doctors learning endoscopy more effectively.

Abstract

Background: Effective endoscopy in pediatric gastroenterology requires seamless integration of technical skill, clinical judgement and clear communication. Considerable variation exists across training programs, raising concerns about the reliance on procedural volume as a marker of competence. This thesis aims to explore strategies for endoscopic training, identify areas that are challenging in pediatrics, and determine existing gaps in pediatric endoscopy education.

Methods: This sandwich thesis comprises of two distinct studies. The first is a scoping review of the literature published over the past decade (2014-2024) examining educational interventions in endoscopy training within gastroenterology and general surgery. Second, a qualitative descriptive study involving semi-structured interviews with pediatric gastroenterology faculty and trainees at training centers across Canada. The interviews explored essential skills for pediatric endoscopy, experiences with simulation and perceived gaps in current training practices.

Results: The scoping review (n=179) revealed a wide range of educational interventions including didactic sessions, simulation-based training and hands-on procedural instruction. Additionally, it highlighted the inconsistent use of several assessment tools, underscoring a lack of consensus for both training and assessment of endoscopy which is amplified in pediatrics. The findings from the qualitative study identified four key themes that elaborated on the these findings, including the critical role of cognitive and integrative skills, the progressive complexity of challenges within training, and the need for a more structured approach to both training and assessment.

Conclusions: By exploring the breadth of the evidence from the scoping review and a the depth of qualitative insights, this thesis ascertains the current practices and gaps within endoscopy training. Recommendations include developing a structured endoscopy training program incorporating regular and constructive feedback, dedicated teaching sessions covering both fundamental and advanced concepts, guidance on troubleshooting and management of complications for complex procedures, and opportunities for longitudinal simulation practice.

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Preface – Declaration of Academic Achievement

The two manuscripts included in this thesis represent original work completed by **Dr. Ruchika Sharma.** As first author of both these manuscripts, she developed the project question, design conducted interviews, collected data, performed thematic analysis and wrote the majority of both papers.

Dr. Elif Bilgic, as primary supervisor and senior author on both articles, contributed to and refined the project design, data analysis and provided meaningful feedback that shaped the project in its entirety and both manuscripts.

Co-author contributions are as follows:

Dr. Anita Acai: Refined the manuscripts and final thesis with feedback.

Dr. Mary Zachos: Refined the manuscripts and final thesis with feedback.

Jasmin Dhanoa: Contributed to the writing and data collection for paper one.

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Cynthia Youssef: Contributed to the writing for paper one.

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Jo-Anne Petropoulos: Contributed to the online search strategy of the literature for paper one.

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CHAPTER ONE: INTRODUCTION

Thesis Structure

This work is presented in a sandwich thesis format and consists of two independent manuscripts that have been prepared for submission to peer-reviewed journals. Consequently, the first chapter, or introduction, aims to establish the foundation for this work by providing a comprehensive background, rationale and objectives for this work. Following this, chapters two and three include a pair of manuscripts that represent distinct yet interconnected aspects of the goals of this work— one a scoping review to better understand the existing learning interventions for endoscopy training and the second, a qualitative study exploring the skills required for endoscopy and the challenges and opportunities within pediatric endoscopy training. The final chapter, chapter four, reviews and synthesizes the data from both manuscripts together and how it relates to the current educational landscape.

Purpose

The purpose of this thesis is to explore the current landscape of endoscopy training as a whole, determine the aspects of training that can be particularly challenging in pediatric endoscopy training, and explore the unmet needs in pediatric endoscopy training.

Objectives

1. To identify existing endoscopy curricula available for training within the fields of gastroenterology (both adult and pediatric) and general surgery.
2. To identify skills required to perform endoscopy in pediatrics and to better understand faculty and trainee perspectives on the challenges and needs within the current training programs.

Overview of Introductory Chapter

This introductory chapter includes the following sections:

Reflexivity Statement

As a newly trained pediatric gastroenterologist with a specific interest in pediatric endoscopy training and simulation, my engagement with this work has been shaped by both my recent experience as a trainee and by my emerging role as a clinician-educator. Having recently undergone sub-speciality training and navigating the challenges associated with learning endoscopy in the pediatric setting provides a deep understanding of the learning curve, emotional demands and technical intricacies involved in becoming a competent pediatric endoscopist. These perceptions and my own personal experiences have likely influenced how I approached interview design, interview question development, and the analysis of participant responses.

As such, given my personal and educational interests in improving endoscopy training and positive experiences with simulation in endoscopy may have led me to highlight certain themes such as standardization of training, gaps within training and simulation, as well as

approach to feedback in endoscopy. While my passion for these aspects of training drives my research, I have remained conscious of my assumptions and have continuously questioned my interpretations to ensure that that participants' voices have truly shaped the outcomes of this research irrespective of my presumptions.

Throughout this process, I have aimed to maintain reflexivity by regular discussions of the findings of this research with my research supervisor and revisiting the data through a critical lens. My aim has been to balance my perspectives as a recent trainee and emerging educator centering around maintaining the authenticity of participants' experiences.

Introduction to Pediatric Endoscopy in Competence by Design (CBD)

The field of pediatric gastroenterology has been established as a discipline since the 1960s and has continued to grow rapidly since.[1] With further recognition of pediatric disorders within the speciality and the need to better evaluate the gastrointestinal (GI) tract, the need for pediatric esophagogastroduodenoscopy (EGD) and colonoscopy has become routine.[1] These procedures allow for direct visualization of the intestinal mucosa and diagnosis of a variety of gastrointestinal conditions.[1] In children, these procedures are completed by specialized pediatric gastroenterologists and the need for training in these procedures has been evident since the development of initial guidelines by the North American Society of Pediatric Gastroenterology and Nutrition (NASPGHAN) in 1999.[1] Performance of pediatric endoscopy in a safe, effective, and efficient manner is vital for all trainees and practicing physicians within pediatric gastroenterology.[2]

Much like in the adult population, completion of pediatric endoscopy requires the expert execution of technical, cognitive, and integrative skills for both diagnosis and

management of a variety of gastrointestinal disorders.[2] However, unlike in the adult population, the diversity of clinical presentations and conditions in children and the integration of patients' families during procedures add layers of complexity.[2] Furthermore, the procedural indication, paramount need for ileal intubation, and importance of routine biopsies differ among adults and children.[2] Lastly, the spectrum of patient sizes and need for general anesthesia makes learning and performing pediatric endoscopy uniquely challenging both from an equipment perspective as well as from a technical standpoint.[3]

Training in both pediatric and adult endoscopy has traditionally been conducted using an apprenticeship model.[2] Typically, this involved trainees initially observing and then performing foundational skills in endoscopy under the direct supervision of an skilled endoscopist during clinical encounters.[2] With this model, the trainee's skill acquisition, aside from innate ability, has been considered dependent on procedural volume and the quality of feedback received during direct observation.[2] However, the implementation of competence by design (CBD) across Canada in pediatric gastroenterology after 2019 has resulted in a need for more learner-focused training.[4,5] CBD aims to evaluate the understanding and skills required for specific tasks required to practice safely and effectively, rather than a reliance on time-based exposure or training.[5] As a result, Entrustable Professional Activities (EPAs) have been developed to assess specific knowledge, skills and abilities required to entrust an individual to conduct these activities safely and independently without oversight.[5] Completion of these professional activities over the course of training with graded complexity ultimately is used as a measure of adequate performance prior to moving to independent practice.[5]

In the context of endoscopy, adequate performance on EPAs in training is used as a measure of endoscopic competence prior to completion of training. Endoscopic competence has been defined as "the minimum level of skill, knowledge, and/or expertise, derived through training and experience, required to safely and proficiently perform a task or procedure."[6] Therefore, in the context of CBD, there has been further interrogation into how competence is determined and the training required to achieve it.[2] As mentioned, skills required for endoscopic competence can often be divided into technical, cognitive, and integrative skills, which are all aspects that procedural EPAs in pediatric gastroenterology aim to evaluate.[2]

Technical skills may include handling of the endoscope/colonoscope, insertion and advancement, loop reduction, completion of biopsies, as well as ileal and esophageal intubation.[2,7] Cognitive skills include understanding of procedural indications and contraindications, pathology identification, and complication management.[2,7] Lastly, integrative competencies are defined as "higher-level competencies required to perform an endoscopic procedure that complement an individual's technical skills and clinical knowledge to facilitate effective delivery of safe and effective care in varied contexts."[2] Examples of integrative competencies may include skills like communication, teamwork and professionalism.[2] However, despite the development of EPAs and transition towards CBD, there continues to be an emphasis on procedural volume and subjective "gestalt" of procedural skill by the supervising physicians, which persists within pediatric gastroenterology training. Despite the rigorous process of developing EPAs within pediatric endoscopy and the shift towards CBD, there continues to be a wide spectrum of instructional methods used to facilitate skill acquisition in training programs in pediatric gastroenterology.[2]

Competence in Endoscopy

Current Metrics in Pediatric Endoscopy Training and Assessment

Historically, pediatric endoscopy has been taught via an apprenticeship training model, which has been the mainstay for teaching numerous procedural skills for decades.[8] This model allows for the provision of immediate feedback, graduated responsibility, assistance in performing challenging or complex tasks, and for teachers to observe individual progress over time.[9] However, as a training method, the apprenticeship model is associated with several limitations. Specifically, individuals who teach endoscopy often do not receive additional training themselves regarding effective teaching strategies.[8] Additionally, when trainees learn procedural skills on patients, there is increased potential for patient discomfort and prolonged procedural times to account for teaching, which subsequently can lead to decreased procedural efficacy and increased cost.[8,10] Lastly, procedures completed on patients are greatly affected by patient stability and time constraints related to efficient use of time and resources.[8,10] As a result, there has been a paradigm shift towards competency-based medical education with an emphasis on acquiring specific skills to demonstrate competence over the course of training.[11]

Despite this shift, there have been no standardized methods implemented within pediatric gastroenterology for either training or assessment of competence in endoscopy.[9] The Royal College of Physicians and Surgeons of Canada (RCPSC) defines training experiences as "experience[s] in a particular environment or set of environments selected/designed to support the learner's achievement of competencies."[12] In the context of pediatric endoscopy, this can include didactic teaching, simulation, directed feedback, use of novel technologies (e.g., artificial intelligence, magnetic endoscopic imagers), or clinical care, including procedures on

patients under direct supervision.[9] Competence is defined by the American Society for Gastrointestinal Endoscopy (ASGE) as "the minimal level of skill, knowledge and/or expertise derived through training and experience that is required to safely and proficiently perform a task or procedure."[13] To determine the effectiveness of training experiences in acquiring competence, the training opportunities themselves must undergo a rigorous assessment process. The Royal College (RCPSC) defines assessment as a systematic "process of gathering and analyzing information in order to measure a physician's competence or performance and compare it to defined criteria," which in the context of CBD is conducted for the goal of determination of competency needed for the progression to independent practice.[12,14] With respect to pediatric endoscopy, methods of assessment include procedural volume, clinical quality indicators, competency-based practice milestones, self-assessment, and direct observation endoscopic tools.[9]

Training in Endoscopy

Didactic lectures

While guided by competency acquisition rather than a defined time frame within the CBME framework, most pediatric gastroenterology training typically occurs over 2 to 3 years for most training programs in North America. While didactic teaching is a mainstay for many aspects of pediatric gastroenterology training, its use in endoscopy training is limited. Knowledge-based training may be beneficial in training for improving diagnostic accuracy, improved detection, and description of lesions.[13] However, this is not widely implemented and despite the opportunity to teach cognitive skills in this format, data suggest that cognitive skills are often acquired at the same time as basic procedural skills.[15] Often, lectures have been

paired with simulation-based-training to optimize acquisition of knowledge in addition to hands-on skills.[13,16] Additionally, lecture-based interventions on their own are unlikely to be adequate to improve procedural performance in clinical settings.[13]

Feedback

Feedback is defined as a "specific information about the comparison between a trainee's observed performance and a standard, given with the intent to improve the trainee's."[17] Typically, immediate feedback along with direct observation of skills has been the mainstay of endoscopic training in an apprenticeship based model. In this way, feedback that is provided in a constructive and non-judgmental manner can provide trainees knowledge and shape future performance over time through cycles of ongoing practice and feedback.[9] However, provision of constructive feedback can be challenging for trainees and teachers as it requires the teacher to recognize the challenges faced by the trainee, how the problem can be resolved, and for this to be communicated in a clear and actionable way. Research suggests that while both in the moment and post-procedure feedback can be helpful, the benefits of post-procedure feedback are better sustained.[9,13,16] Practically, it is recommended for feedback to be focused on established goals for the session, use consistent and direct language during the procedure, and largely be discussed after the procedure has been completed.[13,16]

Novel Technologies

As technology has continued to advance, tools have been developed to aid in the teaching and learning of procedural skills. Specifically, within endoscopy two key technologies have been magnetic endoscopic imaging (MEI) and artificial intelligence (AI)-enhanced technologies. Magnetic imagers provide real-time visualization of the scope position and

shape.[18-20] This allows for direct visualization of the effect of insertion, withdrawal, and torque on the position of the scope, which allows trainees to obtain visual feedback that can be correlated to haptic feedback of resistance and one-to-one movement of the scope during the procedure.[18,20,21] As a result, studies have demonstrated that use of MEI results in decreased loop formation, increased loop reduction strategies, and higher cecal intubation rates without assistance from a supervisor.[13,18-21] While there have only been a few, small-scale studies regarding using MEI for quantification of kinematic data during a procedure, there is potential for this technology to quantify an endoscopist's ability to navigate the colon during a procedure.[20-22] Regarding AI technologies, at the moment, the focus has been on improving adenoma detection rates by reducing blind spots, more complete mucosal exploration ,and improved identification of small or subtle colorectal polyps.[11] However, in the future, AI may be able to provide feedback for endoscopic performance and withdrawal technique, measuring the accuracy of polyp sizing or lesion identification using more accurate trainee quality metrics, such as cecal intubation rate.[11,23]

Simulation

Simulation models were first introduced to endoscopy teaching in the 1960s.[10] Simulation has been defined as "the creation of a situation or environment that allows participants to experience a representation of a real event for the purpose of practice, learning, evaluation, testing, or to gain an understanding of systems or human actions."[24] The goal of simulation-based training, since its introduction, has been to help trainees acquire new skills, accelerate the learning curve and provide a learning environment in which trainees can learn and practice with no risk to patients.[24-26] Beyond technical skills, simulation can be used to

augment non-technical skills such as communication and teamwork.[24,25,27] By practicing such skills in team-based settings, trainees can learn to automate effective behaviours and potentially reducing stress, which is critical in clinical settings.[24] Despite these advantages, simulation training has not been shown to be comprehensively effective as the benefits of simulation with respect to skill acquisition have not clearly been demonstrated to persist over time.[8,24] Additionally, barriers to wide-spread incorporation of simulation into training programs includes a need to determine the appropriate timing, frequency and application of deliberate practice for simulation.[8,24]

In endoscopy training, there are four primary forms of simulators that are currently used. This includes: (1) mechanical simulators, (2) part-task trainers, (3) in or ex-vivo animal organ simulators, and (4) computerized/virtual reality simulators. [8,28] Mechanical simulators are physical models that are made from non-tissue materials and represent anatomic structures with which endoscopic procedures can be performed.[8,28] Many mechanical models are commercially available for a multitude of tasks such as upper endoscopy, colonoscopy and ERCP, and are often used for novices early in training because they lack realism. Alternatively, part-task simulators such as the Thompson Endoscopic Skills Trainer (TEST) box do not attempt to duplicate gastrointestinal anatomy but deconstruct endoscopic procedures into component skills and are another example of mechanical simulators.[8] These can include tasks such as knob/dial control, torque steering, polypectomy, tip control etc.[8] In-vivo models are live animals that are sedated and used for practice of endoscopic procedures.[8,28] However, their use is limited due to the associated expenses and infrastructure required to regularly sedate animals, along with the associated ethical concerns. Ex-vivo organ models are typically a

combination of plastic or silicone housing with explanted animal organs, which provide the increased realism with haptic feedback of real tissue and ability to use real endoscopic tools while limiting some of the ethical and resource limitations of in-vivo models.[8,26-28] Computerized or virtual reality simulators combine tactile and visual interfaces, which allow trainees to practice cognitive and technical skills in different environments or conditions.[8] These models can be expensive but allow for standardization of training and allows trainees to obtain experience with procedural complications without risk to patients.[8,27-29] Overall, simulation training is meant to augment learning as opposed to replace patient-based experience , particularly with new equipment or techniques.[27]

Thus far, there has been widespread interest in incorporating simulation into endoscopic training; however, it has not yet been universally adopted. The optimal timing, frequency, and type of simulation and delivery methods have not yet been established. However, the following four best practices have been identified to improve the efficacy of endoscopic simulation training: (1) deliberate practice with masterly learning, (2) feedback and debriefing, (3) contextual learning, and (4) innovative educational strategies.[24] Deliberate practice is defined as repetitive performance of a skill with feedback where exercises can be used to correct mistakes and improve performance.[24] Mastery learning is defined as consistent execution of a skill at a clearly stated proficiency level.[24] Currently, the literature suggests that endoscopy simulation is beneficial in the early on in training with increased skill acquisition; however, these effects have not been shown to persist past 20-50 real-life procedures.[8,24,26,27] Additionally, ex-vivo simulation has been shown to be effective at teaching advanced therapeutic maneuvers such as hemostasis, demonstrating clinical benefits such as more rapid

hemostasis and decreased re-bleeding rates. The American Society for Gastrointestinal Endoscopy (ASGE) has developed the following goals for curricula surrounding endoscopy simulation: (1) Simulator training ideally results in a 25% decrease in clinical cases needed for trainees to achieve competence, and (2) simulation assessment tools should correspond with minimal competence thresholds with a kappa value of 0.70 or more.[8] Major gaps exist in the assessment of clinical competence due to difficulties correlating performance on simulators and clinical competence. Thus far, assessment using endoscopic simulators have not been able to reliably discriminate between novices and experts.[29] Lastly, prior to the universal adoption of simulation modules, the optimal timing and frequency of simulation modules must be established.[8] Trials of structured simulation curricula have demonstrated spaced practice to be effective in accelerating performance. This type of curriculum has not been evaluated with "just-in-time" simulation practice wherein trainees practice on simulators prior to performing procedures on real patients or other gamification strategies.[24,30] Gamification refers to the use of concepts associated with game design in non-traditionally game-related concepts, which in the endoscopy context may include concepts such as medallions that are achieved through VR simulation to encourage repetition and accuracy.[30] Therefore, current research priorities include: (1) investigation of effective simulation training models and (2) development of guidelines for integration of simulation practice within training programs.[8,25,26]

Assessment in Endoscopy

As mentioned above, endoscopy training aims to provide opportunities for trainees to learn and practice the cognitive, technical, and integrative skills required to complete pediatric gastroenterology training and enter independent practice. However, to determine if training

strategies are effective, one must have methods of assessment that have established and evolving validity evidence to measure if current training strategies are successful in reaching this goal. Unlike other aspects within pediatric gastroenterology training, there is no summative assessment for competence within endoscopy. Rather, determination of competence for the purposes of graduation and transition to independent practice is based on a combination of the following metrics: procedural volume, clinical quality indicators, formative assessments through direct observation using assessment tools such as EPA assessment forms. However, the use of these metrics for assessment is variable, and the ideal metric of assessment in pediatric endoscopy have not yet been determined.

Procedural volume

Until the recent shift towards Competency Based Medical Education (CBME), procedural volume was the primary surrogate for competence within endoscopy training.[31] There is limited learning curve data in pediatrics, so numeric thresholds have been largely inferred from adult data.[2] In pediatrics, the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN) have determined that a minimum of 100 esophagogastroduodenoscopy (EGDs) and 120 colonoscopies are required for competence with a goal of cecal intubation rate >90%.[2] This is slightly less than the adult gastroenterology thresholds outlined by the ASGE, which suggest the minimum procedural targets by the end of gastroenterology fellowship denoting competence to be 130 EGDs and 275 colonoscopies. The thresholds by ASGE has been based on learning curves that demonstrate the minimum threshold of consistently demonstrating a 90% independent intubation rate of the second portion of the duodenum and cecum, respectively.[9,16,32] Furthermore, as previously mentioned, in the pediatric context cecal

intubation rates alone are inadequate as intubation of the terminal ileum is often required and critical for diagnosis, yet are not even included in these metrics related to procedural volume.[2] Much like in the adult population, there is variation within the pediatric thresholds among different regulatory bodies, with the United Kingdom (UK) recommending 100 EGDs and 100 colonoscopies with ileal intubation, Australia requiring 200 EGD and 100 colonoscopies, and Korea requiring 100 EGDs and 30 colonoscopies.[2,33] Finally, while EPAs do take terminal ileal intubation into account, competence standards for graduation only require 10 colonoscopy procedures to the level of the terminal ileum, further highlighting the variation present in thresholds for procedural volume.[34] Additionally, procedural volume alone is a less reliable method of measuring competence as it does not provide trainees or educators adequate information about the nature of the learning that was achieved from each case.[31] As such, there has been a shift towards the use of procedural volume as a minimum competence threshold, which is defined as "a recommended minimum number of supervised procedures that a trainee is required to perform before competence can be reliably assessed."[31,33]

Clinical quality indicators

In the adult population, due to the importance and increasing frequency of colonoscopy for colorectal screening, there has been a rising emphasis on ensuring adequate quality of procedures using clinical quality indicators including adenoma detection rates (ADRs), withdrawal time (WT), and cecal intubation rates (CIRs).[2,9] However, in the pediatric context, these factors may not be applicable to the delivery of safe and high-quality care.[2] In particular, cecal intubation rate may not reflect the need for consistent terminal ileal intubation for pediatric colonoscopy.[2] In the adult population, there has been a trend of increasing ADR

throughout training, which may demonstrate development of skill;, however, other studies show that ADR may be more dependent on the supervising physician compared to the individual trainee.[9] Furthermore, while the development of pediatrics-specific quality indicators may assist in the assessment and provide improved quality of endoscopic care, their usefulness as a method of providing feedback for training purposes is limited as they do not provide detailed information regarding which aspects of the procedure need to be improved.[2,31]

Direct Observational Assessment Tools

The transition to CBD has led to the development of milestones and continuous assessment of the acquisition of EPAs.[2,9,35] Milestones have been developed based on progression from novice to competent per Dreyfus' developmental pathway, although the final stage of development in this pathway is expert.[9] EPAs have been developed through expert consensus with collaboration of different GI societies and licensing bodies in the USA and Canada, but this may differ for other countries around the world.[36] CBD has been adopted for adult and pediatric gastroenterology programs across Canada and has become the mainstay of assessment of endoscopic competence within gastroenterology training.[34,36] This includes EPAs for upper endoscopy, colonoscopy, common therapeutic procedures such as endoscopic hemostasis, foreign body removal, and polypectomy has become the mainstay of assessment of competence within gastroenterology training.[34]

In addition to EPA assessments, there have been a number of direct observation assessment tools that have been implemented in the adult population.[22,35] The Direct Observation of Procedural Skills (DOPS) is an assessment tool that assesses both global and specific skills on a five-point Likert scale.[22,35] It has been found to have good inter-observer

reliability with Cronbach's alpha scores of 0.85 and 0.80 for general and specific skills respectively.[22] Because of its correlation with quality measures such as CIR, ADR, and procedural volume, the DOPS has been recommended for clinical assessment as this has helped to establish a competence threshold.[22] Additionally, this tool has been modified for polypectomy to produce the DOPyS for assessment.[35] Another assessment tool, the Assessment of Competency in Endoscopy (ACE) assesses five cognitive skills (i.e., indication for procedure, management of patient comfort, effective use of air/water/suction, lumen identification and pathology recognition/interpretation) and five motor skills (i.e., scope steering, tip control, loop reduction, mucosal visualization, and depth of insertion) for both upper endoscopy and colonoscopy.[22,35] It also provides an overall assessment of each category and additional assessment of participation in therapeutic interventions where applicable. The ACE, unlike the DOPS/DOPyS, has also established clear learning curves within endoscopy training in addition to having defined competency benchmarks.[35] It is able to discriminate between the experience of trainees in as few as 50 procedures, providing an opportunity to both follow a trainee's progress throughout training and identify those in need of early remediation.[37]

On the other hand, the Global Assessment of Gastrointestinal Endoscopic Skills (GAGES) for Upper Endoscopy (GAGES-UE) and Colonoscopy (GAGES-C) are assessment tools on a five-point Likert scale that can be used for assessment of the effectiveness of simulation-based training.[38] Similarly, when considering box-training models focused on deconstructed colonoscopy skills, the Simulates Colonoscopy Objective Performance Evaluation (SCOPE) can be used to structure feedback but may require further validation and assessment of competence thresholds before widespread application for assessment.[22] In the pediatric

context, the GiECAT$_{KIDS}$ is the only direct observational assessment tool that has demonstrated reliability and validity.[31] It, much like the ACE and DOPS, assesses both cognitive and motor skills. While it can differentiate between experienced and novice endoscopists, there are no defined learning curves or competency thresholds for this assessment tool. Lastly, despite establishment of these tools with established validity evidence, their use remains variable based on the structure of the program and the adoption of a particular tool by different groups for assessment. For example, the ASGE recommends that at least 10% of procedures completed by trainees should have an associated direct observational assessment completed.[39] These may be incorporated for randomly selected cases, a specific day per week, or at particular time intervals (i.e., after every 50 procedures).[39] Unlike in the UK where the DOPS has been integrated into the training and credentialing guidelines, there has been less consistent uptake of these assessment tools in other parts of the world, including North America.[31]

Challenges to Achieving Endoscopic Competence in Pediatrics

In pediatric endoscopy, both the volume of endoscopic procedures due to the need for general anesthesia and number of trainees and teachers are significantly reduced compared to the adult population.[40] However, there are many distinctive aspects of endoscopy in pediatrics that include but are not limited to differences in anesthesia, procedural indication, need for ileal intubation, routine biopsy sampling, and age or size-specific equipment specifications.[2] As a result, training and assessment of endoscopy cannot be directly translated from the adult setting to the pediatric context.

Furthermore, there appears to be a considerable difference between the recommended pediatric procedural volume competency thresholds and the procedural volume trainees report in practice. A survey completed by second and third year North American pediatric gastroenterology trainees found that only 58% of trainees met the recommended thresholds for upper endoscopy, 11% for colonoscopy, and 10% for polypectomy thresholds.[40] Similarly, another survey found that irrespective of the size of the North American training program, 48% of the trainees completed less than 100 colonoscopies in their training program, despite the recommended threshold of more than 120 colonoscopies for achieving competence.[40] This disparity is further highlighted in therapeutic endoscopy procedures. In North America, only 67% of training programs met the thresholds for polypectomy, 17% for non-variceal hemostasis, 42% for endoscopic dilatation, and 58% for foreign body removal.[40]

As a result, there is a clear need for training strategies to improve both the learning curve for the above procedures in pediatric gastroenterology and the development of pediatric-specific assessment strategies for the same. Current methods of assessment, such as quality

metrics used in the adult population or simulation-based assessments, are challenging to use in the pediatric context because of their limited applicability (e.g., adenoma detection rates) or lack of clearly defined learning curves in pediatrics.[2,40] There continues to be ongoing research in developing assessment tools and establishing validity evidence for measurement of competence in pediatric endoscopy; however, a defined training curriculum has yet to be developed. It is also important to acknowledge that competency in pediatric endoscopy extends past fundamental technical skills. Understanding the specific skills that would be important to be taught during endoscopy training, in addition to optimal assessment strategies, will help in the development of a pediatric endoscopy curriculum that go beyond the fundamental skills that are the focus of the currently available education programs. Exploring the experiences of both staff and trainees within current endoscopy training practices in Canada may help elucidate which approaches have been effective in addressing these concerns, and which areas require further research and development.

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CHAPTER TWO: Paper One – Exploring Curricular and Assessment Interventions in Gastrointestinal Endoscopy: A Scoping Review

Exploring Curricular and Assessment Interventions in Gastrointestinal Endoscopy: A Scoping Review

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Introduction

Endoscopy plays a fundamental role in pediatric gastroenterology, enabling practitioners to diagnose and manage gastrointestinal disorders. It requires both technical proficiency and cognitive competencies to ensure safe completion of the procedure. Like adult gastroenterology, pediatric endoscopy demands a blend of skills. However, pediatric endoscopy introduces additional challenges due to age-specific anatomical and physiological variations, differences in indications for procedures, and a broader spectrum of diseases resulting in children.[2]

Pediatric gastroenterology training is typically structured as a two- to three-year subspecialty residency program. Historically, endoscopy training has followed an apprenticeship model, where trainees develop skills under the direct supervision of experienced endoscopists.[2] In 2021, Canada's medical field transitioned to Competency by Design (CBD), which follows the Competency-Based Medical Education (CBME) framework.[41] CBME can be defined as "an outcomes-based approach to the design, implementation, assessment, and evaluation of a medical education program using an organizing framework of competencies."[42] The CBD framework has four main stages of postgraduate training: Transition to Discipline, Foundations, Core, and Transition to Practice.[43] Each stage encompasses Entrustable Professional Activities (EPAs; e.g. performing procedures, patient management, forming a diagnosis, etc.) and milestones, which are used to determine competency of trainees.[43] Additionally, the CBD framework is transforming specialties and subspecialties by shifting training from time-based learning to outcome or competency based outcomes. This allows for tailoring of assessments

based on the needs of specialty/subspecialties by evaluating observable skills aside from knowledge alone.[41]

The CBME framework emphasizes the need for well-defined proficiency thresholds to ensure that trainees develop the necessary skills to perform pediatric endoscopic procedures competently. While structured endoscopy curricula exist for surgical and adult gastroenterology programs, these primarily focus on basic techniques.[7,44,45] Endoscopy competence focuses on technical (e.g. tip control, torque steering), cognitive (e.g. knowledge of indications and risks of procedure), and integrative (e.g. communication, collaboration) domains.[2] In adult gastroenterology, independent procedural volume has traditionally served as a proxy for competency. However, skill acquisition varies significantly among trainees, and applying this approach to pediatric endoscopy remains problematic.[2]

Pediatric endoscopy presents unique challenges, including differing indications for procedures, the critical role of ileal intubation, and the necessity of routine biopsies. There is limited research on learning curves for endoscopic skills in pediatric trainees, meaning current estimates for minimum procedural requirements are largely extrapolated from adult data.[2] Despite these distinctions, a standardized pediatric endoscopy curriculum tailored to these complexities has yet to be fully developed.[2,46] Existing data suggest that many pediatric gastroenterology trainees do not meet recommended procedural thresholds by the end of their training. A survey of second- and third-year trainees in North America found that only 58% met NASPGHAN's recommended threshold for upper endoscopy, while even fewer—11% and 10%, respectively—achieved competency targets for colonoscopy and polypectomy.[40] Additionally, nearly half (48%) of third-year trainees had performed fewer than 100 colonoscopies, despite a

recommended minimum of 120.[40] These findings raise concerns about whether current training structures provide sufficient hands-on experience for trainees to achieve competency.

Lastly, advancements in endoscopy training have introduced novel techniques and tools, such as Magnetic Endoscopy Imaging (MEI), dynamic position changes, water-assisted ileocolonoscopy, and endoscopy simulation.[3] However, most of these innovations have been designed with adult patients in mind (i.e., unique anatomy, size-appropriate equipment), limiting their applicability to pediatric trainees.[3] Moving forward, there is a pressing need to adapt these training advancements to the pediatric population and to establish evidence-based guidelines for competency assessment of the requisite skills.

Objectives

The purpose of this scoping review is to identify existing endoscopy curricula currently available for training within the fields of gastroenterology (both adult and pediatric) as well as in general surgery. With this, we hope to identify the common topics within the curricula, methods of assessment, and key competencies that are targeted within both esophagogastroduodenoscopy (EGD) and ileocolonoscopy.

The specific objectives of this review are:

1. Identify the curricula available to adult and pediatric gastroenterology trainees and general surgery trainees to learn endoscopy and colonoscopy skills
2. Identify the types of educational interventions used within these curricula
3. Determine the challenges and future directions of endoscopy training

Methods

This scoping review is centered around the reporting guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA). The primary methodology chosen was a scoping review as this would allow for the identification of existing curricula and learning interventions in training gastroenterology trainees, how research is conducted on these learning interventions, and to identify any knowledge gaps within the field. Moreover, a scoping review would help identify the breadth of existing knowledge within gastroenterology training and CBME and the areas that lack research and understanding. A scoping review is the ideal methodology to map and explore the current understanding of the learning interventions in gastroenterology given that the evidence within this domain is changing in the context of the transition towards CBME.

Search Strategy

A search was conducted in November 2023 to identify relevant articles published between January 2014 and January 2024 using the bibliographic databases ERIC via EBSCO, LILACS, MEDLINE, PubMed, Embase, PsychINFO, Scopus, The Cochrane Library, RDRB, CINAHL (Medline Search Strategy in **Appendix A**). A 10-year time frame (2014 – 2024) was selected to ensure the scoping review included the most relevant evidence reflecting current practice, while balancing comprehensiveness with feasibility to ensure the volume of literature was manageable and captured key innovations in technology and simulation. The research objectives were considered by assessing the relevance of the first ten articles obtained from each iteration of the search strategy. Key words and a search strategy were developed with the help of a librarian at McMaster Health Sciences Library. The search strategy was adapted for

each database, allowing key words to be mapped onto the subject headings to search for relevant articles.

Inclusion & Exclusion Criteria

Articles were included if the studies (1) were in English, (2) were published from January 2014 to January 2024, (3) were empirical studies (i.e., validity studies, surveys, interviews, retrospective studies, observational studies, prospective studies, cross-sectional studies, longitudinal studies), editorials, letters, or original commentaries, (4) involved studying postgraduate medical learners (residents or fellows), (5) focused on skills in the context of the gastrointestinal tract (e.g., endoscopy, esophagogastroduodenoscopy, colonoscopy, polypectomy, percutaneous endoscopic gastrostomy (PEG) tube placement, endoscopic hemostasis, foreign body removal, esophageal dilation), (6) reported data on the development and/or use of the endoscopy curricula, and (7) reported on use of a learning intervention for the assessment, formative evaluation and/or improvement of endoscopy skill acquisition.

Articles were excluded if the studies (1) were theses, protocols, reviews, unpublished literature, or conference abstracts, (2) exclusively involved medical students, faculty, or health professionals other than postgraduate medical learners (residents or fellows), (3) focus on procedures unrelated to endoscopy (e.g., laparoscopy, arthroscopy) or investigate endoscopic skills outside of the gastrointestinal tract (e.g., bronchoscopy, laryngoscopy, cystoscopy, hysteroscopy, colposcopy, neuroendoscopy), (4) investigate advanced endoscopic techniques (e.g., POEM (Peroral Endoscopic Myotomy), Endoscopic Ultrasound (EUS), Endoscopic Mucosal Resection (EMR), Endoscopic Submucosal Resection, ERCP (Endoscopic Retrograde Cholangiopancreatography), esophageal stent placement, double-balloon push enteroscopy,

capsule endoscopy, esophageal manometry, esophageal pH monitoring, fecal microbiota transplant (FMT)), (5) focus on medical education but exclusively examine other aspects of education (e.g., only clinical outcomes) without addressing endoscopy training, or (6) assess only the endoscopic skills of trainees without reporting on training methods or do not include any evaluation of trainee skills.

For the purposes of this scoping review, key topics were defined and used to guide text screening. Given this scoping review aimed to assess methods of improving learning outcomes or addressing educational gaps, a curriculum for the purposes of this review was defined as a learning intervention aimed at improving or acquiring endoscopic skills. A learning intervention was defined as any teaching method used to help trainees learn a set of objectives or skills, which was extrapolated from the Royal College of Physicians and Surgeons of Canada's definition of teaching interventions.[12] Some examples may include, but are not limited to didactic lectures, use of part-task trainers or endoscopy/colonoscopy models, video-based feedback, or simulation. The definition of simulation was adapted from Gaba's conceptualization: "a technique – not a technology – to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner."[47]

Study Screening and Inclusion

Four reviewers (RS, JD, MK, AZ) were involved in the title and abstract screening. Three pilots were conducted using a web-based tool called Rayyan to facilitate collaborative title and abstract screening pilots of articles using the program's 'blind' setting, with a small sample of the articles. Online meetings were held after each pilot to discuss the conflicts and exclude

abstracts that were not relevant to the overall goal, include any ambiguous abstracts for further review, and revise the inclusion criteria. These pilots were conducted to ensure agreement amongst reviewers and abstract screening did not begin until there was a 75% to 80% agreement rate among the reviewers.

Following this, articles were uploaded to Covidence, which is a similar web-based tools for collective abstract screening because of it's easy to navigate platform to perform a title and abstract screening from January to April 2024. The abstracts were divided and screened by the same four reviewers (RS, JD, MK, AZ). Reviewers RS and EB reviewed the abstracts that were labelled as "yes" or "maybe" by the reviewers for inclusion. In case of discrepancies, EB acted as an adjudicator and disagreements will be resolved by discussion and consensus. Eligible studies and any ambiguous articles were included if they met the inclusion criteria for the full text search.

The results of the title and abstract screening were transferred to an Excel spreadsheet. A full text search was performed using Google Scholar and the McMaster Health Sciences Library Databases from April to May 2024. If a reviewer was unable to locate a full text article, another reviewer attempted to locate the article or confirm its exclusion. Full texts that were selected for inclusion were screened independently by a second reviewer to confirm inclusion. EB acted as an adjudicator and review discrepancies/conflicts between any of the screened articles.

The full texts were then screened from May to June 2024. The full texts in the excel sheet were divided among four reviewers (RS, JD, MK, AZ) and three pilots were conducted with a small sample of the articles. Again, these pilots were conducted to ensure consistent

agreement amongst reviewers, with a pre-specified agreement rate of 75% to 80% amongst the reviewers, which follows recommended practice in the literature.[48] If agreement was below 75%, then the reviewers discussed discrepancies, refined criteria, and completed another pilot. The remaining full texts were added to an Excel sheet and divided among the four reviewers for screening and the reasons for exclusion can be found in **Figure 1**. Disagreements or questions regarding study inclusion or exclusion after pilots were resolved through discussion with the first author and research supervisor, who made the final determination by consensus.

Data extraction

The data extraction excel sheet was created by RS. The sheet was used to organize information such as publication details, participants, aims/purpose, methods, procedures within endoscopy, and relevant key findings from the full texts that were collected. Data extraction took place between June and November 2024 by four reviewers (RS, JD, MK, AZ). Two pilots were performed before the actual data extraction to ensure agreement with the data extracted. After the pilots, each reviewer extracted data from their assigned articles and added it to their individual data extraction excel sheets. After the data extraction was complete, all the data extraction sheets were combined into one Excel sheet.

Data Analysis

In this scoping review, articles were characterized based on number of articles, publication date, target population, endoscopy training, learning intervention, and our research objectives.

Results

Our scoping review yielded 8,570 unique sources of evidence, and further 365 were excluded based on year of publication. Among them, 7,532 were excluded during title and abstract screening, and another 256 were excluded as full texts were not available or the evidence source was not available in English. A total of 417 articles underwent full text screening and 179 of these underwent data extraction **(Figure 1).**

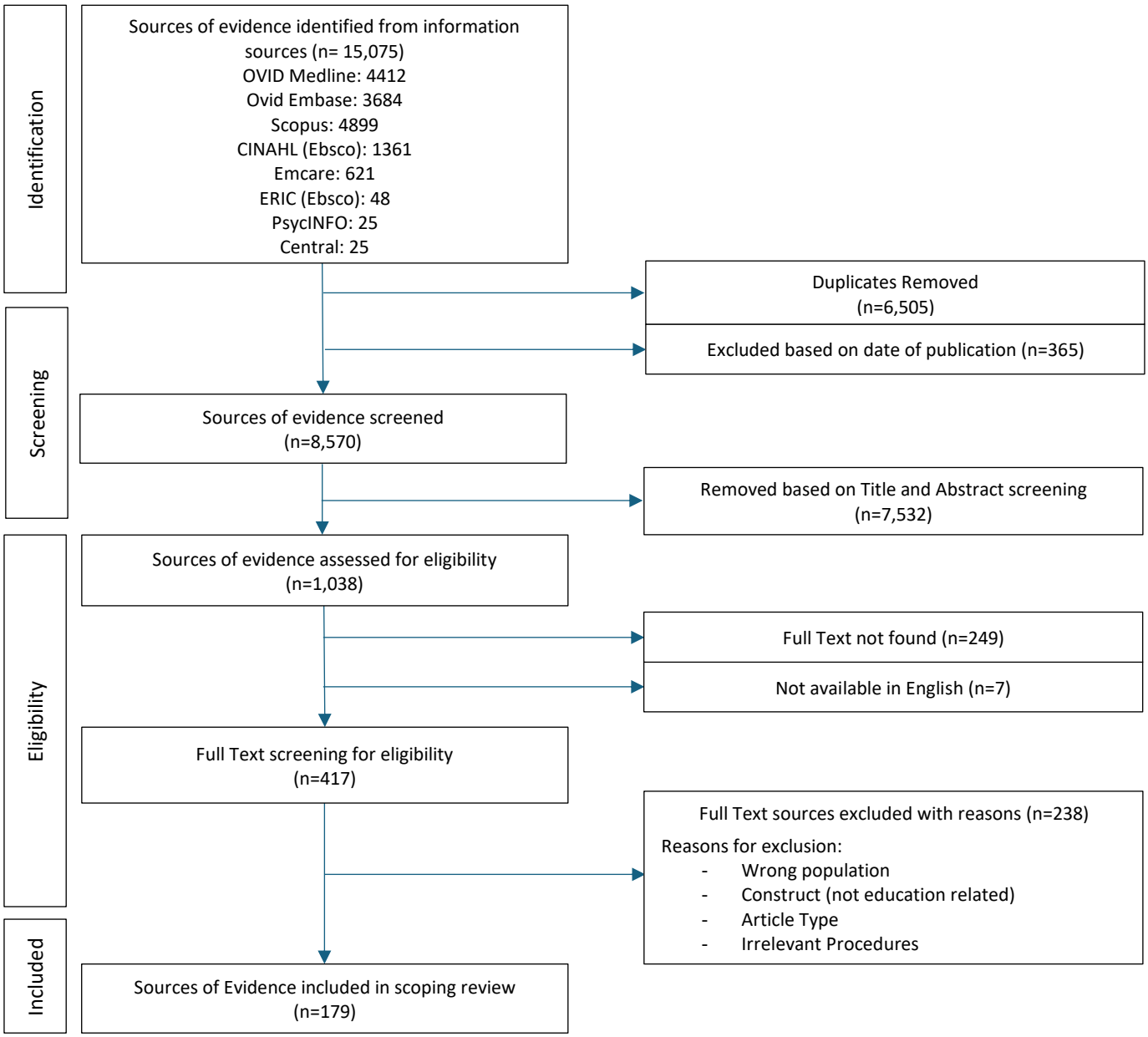

Figure 1. PRISMA-Scr diagram

Paper Characteristics

Of the 179 papers, 95 (53%) were published between 2014 and 2019, while 84 (79%) were published after 2020. Fifty-eight (32%) of these papers received dedicated funding for the project. The majority of the studies included were from the USA (87; 48%), followed by Canada (24; 13%) and the UK (15; 8%). More information can be found in **Table 1**.

Table 1. Article Characteristics

Article Characteristics	N = 179	%
Year of Publication		
2020 – January 2024	84	47%
2014 - 2019	95	53%
First Author Corresponding		
Yes	139	78%
No	40	22%
Country where the study was conducted		
USA	87	49%
Canada	24	13%
UK	15	8%
Korea	7	4%
China	6	3%
Denmark	4	2%
France	4	2%
Netherlands	4	2%
Japan	4	2%
Portugal	3	2%
Singapore	2	1%
Taiwan	2	1%
Argentina	1	0.5%
Brazil	1	0.5%
Columbia	1	0.5%
Germany	1	0.5%
Italy	1	0.5%
India	1	0.5%
Indonesia	1	0.5%
Philippines	1	0.5%
Poland	1	0.5%
Turkey	1	0.5%
Uganda	1	0.5%
Multiple Countries	6	3%
Funding		
Yes	58	32%
No	121	68%

Study Design

Of the 179 studies included, most were quantitative studies (132; 73%). One hundred and forty-three studies collected data, of which 52 (36%) were cross-sectional while 91 (64%) collected repeated measurements. Of the studies that collected data, 98 (69%) included an educational intervention. If no intervention was included, most studies used surveys (21) to collect data. Of the interventional studies, most studies were completed at a single center (92). Of those that did not collect data, the majority were letters or commentaries (26). More information can be found in **Table 2.**

Table 2. Study Design

Study design	N = 179	%
Study Type		
Quantitative	132	73%
Qualitative	13	7%
Letter/Commentary	33	18%
Multi-Method	1	1%
Number of centers involved in data collection		
Single Center	85	60%
Multi-center	58	40%
< 5 Centers	*16*	
5 – 10 Center	*13*	
11 – 50 Centers	*6*	
50+ Centers	*4*	
Not specified	*19*	
Data Collected		
Yes	143	80%
Cross-Sectional	*52*	
Repeated measurements	*91*	
No	36	20%
Letter/Commentary	*26*	
Guideline Development	*2*	
Development of a simulator	*5*	
Development of an assessment tool	*1*	
Development of an educational framework	*2*	
Educational Intervention		
Yes	98	94%
Randomized Control Trial	*13*	
Randomized Group Comparison	*8*	
Single Group Comparison/Observational	*77*	
No	6	6%
Survey	*21*	
Focus Group	*2*	
Interview	*1*	
Assessment only	*4*	
Other	*16*	
Occurrence of Verbal Feedback	*1*	
Secondary use of data	*15*	
Data from RCT	*1*	

JETS e-Portfolio Database	*5*
FES Exam Data	*3*
Retrospective Chart Review	*7*

Study Participants, Purpose, Setting

Among the 179 articles, most studies included predominantly gastroenterology fellows/residents (91; 53%) or general surgery residents (59; 35%). The purpose of these studies most commonly was for training (72; 50%), followed by assessment of performance (42; 29%). These studies were largely conducted in simulation settings (64; 58%). Assessments within these studies were most frequently completed repeatedly over the study period (52; 43%), followed next by before and after the intervention (26; 21%). More information can be found in **Table 3**.

Table 3. Description of Study Participants and Setting

Study Participants and Setting	N = 179
Population	
Residents and Fellows	171
Adult Gastroenterology	*89*
Pediatric Gastroenterology	*2*
General Surgery	*59*
Internal Medicine	*7*
Not Specified	*14*
Faculty	68
Adult Gastroenterology	*36*
Pediatric Gastroenterology	*1*
General Surgery	*20*
Not specified	*11*
"Novice" Endoscopist, not specified	5
Medical Student	7
Undergraduate Student	1
Non-Medical/Nurse Endoscopists	8
General Practitioner	4
Purpose	
Training	72
Assessment of Performance	42
Both Training and Assessment	17
Assessment of Simulator	12
Study Setting	
Simulation Lab/Center	64
In-situ Clinical Environment	37
Classroom	8
Remote/Online	2
Timing of Assessment	
Once	19
Repeated Measurements	52

Before/After Intervention	26
After Intervention only	17
Assessment only	7

Targeted Skills and Assessment

Articles largely focused on the following procedures: esophagogastroduodenoscopy (EGD; 70; 49%), colonoscopy (91; 64%) and polypectomy (18; 13%). Among the studies that collected data, 82 (57%) targeted technical skills, 34 (24%) targeted non-technical skills, and 11 (8%) targeted integrative skills. There was a wide breadth of skills included within these categories, which ranged from scope navigation to identification of pathology and communication skills. A wide variety of assessment measures were used, which included quality metrics (e.g., adenoma detection rate, cecal intubation rate, etc.), clinical measures (e.g., correlation of findings to pathology, sedation use, etc.), and specific assessment tools (e.g., Gastrointestinal Endoscopy Assessment Tool, Skill Assessment in Fellow Endoscopy Training, Direct Observation of Procedural Skills etc.). Apart from standardized examinations where trained proctors rated examinations, most studies used assessments made by expert endoscopists without specific training on the assessment tools used. More information can be found in **Table 4.**

Table 4. Targeted Skills and Methods of Assessment

Targeted Skills and Assessment	N = 143
Procedures	
Esophagogastroduodenoscopy (EGD)	70
Colonoscopy	91
Polypectomy	18
Esophageal Dilation	3
Hemostasis	11
Not Specified	*4*
Argon Plasma Coagulation (APC)	*1*
Clipping	*2*
Cautery	*1*
Variceal ligation	*3*
Percutaneous Gastrostomy (PEG) Tube Insertion	5
Foreign Body Removal	3
Flexible Sigmoidoscopy	2

Procedure not specified	4
Advanced Procedures	2
Targeted Skills	
Technical	82
Tip control	
Esophageal Intubation	
Procedural speed/efficiency	
Procedural completion	
Lesion Targeting	
Mucosal Inspection/Withdrawal	
Retroflexion	
Loop Reduction	
Scope Navigation	
Quality indicators (ADR, CIT, WT etc)	
Visualization of lumen	
Polyp retrieval	
Position change	
Air/Water insufflation	
Non-Technical	34
Lesion size estimation	
Photo documentation	
Management of Stress	
Classification of lesions	
Knowledge of accessories/tools	
Loop recognition	
Knowledge of ergonomic practices	
Sedation use	
Treatment options	
Procedural knowledge (Anatomy, equipment, pathology, technique, indications and contra-indications, bowel prep, recognition of complications)	
Integrative	11
Communication	
Global rating	
Leadership	
Teamwork	
Situational awareness	
Professionalism	
Decision making	
Comfort/Confidence with skills	
Documentation	
Assessment Metrics	
Quality indicators	63
Adenoma Detection Rate (ADR)	
Adenoma Miss Rate (AMR)	
Advanced Adenoma Detection Rate (AADR)	
Polyp Detection Rate (PDR)	
Mean number of Polyps per Patient (MPP)	
Mean number of Adenomas per patient (MAP)	
Withdrawal Time (WT)	
Cecal Intubation Rate (CIR)	
Terminal Ileum Intubation Rate	
Insertion time (IT)	
Polyp retrieval rate	
Efficiency metrics not specified	
Colonoscopy inspection quality	
Clinical metrics	75
Need for hands-on assistance (by faculty)	
Frequency of Position Change	

Need for Abdominal Pressure	
Air/Water volume used	
Hand Motion	
Sedation use	
Extent of Examination/Furthest landmark reached	
Percent of time in Pain	
Excessive bowel wall pressure/Colonic displacement	
Frequency of inappropriate maneuvers	
Efficiency of polypectomy	
Perforation rate	
Procedural Volume	
Correlation of findings to histology	
Procedure Time	
Performance indicators of colonic intubation	
Magnetic Endoscopic Imager	
Excessive Loops	
Eye Tracking	
Automated Metrics (not specified)	
Percent of time with lumen in view	
Procedural completion	
Targeting Lesions	
Questionnaires	22
Modified colonoscopy simulation realism questionnaire	
State-Trait Anxiety Inventory (STAI-6)	
NASA Task Load Index	
Questionnaire not specified/researcher developed	
Assessment Tools	49
Assessment of Competency in Endoscopy (ACE)	
Cognitive Load Inventory for Colonoscopy (CLIC)	
Skill Assessment in Fellow Endoscopy Training (SAFE-T)	
Resident Practice Audit in Gastroenterology (RPAGE) Tool	
Global Assessment of Gastrointestinal Endoscopic Skills (GAGES) Checklist	
Gastrointestinal Endoscopy Assessment Tool (GiECAT)	
Direct Observation of Procedural Skills (DOPS)	
Direct Observation of Polypectomy Skills (DOPyS)	
Rapid Entire Body Assessment (REBA)	
Rapid Upper Limb Assessment (RULA)	
Percutaneous Gastrostomy (PEG) Tube Checklist	
Simulated Colonoscopy Objective Performance Evaluation (SCOPE) Tool	
Cold Snare Polypectomy Assessment Tool (CSPAT)	
Imperial Stress Assessment Tool	
Researcher Developed Assessment Tool	
Knowledge tests	29
MCQ Exams (Researcher developed)	
Fundamentals of Endoscopic Surgery (FES) Exam	
Gastroenterology Self-Assessment Program (GESAP) Exam	
CUSUM Learning curves	3
Error/Accuracy (Simulated VR Tasks)	6

Educational Interventions and Simulation Training

Of the studies that included and educational intervention, most used simulation (70), while 26 included a didactic component either in isolation or in combination with simulation. Less common interventions included use of artificial intelligence (AI) systems, video-based

feedback, ocular metrics such as eye tracking, or multimedia-based curricula (i.e., images or videos). Only one studies stated their research was based on an educational theory which included Miller's Pyramid of Clinical Competence along with Kirkpatrick-Phillips Model of educational evaluation applied to self-assessment.

Of the studies including simulation (70; 71%), most of them used mechanical models and virtual reality simulators. Few studies used animal models; however, those that did all used pig models. Of the studies involving didactic teaching sessions (26; 27%), there were a wide variety of topics taught including a variety of technical and non-technical skills. More information is provided in **Table 5**.

Table 5. Educational Interventions and Simulation

Educational Interventions and Simulation	N = 98
Intervention Type	
Simulation	70
Didactic	26
Gastrointestinal diseases and anatomy	
Basic and Advanced polypectomy technique	
Characteristics of endoscopes and equipment set up	
Therapeutic endoscopy techniques (Argon Plasma Coagulation, PEG tube placement, Foreign Body Removal, Basic and Advanced Polypectomy, Balloon Dilatation)	
Technical Skills (scope insertion/handling, luminal observation, loop reduction, position change, biopsy technique, torque steering, recognition of pathology)	
Ergonomic positioning	
Importance of Polyp retrieval	
Integrative Skills (communication, leadership, situational awareness, teamwork, professionalism, decision making)	
Indications and Contraindications to endoscopy	
Other	
AI Systems	
Video-based feedback	
Patient-based procedures	
Multimedia/Image Curricula	
Ocular metrics (CADEYE Program, eye tacking)	
Simulator Type	
Animal Models	7
In vivo (porcine)	*2*
Ex vivo models (porcine)	*6*
Welsh Institute for Minimal Access (WIMAT) Model	
Part-Task Simulator	7
Basic Endoscopic Skills Training (BEST) Box	*2*
Thompson Endoscopic Skills Trainer (TEST)	*1*
Tip Deflection model (Academy of Endoscopy)	*1*

Researcher developed/Self-made	*3*
Mechanical Models	26
Koken Ltd. Upper Endoscopy model	*1*
Kyoto Colonoscopy Simulator	*10*
Endoscopist and Assistant's Simulator DrY Lab (EASY)	*1*
Rutgers Open Source Colonoscopy Simulator (ROSCO)	*1*
Noda-Kitada-Suzuki (NKS) Model	*1*
Modular Colon Simulator (MCS)	*1*
Endoscopy Training System (ETS)	*1*
Trus Upper Endoscopy Model	*3*
YazanoScope	*1*
Researcher Developed/Self-made	*6*
Virtual Reality Models	34
EndoVR Endoscopy Simulator (previously AccuTouch)	*7*
GI Mentor II	*23*
GI Mentor Express	*3*
ScopeVu	*1*
Hybrid Model	1
ProMIS Augmented Reality Laparoscopic Simulator	*1*

Discussion

This scoping review surveyed the extent of current practices in endoscopy and colonoscopy training with a focus on the types, validity and effectiveness of educational interventions in the available curricula. The findings of our review demonstrate that over the last 10 years there has been a large variation in the approach to teaching endoscopic skills. It highlights highly contextual nature of education, however the lack of a systematic approach to endoscopic training makes it challenging to uniformly define and assess competencies. Additionally, this review highlighted several gaps that remain within the literature in adult endoscopy training, and particularly within the realm of pediatric endoscopy such as the lack of educational interventions targeting therapeutic endoscopy procedures, methods and frequency of simulation sessions, and the lack of thresholds for competence across various assessment tools. Due to the heterogeneous nature of the study data, critical appraisal of the quality of the data included was not possible.

Many articles targeted training in either upper endoscopy or colonoscopy. Outside of polypectomy, very few targeted other interventional procedures that may be technically or cognitively more challenging but still within the realm of routine procedures and required competencies (e.g. polypectomy, foreign body removal, balloon dilatation etc.). Furthermore, the skills targeted were primarily technical skills, while non-technical and integrative skills which are often acquired later in training, were the focus of fewer studies included in this review.[49,50] This suggests that most efforts of endoscopy training have been targeted for earlier on in training, and while many of the skills are transferrable, this highlights the need for endoscopy training beyond foundational skills.

Most articles with educational interventions implemented various methods of simulation. These predominantly used mechanical models or virtual reality simulators targeting colonoscopy and upper endoscopy. The simulation setting provides greater opportunity to control factors that may affect training such as available time to provide greater opportunities for trainees to practice and obtain feedback.[51] Most studies demonstrated the positive impact of simulation on skill acquisition, particularly early on in training. However, despite this, the lasting and continued impact of simulation training remains unclear.[52]

Consequently, the timing and frequency of simulation sessions, and how they can be integrated into training practices longitudinally remains uncertain. Some potential suggestions based on the literature include but are not limited to the use of simulation as a pre-requisite for training or in parallel with clinical training either as single-day sessions or year-long curricula. Additionally, the cost and high resource requirements for high-fidelity simulation training can limit access to such learning interventions. As a result, there is growing research on the

effectiveness and utility of low-cost simulation. Studies advocating for implementation of modular simulation sessions indicate that while high-fidelity simulation can be beneficial, positive educational outcomes are more dependent on the quality of feedback and deliberate practice than simulator fidelity alone.[53,54]

The diversity of simulation-related educational interventions make comparison amongst them challenging. This review supports the existing data that suggests the effects of simulation intervention are most beneficial early on in training and the benefits are lost over time.[26,27] However, more extensive curricula that incorporate didactic teaching, repeated hands-on simulation sessions and trainer feedback have demonstrated improvements in technical skills and entrustment across the board in clinical environments. Clinical environments, unlike the simulation setting, have distinct challenges from a research perspective as each patient and scenario is unique and difficult to standardize, yet these in the moment troubleshooting skills are the target for training programs.

As such, it is important that future studies explore the role of repeated simulation sessions in combination with didactic teaching and feedback for acquisition of skills.[55,56] On the other hand, while there have been fewer studies on didactic teaching sessions, this review suggests that there are several topics including but not limited to endoscopy mechanics, specifics of therapeutic interventions techniques (e.g. foreign body removal, polypectomy etc.), and pathology recognition. These interventions, independent of hands on sessions, have been shown to be effective in improving knowledge of trainees through pre- and post-testing; however, no standardized knowledge assessments exist in endoscopy training.

In particular, in the context of the paradigm shift in endoscopy training towards competency-based medical education (CBME) the need for effective assessment of competence has never been greater.[2] Despite this shift, many studies continue to use time based outcomes such as procedural volume as surrogates for competence in training.[40] Accordingly, clinical and quality metrics were highlighted in this review as the most common methods of assessment of training. However, while targets for such indicators may exist, it remains unclear if these targets are routinely achieved within training.[40] Furthermore, it is possible that in clinical environments, difficulty in achieving these quality indicators may reflect challenging anatomy, or the procedural (i.e. technical or integrative skills) of the trainer rather than the trainee themselves.

The review identified several assessment tools that can be implemented in endoscopy training for evaluation of the efficacy of educational interventions and potentially competency on a larger scale. In the context of pediatric surgery, the Global Assessment of Gastrointestinal Endoscopic Skills (GAGES) has primarily been used for assessment of skills prior to the Fundamentals of Endoscopic Surgery (FES) Exam.[38] Alternatively, the assessment tools used in gastroenterology included the Assessment of Competency in Endoscopy (ACE), Skill Assessment in Fellow Endoscopy Training (SAFE-T), Gastrointestinal Endoscopy Assessment Tool (GiECAT), and Direct Observation of Procedural Skills (DOPS).[37,57-60] Aside from the Direct Observation of Polypectomy Skills (DOPyS), there are limited assessment tools for evaluation of therapeutic endoscopic skills in the literature.[61] While all the aforementioned tools demonstrate improvements over time and training, the uptake and validation of these scores or appropriate targets remains inconsistent. This inconsistency highlights the need assessment tools that can

be integrated into training for both technical and non-technical skills. Additionally, some of these tools have been tailored to summative assessment, rather than for formative evaluation throughout training which can make their application in endoscopy training limited. Ideally these tools can be used to establish criteria for endoscopic competency in training and for continuing education; however, the literature in this area is lacking outside of expert opinion.[62,63]

In addition to appropriate curricula and assessment tools, effective education in endoscopy depends on the quality of teaching and feedback. Clinicians must balance the dual demands of clinical care and teaching which can at times be at odds with each other. Strategies suggested to overcome this duality include structured feedback, video-based feedback, and protected time for educational sessions all of which may offer greater learner satisfaction and learning outcomes.[64-66]Additionally, it is possible that encouraging endoscopy teachers to complete Train the Trainer courses to standardize feedback and approach to training may be beneficial in optimizing feedback. However, these studies were not included within this scoping review as the target of the interventions were not trainees themselves. In this way, similar to a lack of consensus for teaching curricula, there again is considerable heterogeneity in the feedback methods provided which makes identifying targets for improvement more challenging.

Lastly, notably absent from much of the literature was a deliberate focus on equity and inclusion in endoscopy training. Challenges related to barriers to access for procedural opportunities and impact of gender, race, or training level on evaluation were rarely explored explicitly. Evaluation of barriers to endoscopy training requiring structural reform may improve

the learning environment for underrepresented trainees. Additionally, the learner perspective, outside of self-reported satisfaction or self-confidence post training interventions were rarely included. Specifically, understanding trainees' experiences and perceived barriers may allow for development of more effective learner-centered educational interventions.

Conclusion and Future Directions

In conclusion, this scoping review demonstrates the contrast of numerous studies exploring different innovations and strategies in endoscopy education with the lack of consensus in the approach to both training and assessment. In this way, the review highlights the clear need for future research in evaluation of the efficacy of different training modalities including but not limited to simulation, and assessment tools, particularly focusing on long-term retention of skills and improved clinical and educational outcomes. Furthermore, standardized benchmarks for competency must be further evaluated and validated across training levels and practice settings. Greater emphasis on standardized assessment, faculty development to promote effective teaching, and learner inclusivity will be essential in improving the field of endoscopy education.

Appendix A – Medline Search Strategy

Database: OVID Medline Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Present

Search Strategy:

1 endoscopy/ or endoscopy, digestive system/ or endoscopy, gastrointestinal/ or balloon enteroscopy/ or double-balloon enteroscopy/ or single-balloon enteroscopy/ or capsule endoscopy/ or colonoscopy/ or sigmoidoscopy/ or duodenoscopy/ or endoscopic mucosal resection/ or esophagoscopy/ or gastroscopy/ or proctoscopy/ (164027)
2 (endoscop* adj5 (digestive system or gastro* or GI or intestin*)).mp. (55070)
3 (colonoscop* or sigmoidoscop* or duodenoscop* or endoscopic mucosal resection or esophagoscop* or gastroscop* or proctoscop* or esophagogastroduodenoscop* or Ileo-colonoscop* or polypectom*).mp. (109466)
4 gastroenterology/ or gastrointestinal tract/ or intestines/ or intestinal mucosa/ or intestine, large/ or anal canal/ or cecum/ or colon/ or colon, ascending/ or colon, descending/ or colon, sigmoid/ or colon, transverse/ or rectum/ or intestine, small/ or duodenum/ or ileum/ or ileocecal valve/ or lower gastrointestinal tract/ or upper gastrointestinal tract/ or esophagus/ or stomach/ or duodenum/ (506989)
5 (dg or su).fs. (3376512)
6 4 and 5 [line 4 + attached subheadings: diagnostic imaging or surgery] (130205)
7 or/1-3,6 [endoscopy/GI concept] (320695)
8 education, medical, graduate/ or "internship and residency"/ (83050)
9 (resident? or residency or fellow* or ((postgraduate? or post-graduate?) adj3 medic*) or house staff or (surg* adj3 (trainee? or train-the-trainer or learn* or teach* or educat*))).mp. (295591)
10 (Simulation Endoscopic Skill Assessment Score or SESAS or "fundamentals of endoscopic surgery" or FES assessment* or FES exam* or "fundamentals of laparoscopic surgery" or FLS assessment* or FLS exam*).mp. (385)
11 or/8-10 [Residents - population concept; including specific assessments as backup] (312070)
12 education, medical/ or education, medical, continuing/ or education, medical, graduate/ (116555)
13 curriculum/ or competency-based education/ or problem-based learning/ (97865)
14 Clinical Competence/ (106298)
15 computer simulation/ or augmented reality/ or patient-specific modeling/ or virtual reality/ (220492)
16 Educational Measurement/ (41495)
17 simulation training/ or high fidelity simulation training/ or patient simulation/ (11846)
18 ((clinical adj3 competenc*) or ((surgical or medical) adj3 educat*) or (education* adj3 (measur* or assess* or test or tests or testing)) or (assess* adj2 (checklist* or tool?)) or curricul* or simulat* or train* or teach* or augmented realit* or virtual realit* or continuing professional development).mp. (2094315)
19 (Simulation Endoscopic Skill Assessment Score or SESAS or "fundamentals of endoscopic surgery" or FES assessment* or FES exam* or "fundamentals of laparoscopic surgery" or FLS

assessment* or FLS exam*).mp. (385)
20 or/12-19 [Education/curriculum concept] (2096759)
21 7 and 11 and 20 [endoscopy/GI + residents + education/curriculum] (1909)
22 Endoscopy, Gastrointestinal/ed (204)
23 Gastroenterology/ed (1676)
24 Endoscopy/ed (697)
25 Endoscopy/mt [Methods] (19214)
26 Endoscopy, Gastrointestinal/ed (204)
27 Endoscopy, Gastrointestinal/mt (6416)
28 Gastrointestinal Diseases/su (2449)
29 or/22-28 [Endoscopy/GI + education/methods/surgery] (30143)
30 11 and 29 [Residents + endoscopy/GI + education/methods/surgery] (1424)
31 General Surgery/ed (12403)
32 Surgeons/ed (1324)
33 Pediatrics/dg, ed, mt, su [Diagnostic Imaging, Education, Methods, Surgery] (14045)
34 or/31-33 [surgeons + education, OR: pediatrics + diagnostic imaging/methods/surgery] (27332)
35 7 and 11 and 34 [Endoscopy/GI + residents + surgeons + education, OR: endoscopy/GI + residents + pediatrics and diagnostic imaging/methods/surgery] (310)
36 21 or 30 or 35 [Final combination line: endoscopy/GI + residents + education/curriculum, OR: Residents + endoscopy/GI + education/methods/surgery, OR: Endoscopy/GI + Residents + surgeons + education, OR: endoscopy/GI + residents + pediatrics and diagnostic imaging/methods/surgery] (2540)
37 Development of a fundamentals of endoscopic surgery proficiency.m_titl. (1)
38 36 and 37 (1)
39 (Is current surgery resident and GI fellow training adequate to pass FES).m_titl. (1)
40 36 and 39 (1)
41 Development of a train-to-proficiency curriculum for the technical skills component of the fundamentals of endoscopic surgery exam.m_titl. (1)
42 36 and 41 (1)
43 (application of a standardized train the trainer model for faculty involved in a Society of American Gastrointestinal and Endoscopic).m_titl. (1)
44 36 and 43 (1)
45 (Fundamentals of endoscopic surgery creation and validation of the hands-on test).m_titl. (1)
46 36 and 45 (1)
47 animals/ not humans/ (5145921)
48 36 not 47 (2516)
49 limit 48 to yr="2000 -Current" (2100)

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CHAPTER THREE: PAPER TWO – Learning to Scope: Exploring Skill Requirements, Training Barriers and Educational Needs in Pediatric Endoscopy Through a Qualitative Lens

Learning to Scope: Exploring Skill Requirements, Training Barriers and Educational Needs in Pediatric Endoscopy Through a Qualitative Lens

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Introduction

Endoscopy is one of the cornerstones of pediatric gastroenterology. Its' safe and effective completion is vital for the diagnosis and management of a number of gastrointestinal conditions.[2] Like in the adult population, this requires a variety of technical and cognitive competencies that trainees and experienced endoscopists must expertly integrate to manage gastrointestinal disorders.[2] However, there is an added layer of complexity in the pediatric population due to the need for age-specific considerations, differences in the indications for endoscopy, and the resultant wide spectrum of disease.[2] Currently, pediatric gastroenterology training consists of a 2-3 year sub-speciality residency program.[2] In Canada, gastroenterology has transitioned to competency-based medical education since 2021, which necessitates a clearer understanding of what thresholds are required to graduate competent pediatric endoscopists.[2]

Despite its crucial role in gastroenterology practice, there remains a lack of consensus on the optimal approach to the teaching of skills in upper endoscopy and ileocolonoscopy. Endoscopy training traditionally is based on an apprenticeship model wherein trainees learn endoscopy skills under the direct supervision of qualified endoscopists.[2] Endoscopy skills curricula that focus on basic skills targeting learning early on in training have been developed for surgical and adult gastroenterology endoscopic training. [7,44,45] However, due to key distinctions in the indications for pediatric endoscopy, the need for consistent of ileal intubation, and for routine sampling, a comprehensive pediatric endoscopy curriculum that focuses on the challenges faced that are specific to pediatrics and at various stages of training has yet to be developed.[2]

In addition, in adults, the number of procedures completed independently has previously been used as a surrogate for demonstration of endoscopic competence despite a wide variation in the number of procedures required for trainees acquire the endoscopic skills needed for competence.[2] There is a lack of literature to describe endoscopic skill learning curves in pediatrics and estimates of minimum procedural numbers for endoscopic competence are extrapolated from adult data.[2] However, based on surveys of second- and third-year trainees in North America, only 58% met the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN)-recommended thresholds for upper endoscopy, 11% for colonoscopy, and 10% for polypectomies.[40] Similarly, regardless of program size, 48% of third year North American trainees had performed fewer than 100 colonoscopies (the recommended target is >120).[40] Lastly, there have been many recent developments in endoscopy training (e.g., magnetic endoscopy imaging [MEI], use of dynamic position change, water assisted ileocolonoscopy, and endoscopy simulation); however, the focus of these developments have been to support trainees working with adult patients.[3] However, due to limitations in patient positioning due to general anesthesia and limited availability of magnetic endoscopy imaging for pediatric colonoscopes, the application of such technologies have been underexplored in pediatrics.[3]

As a result, there is considerable variability in how trainees acquire and master the complex technical and cognitive skills required for safe and effective endoscopic practice. Efforts to standardize adult endoscopy training have identified specific competencies and learning trajectories, but similar work in pediatrics has lagged behind. A deeper understanding of the specific skills that contribute to successful endoscopic performance in pediatric

patients—and how these skills are perceived and developed by trainees—is essential to inform the creation of effective training and assessment strategies.

Objectives

The main objective of our study is to identify key skills required to perform upper endoscopy and colonoscopy. Specifically, we aim to:

1. Determine key skills within upper endoscopy and ileocolonoscopy that are important for trainees to perform the procedures successfully.
2. Determine skills that trainees find either challenging to perform or have an easier time performing.
3. Understand training opportunities that are currently available, that should be developed, and skills that should be targeted for trainees to learn endoscopy.

Methods

Study Design

An interpretative qualitive research study, using reflexive thematic analysis methodology and guided by a social constructionist perspective was conducted. Open-ended, semi-structured interviews were completed with attending pediatric gastroenterologists and pediatric gastroenterology trainees (post-graduate year 4 and above). These interviews aimed to explore the key skills required to perform upper endoscopy and colonoscopy that trainees find challenging, as well as the current and future interventions that may be incorporated to facilitate achieving competence in these areas. The participants were chosen through purposeful sampling, wherein participants were chosen based on their experience and level of

training. In efforts to obtain a broad range of perspectives, trainees and faculty of all levels of experience and those that practice and trained at a variety of centres within Canada were contacted directly and through program directors for recruitment into the study (e.g., pediatric gastroenterology program directors, competence committee members, simulation leads, and trainees across multiple levels of subspecialty training). The interview questions were developed through an iterative process that incorporated existing literature and expert opinion and consultation with a team member with expertise in qualitative methodology. Two interview pilots were conducted with pediatric gastroenterology faculty, which were not a part of data collection or analysis. These pilot interviews were used to revise and add reflexive and probing interview questions to ensure the questions were clear, focused on the topic of interest and aligned with a social constructivist-informed approach to the questions. The interviews were conducted by videoconference between August 2024 and January 2025. Participants were recruited until thematic sufficiency was reached which was identified by meaningful insights from participants that addressed the research questions, new data no longer introduced new concepts, adequate diversity of participants were sampled and new data re-enforced insights from previous participants. Participants reviewed and signed the consent form and fill out an anonymized demographic survey before the interview.

Interview Questions

The interview guide consisted of 16 questions. Due to the semi-structured nature of the interviews, the questions and their order were modified as deemed necessary by the researcher. The questions focused on the participant's role and experience in endoscopy training, identifying the key skills required to perform upper endoscopy and ileocolonoscopy

along with associated challenges, current training curricula and use of simulation, and questions around the concept of competence in endoscopy. For example, trainees were asked which skills they found most challenging during either upper endoscopy or ileocolonoscopy, while faculty were asked which skills they most often see trainees struggle with, as well as to reflect on challenges in giving feedback to trainees to successfully complete said skills. A copy of the interview guide can be found in **Appendix 1**.

Data Analysis

The anonymized audio files were transcribed and reflective thematic analysis using Braun and Clarke's framework was conducted to determine the key skills required to perform upper endoscopy and ileocolonoscopy in pediatrics.[67]

The data analysis included the following six steps:

1. Familiarization with the data, which included data transcription, transfer of data to a spreadsheet, and multiple iterations of reviewing the data.
2. Generation of initial codes, including by systematic data coding in which codes were created across the data set.
3. Generation of initial themes included combining similar codes together into broader themes. Additionally, Illustrative quotes were included.
4. Revision of themes included searching for additional themes and developing a thematic map of the data. The initial themes were reviewed to ensure they were appropriately defined and aligned with the generated codes.

5. Themes were refined and named. The senior author and supervising researcher reviewed these themes to provide feedback regarding any possible redundancy, need for additional themes, or modifications.
6. The report was produced after themes were defined and connected back to the study's research questions.

Interpretive Rigor

To ensure the credibility of our findings, we adhered to the following framework during the research process:[68]

1. Dependability via audit trails: Thorough decision journals were maintained throughout the project to ensure records of all decisions taken during the study were kept. Examples included documenting when new probes were added to the interview guide or if a question was removed.
2. Confirmability: Official and publicly available documents by the Royal College of Physicians and Surgeons of Canada regarding procedure-focused pediatric gastroenterology Entrustable Professional Activities (EPAs) were reviewed to identify key features of the EPA, assessment plans, and CanMEDS milestones. Additionally, the authors with experience in pediatric endoscopy reflected on their personal experiences with these procedures in the clinical and simulation settings to generate and interpret the themes by exploring and comparing the themes generated from the study to the Royal College expectations and their lived experiences.
3. Fairness: Faculty and trainees from different experience levels and different training centres were recruited to ensure the data accounted for different viewpoints.

4. Authenticity: Medical experts and education scientists in pediatrics were involved in the creation of the interview questions, as well as in the identification of the themes. An expert in qualitative research methodology reviewed the interview questions to ensure that the questions addressed the objectives. Additional experts external to the study reviewed the themes and sub-themes generated to provide suggestions for modification.

Ethics Approval

This study received ethics approval from the Hamilton Integrated Research Ethics Board (HiREB) #16866 and conforms to the Canadian Tri-Council Policy Statement of Ethical Conduct for Research Involving Humans.

Funding

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Reflexivity Statement

As a newly trained pediatric gastroenterologist with a specific interest in pediatric endoscopy training and simulation, my engagement with this work has been shaped by both my recent experience as a trainee and by my emerging role as a clinician-educator. Having recently undergone sub-speciality training and navigating the challenges associated with learning endoscopy in the pediatric setting has provided me with a deep understanding of the learning curve, emotional demands, and technical intricacies involved in becoming a competent

pediatric endoscopist. These perceptions and my own personal experiences influenced how I approached my study design and analysis.

As such, my personal and educational interests in improving endoscopy training and my positive experiences with simulation in endoscopy may have led me to highlight certain themes such as standardization of training, gaps within training and simulation, as well as approach to feedback in endoscopy. While my passion for these aspects of training drives my research, I have remained conscious of my assumptions and have continuously questioned my interpretations to ensure that that participants' voices have truly shaped the outcomes of this research irrespective of my presumptions.

Throughout this process, I have aimed to maintain reflexivity by regular discussions of the findings of this research with my research supervisor and revisiting the data multiple times to ensure fulsome engagement. My aim has been to balance my perspectives as a recent trainee and emerging educator centering around maintaining the authenticity of the participant experiences.

Results

There were four main themes identified from the data: (1) Success in endoscopy is shaped not only by technical proficiency but increasingly by non-technical skills as procedural complexity increases, (2) Skills that trainees find challenging transition from technical to integrative skills over time as they gain more experience, (3) Current endoscopy training lacks a structured approach to teaching, feedback, and simulation, (4) Metrics for assessment in pediatric endoscopy training lacks clear thresholds for competence.

A total of 11 participants were interviewed, including five trainees and six faculty. The participants were from a variety of institutions across Canada including the following: McMaster Children's Hospital (Ontario), The Hospital for Sick Children (Ontario), BC Children's Hospital (British Columbia), Janeway Children's Hospital (Newfoundland and Labrador), and two community pediatric gastroenterologists within the Greater Toronto Area. There were three males and eight female participants. The trainees included primarily first year sub-speciality residents and one second year sub-speciality resident while the faculty included a combination of early- (<5 years), mid- (5 to 10 years) and late stage- (10+ years) career individuals. Based on the data from these interviews, a total of 4 themes were identified. These themes have been defined and examples provided for each theme in **Table 1**.

Theme 1: Success in endoscopy is shaped not only by technical proficiency but increasingly by non-technical skills as procedural complexity increases, with faculty focusing more on the non-technical skills

Most participants primarily identified technical skills such as esophageal intubation, navigation through the upper GI tract, and navigation past the duodenal sweep to the second portion of the duodenum as key skills required for upper endoscopy. On the other hand, there tended to be less focus on cognitive and integrative skills aside from communication with team members, knowledge of the number and location of biopsies required by indication, and anticipation of needs. These skills tended to be consistent between both trainees and faculty. In this way, skills in upper endoscopy were perceived to be easier to acquire and complete consistently due to the decreased variability in anatomy. On the other hand, participants reported much greater variability in the key skills required both in number and type of skill for ileocolonoscopy, contributing to its complexity. Overall, both trainees and faculty described

similar skills required for the completion of upper endoscopy and colonoscopy as highlighted in the non-exhaustive list of skills mentioned in **Table 2**. These skills have been categorized into technical or psychomotor skills (e.g. tip control), cognitive skills (e.g. knowledge of indications and risks of procedure), and integrative skills (e.g. communication, troubleshooting).

> *"So, [upper endoscopy] is more straightforward compared to colonoscopy. That that's for sure. But in terms of like I find it's that it's not as steep learning curve I guess compared to colonoscopy. And that's why I say that it's quicker to get the routine and they can do it independently much faster than a colon"*

With respect to upper endoscopy, nearly all participants discussed esophageal intubation, and navigation through the pylorus and into the second portion of the duodenum as key skills for upper endoscopy. While there was general agreement amongst participants, faculty discussed the need for adequate visualization of the mucosa, photodocumentation and need for targeted biopsies more frequently than trainees. Additionally, both trainees and faculty discussed cognitive and integrative skills for upper endoscopy such as the skills required for consent and communication with family and team members. However, faculty members typically discussed and placed greater importance on procedural planning and anticipation of needs or management of complications that may occur.

> *"And you kind of have to know, like, what do I do in that situation? Like do I biopsy it, do I take it off? Do I like biopsy next to it, do I send it to path? Do I send it to cytology? Do I ask someone to come in and look at this too because I don't know what it is?"*

With regards to ileocolonoscopy, most participants described the pre-procedural skills to be similar to those for upper endoscopy apart from the importance of knowledge of and assessment of adequate bowel preparation. Unlike in upper endoscopy, both trainees and faculty alike emphasized the importance of similar technical, cognitive, and integrative skills. In particular, most participants discussed the importance of scope handling, navigation through

the colon, recognition of landmarks, loop recognition, reduction and prevention, as well as troubleshooting skills. However, faculty typically were able to break down these skills and explain their importance in much more detail. Skills such as scope handling were broken down into the description of the "C-technique" and the differences between utilization of torque steering compared to use of wheels/tip deflection alone. Similarly, while trainees commented on prevention of loop formation broadly, faculty were able to further explain that prevention of loop formation may employ strategies such as proactive turning of patients, application of clockwise torque in the left colon, and application of different strategies for preventing loops from re-forming once reduced. Lastly, faculty discussed the safety of procedures and determination of when to terminate a procedure due to increased risk of complications whereas this was not mentioned by trainee participants.

> *"I think also knowing like when it's safe to proceed because sometimes we scope kids have really acute severe colitis. And I think also knowing like when not to push it into kind of be like, okay, just kind of get your samples where you are. And get out."*

Theme 2: Skills That Trainees Find Challenging Transition from Technical to Integrative Skills Over Time as They Gain More Experience

Both trainees and faculty expressed similar skills as major challenges for individuals completing endoscopy procedures; however, the complexity of these challenges changed over time. Initially, trainees require assistance with scope handling and orienting themselves to the scope, with respect to understanding how tip deflection and torque effects the movement of the endoscope or colonoscope, which was not mentioned by any faculty participants. Both trainees and faculty described similar challenging technical skills in upper endoscopy, which includes esophageal intubation navigation around the duodenal sweep. For example,

participants voiced that the confined space in the oropharynx, poor visualization, and stress associated with causing discomfort to the patient are the major causes for this. Unlike in the adult population, however, an advantage to learning upper endoscopy in pediatrics is general anesthesia, which reduces discomfort for patients during this step. Additionally, technical skills such as navigation around the duodenal sweep in upper endoscopy and loop reduction in ileocolonoscopy were identified as significant challenges. While complex skills independently, both of these skills require understanding of the scope in 3-Dimensional space within the body, which contributes to their greater complexity. As a result, trainers reported that strategies to combat these challenges include demonstration of endoscopic maneuvers outside the patient, drawings, or use of magnetic endoscopic imagers, which allow trainees to better conceptualize the task.

> *"I think that something I was not well taught, and I realize it now because we use scope guide, we have the option to use scope guide which I don't use here because we never had it in Calgary. But I don't think I had a great understanding of what was happening with like loops"*

Moreover, most participants identified terminal ileum intubation as being particularly important for pediatric colonoscopy, which may differ from adult gastroenterology practice as a result of the differences in indications for the procedure (i.e. greater diagnostic procedures for Inflammatory Bowel Disease). Terminal ileal intubation was described by most participants as a particularly challenging aspect of ileocolonoscopy and was viewed as a separate skill independent to consistently navigating the scope to the cecum. Challenges associated with terminal ileal intubation included first identifying the landmarks of the cecum and ileocecal valve, and the need for fine tip control. As a result, both trainees and faculty reported the need

for adequate loop reduction for successful ileal intubation as large loops were felt to limit scope maneuverability, limiting change in position of the TI and tip control.

> *"… I think for me learning how to deloop … because that's what's sometimes it's frustrating because I see right there. I'm looking at the appendix, but I cannot I push, and it comes right out. So that for me is so frustrating. You know it's right there, but you cannot advance. So sometimes either they take out all the scope, the staff, or you come out."*

Theme 2A: Limited Time, Variability in Practice, and Lower Procedural Volume Contribute to Difficulties in Developing Integrative Troubleshooting Skills

Participants identified that the development of skills to troubleshoot the challenges they encounter during endoscopy, and particularly in ileocolonoscopy, as one of the most challenging aspects of learning how to perform the procedure. There were three main aspects of training that served as barriers to the development of troubleshooting strategies. First, trainees reported that they lacked time to attempt different strategies to overcome the challenges they were facing. Additionally, some faculty reported that once in independent practice, they had increased opportunities to attempt different strategies which was effective in improving their own comfort in performing ileocolonoscopy. Similarly, faculty acknowledge that limited time is a significant barrier to learning for trainees, but that modification of booking endoscopy lists to designate greater time for procedures involving trainees is ideal but impractical.

> *"… time barriers should be try to be eliminated, but that's impossible. I know one thing that we don't like adjust timing according to the seniority of a trainee. And so, if it's a new person, should you allow them more time. That's always an argument. But honestly, we kind of have to book as though it's the same every day."*

Second, trainees report that the variability in practice of different faculty poses an additional challenge for them when developing an approach to troubleshooting strategies.

There may be a hesitation to allow trainees to approach strategies that they have learned if they are inconsistent with a faculty's individual practice. Alternatively, they may receive conflicting instruction, making it more challenging to understand which approach may be utilized based on the clinical scenario. Third, trainees report that repeated practice significantly affects their ability to build upon skills. Specifically, both trainees and faculty alike report reduced procedural volumes as a challenge in learning endoscopic skills. In addition to decreasing the exposure of endoscopists to different pathology, because of the inherent variability in colonoscopy due to differences in anatomy and patient factors, greater procedural volumes allow for repeated practice. In this way, most programs had varying degrees of exposure to participation in procedures with adult gastroenterologists, primarily to increase procedural volume to build upon skills that could then be applied to participants' practice in pediatrics which was felt to be beneficial by nearly all participants.

> *"Particularly on the adult list because they have many more procedures than we do, which makes it fruitful for learning in some regards because you're exposed to a variety of different things."*

Theme 2B: Emotions and Time Pressures Contribute to Trainees Cognitive Load

Trainees report a high degree of cognitive load, particularly early on in training. As discussed, many trainees report that orienting ones' self to the endoscope and understanding how their movements impact the tip of the scope requires significant conscious thought. Additionally, most trainees discussed that this higher cognitive load, particularly in ileocolonoscopy, impacts their ability to focus on additional aspects of the procedure such as maintaining ergonomic positioning or communicating what they are doing when it comes to navigating through the colon or troubleshooting. As a result, additional distractions as time

pressures can further contribute to trainee stress, cognitive load, and confidence. Trainees may worry about the scope being taken over by the faculty as time restrains were often voiced by faculty as a driving factor in their decision to take over the scope from a trainee. Alternatively, comments made from other team members in the room may impact trainees' self-esteem, making the already existing cognitive load more challenging to manage.

> *"But along the way [the nurses] forgot that you need time to learn. And sometimes I feel that we are also vulnerable at that part. We have literally a scope inside somebody's body. And like they want to rush things. And they might say something like oh this is taking so much time."*

Both trainees and faculty identified using position change as a challenge in ileocolonoscopy due to the physical challenges with turning fully anesthetized patients. However, some faculty also acknowledged that given that position change requires cooperation from the entire team, trainees may worry about the implications of asking for help and lack the confidence to do so. Of note, while there were only three participants that identified as male in the study, only female participants discussed the effect of external comments, the public nature of intraprocedural feedback or a lack of confidence in their own skills as contributing factors to the challenges in learning endoscopic skills.

> *"… not really being comfortable enough to like ask for that pressure or ask to reposition the patient because I just didn't have that experience. It's like, okay, I've heard others ask for it. Like can I do it too? Or are they gonna think that I don't know what I'm doing if I have to use all these different factors?"*

Theme 3: Current Endoscopy Training Lacks a Structured Approach to Teaching, Feedback, and Simulation

Current endoscopy training across all participants and centres followed the apprenticeship model of teaching under direct observation and with graduated responsibility.

There was some variability in practice with respect to starting with adult vs pediatric procedures, a combination of upper endoscopy and colonoscopy, or a more linear progression from upper endoscopy to colonoscopy or the use of specific milestones/checklists to guide progression of exposure. As a result, both trainees and faculty recognized the high degree of variability in endoscopic training with respect to procedural exposure and the differences in approach to both endoscopy and teaching based on the individual trainer. Most participants endorsed that a more structured approach to training and feedback would be very beneficial to training.

> *"I also think a way to standardize it, because depending on who you scoped with, at least in my training the approach to doing things was very different. ... And so, then you end up kind of having to do what your staff does."*

Theme 3A: Integration of Didactic Teaching Sessions and a Structured Approach to Feedback Can Help Standardize Endoscopy Training

When considering training of procedural skills, typically the focus remains on the entrustment of technical or hands on skills, which continues to play a large role in pediatric endoscopy training. However, some faculty and trainees reported that there is a need for greater didactic teaching to establish a uniform baseline of knowledge and exposure to various aspects of endoscopy. Topics that were identified as potentially beneficial included introductory sessions regarding the indications, contraindications and applications for endoscopy, the parts and function of an endoscope, anatomy and landmarks, explanation of common conditions that may require endoscopic evaluation, and the approach to biopsy sampling based on the indication.

> *"The sessions that we would get were like super high level where we'd be like, you know, just talking about the statistics of like combined biologics and IBD. But like we never*

really got that just like endoscopist boiled down information that we need to know"

Aside from introductory sessions, a need for teaching around more complex topics was also highlighted. The faculty that underwent the Canadian Association of Gastroenterology's Train the Trainer or Colonoscopy Skills Course highlighted the importance of these types of courses for Trainers to standardize their approach to feedback but also for trainees.[69] They reported that as a trainee, topics such as loop recognition, types of loops and common approaches to challenges that are faced in different parts of the colon would be helpful while learning to allow individuals to incorporate it into their practice. Lastly, didactic teaching sessions may also be able to explore topics such as different endoscopic equipment and the advantages/disadvantages for each, particularly when discussing therapeutic endoscopic interventions as the frequency of clinical exposure is incredibly limited and very variable in the pediatric setting.

> *"… talking about a little bit more in services, let's call it, for equipment … But I think trying to do that when there's not an acute case or bleed. Like some people haven't had the chance to use a hemospray or something for quite some time."*

Theme 3B: Simulation Training Can be an Adjunct to Endoscopic Training, But its' 'Fidelity' Limits Use

Most participants reported some simulation exposure during their sub-speciality training which included primarily mechanical models which are models typically made from plastic or silicone that resemble the upper or lower GI tract but also included part-task simulators such as boxes targeted for specific skills such as tip control (i.e. using the scope or biopsy forceps to touch/target different locations) and virtual simulation such as screen-based and Virtual Reality (VR) simulators. There was disagreement regarding the degree of utility of simulation training across participants, and many faculty reported that simulator's functional

fidelity (i.e. how well a simulator reflects the reality of the completing the procedure) greatly impacted the efficacy of the model and translation of skills from the simulation environment to clinical practice was limited.

" I don't think it replicated anything close to what like the real experience was like."

However, there were two main areas of training in which simulation was felt to be effective, which included at the beginning of training and for therapeutic interventions to which exposure is sporadic throughout training. Early on in training, simulation allowed removal of time barriers to trainee learning and allowed them to practice scope handling and better conceptualize scope movements in 3D space. Additionally, the majority of simulation sessions that participants had reported participating in were done very early on in training as an introductory or orientation session. As such, trainees reported that repeated sessions over the course of training may allow for better translation of simulation sessions to clinical procedures by incorporating real-world experience with simulation and lead to greater retention of skills.

> *"I would say like loop reductions again. Having that like context to visualize. Like it was great at the beginning. But you are like I don't quite like get it or like I don't know how this would feel like. So having that to revisit I think would be very helpful"*

Lastly, for participants that completed simulation for infrequently encountered procedures, they felt that this was the most effective aspect of simulation training. It was primarily used for therapeutic skills such as foreign body removal and polypectomy. Participants reported that these sessions allowed for review of the procedure itself, potential complications, and available equipment. One participant reported that the fidelity using gelatin polyps was representative of clinical polypectomy, which added to the experience. However, both faculty and trainees reported a greater need for additional simulation for infrequently encountered procedures in

training. A limitation of this includes the lack of availability of models that can be used for therapeutic procedures, particularly for esophageal dilation or variceal bleeding.

Theme 4: Metrics for Assessment in Pediatric Endoscopy Training Lacks Clear Thresholds for Competence

Nearly all participants reported that the skills required for competence required a clear proficiency in technical skills, which is required for consistent, independent, safe and timely completion of upper endoscopy and ileocolonoscopy. In addition to technical skills, several cognitive skills such as communication, understanding of indications, risks, benefits and knowledge of equipment and biopsies were also highlighted as skills needed for competence. Furthermore, integrative skills such as procedural planning, application of troubleshooting strategies, and anticipation and management of complications during the procedure were all felt to be important factors in competence.

Training in pediatric endoscopy does not have any clearly defined thresholds within the metrics used for assessment of competence despite the implementation of EPA assessments or locally developed checklists. Most participants reported either procedural volume or terminal ileal intubation rates as markers of competence. Regarding procedural volume, faculty and trainees did not report a clear threshold but rather endorsed a minimal procedural volume to reflect consistent and reproducible completion of the procedure. However, it was reported that procedural volume in itself is inadequate and does not reflect the quality of the procedure.

Similarly, for terminal ileal intubation rates, these can be challenging to obtain reliably within training outside of self-reported procedure logs because electronically documented terminal ileal intubation rates may reflect the trainer rather than the trainees' skills. Once in

independent practice, these rates can be inconsistent and may not reach the threshold of 90% based on an audit at one of the participant's institutions. As such, using this as a threshold for competence can be challenging for trainees if faculty themselves do not reach this threshold.

> *"… and to be honest, it's not everyone, even by the end of two years, they may not be at 90%. They might be 50%. And that's tough because then they, you know, they're lacking some confidence. And will I be able to do this … audit of faculty was also inconsistent, varying between 70 - 97%"*

With respect to the learning curve in pediatric endoscopy, nearly all participants reported that competence for upper endoscopy was achieved during sub-speciality training sometime between 6 – 18 months into training. Regarding colonoscopy, on the other hand, most participants said that 'comfort' in colonoscopy was likely achieved by the end of two years of sub-speciality training. It was thought that safe completion of the procedure was often achieved by end of training, however competence in all domains likely builds after completion of sub-speciality training and into independent practice. Furthermore, terminal ileal intubation was deemed to be a separate skill from colonoscopy. Participants reported that 'comfort' was likely achieved by the end of sub-speciality training, but competence was thought to be achieved in independent practice.

Finally, with respect to therapeutic interventions, both faculty and trainees reported that competence is likely not achieved within sub-speciality training; however, this varied with the complexity of the procedure. Some trainees expressed the goal of comfort with basic polypectomy, injection/hemostasis, and balloon dilatation by the end of sub-speciality training. However, both faculty and trainees agreed that comfort and competence in complex polypectomy and variceal bleeding likely require additional training or exposure after sub-speciality training. In particular, because the procedures themselves are less frequent, the

opportunity to build comfort in managing complications is even less. Yet, complications such as significant bleeds can have a significant impact on endoscopists' confidence in performing such procedures.

> *"I've had a handful of them that like bleed really badly afterwards. And I have to clip them. So, it just kind of makes me a little bit twitchier the next time around ... So yeah, I don't feel like a huge amount of comfort with that."*

Faculty report that this poses even greater challenges in determining the role of ensuring equal access to therapeutic interventions compared to limiting these procedures to a few individuals to build competence. Along these lines, trainees and faculty reported that it may be beneficial to determine the expectations for skills in therapeutic endoscopy at the end of sub-speciality training for the "average endoscopist" given that the need for such procedures may vary based on practice location.

Discussion

In this interpretative qualitive research study using reflexive thematic analysis methodology involved semi-structured interviews with trainees and faculty across Canada. It explored the specific skills required for upper endoscopy and ileocolonoscopy, which skills are challenging for trainees, and opportunities for improvement in current pediatric endoscopic training programs. There were four main themes identified from the data: (1) Success in endoscopy is shaped not only by technical proficiency but increasingly by non-technical skills as procedural complexity increases, (2) Challenges in Upper Endoscopy and Ileocolonoscopy Change in Complexity Over Time (3) Current Endoscopy Training Lacks a Structured Approach to Teaching, Feedback and Simulation (4) Pediatric Endoscopy Training Lacks Consensus Regarding the Metrics and Assessment of Competence.

Overall, the technical and non-technical skills identified by trainees and faculty for successful completion of pediatric upper endoscopy and ileocolonoscopy closely correspond to those outlined in several of the assessments tools created for gastroenterology, including the Gastrointestinal Endoscopy Competency Assessment Tool (GiECAT), which has established validity evidence in pediatrics, as well as the Assessment of Competency in Endoscopy (ACE) Tool, and Direct Observation of Procedural Skills (DOPS) Tool. [58,60,70] Despite the overlap of identified skills in this study and the assessment criteria in the existing colonoscopy assessment tools, use of these tools has not been integrated into training programs for summative purposes. Aspects of the GiECAT has been integrated into EPA milestones which can serve as a guide for formative feedback along with a minimum number of procedures with terminal ileal intubation.[34] In this way, CBD has attempted to establish thresholds for competence within pediatric gastroenterology, however, while there has been research to support increasing scores across these tools with increased experience a threshold or minimum score for competence has yet to be established.[58] Furthermore, despite the traditional focus on technical skills in endoscopy training, both the literature in endoscopy training and this study highlight the need for greater focus on non-technical skills.[71] However, this study highlights the need for further training specifically with respect to development of troubleshooting strategies which has not traditionally been a focus of non-technical skills.

This study highlights the need for a structured endoscopy training program that can be integrated to address development of technical and non-technical skills using both simulation and direct observation with feedback. Attempts have been made previously to assess different sessions or curricula that integrate simulation training into sub-speciality training; however,

there has not yet been one that has been established to be effective.[56] Based on this study, the need for a new curriculum include structured and consistent feedback, didactic teaching sessions for both introductory concepts, troubleshooting strategies and approaches to complications or advanced procedures, and repeated simulation sessions over the course of training.

Within the literature there is a wide variety of simulation models that have been used in pediatric endoscopy. First, part task simulators focusing on specific endoscopic skills but do not resemble the gastrointestinal tract such as the Basic Endoscopic Skills Training (BEST) Box, Thompson Endoscopic Skills Trainer (TEST) have been shown to be cost-effective and demonstrate correlation with endoscopist experience.[72,73] The cost effectiveness of these models is their greatest advantage, however, by design, these models can only target specific technical skills so their utility throughout training may be limited beyond fundamental skills.[25] On the other hand, there are numerous commercial mechanical simulators which are designed to better reflect the anatomy of the gastrointestinal tract. Common commercial models include the Koken Ltd upper and lower endoscopy models, the Kyoto colonoscopy simulator, Endoscopist and Assistant's Simulator DrY Lab (EASY) and Noda-Kitada-Suzuki (NKS) model.[74-76] While these commercial simulators are typically associated with greater costs, they offer greater structural and functional fidelity which allows trainees to target more complex technical or integrative skills such as scope navigation and loop recognition and reduction. Additionally, these models offer the opportunity for learning of some therapeutic interventions such as polypectomy.[76] To account for the costs of such simulators, there have been efforts to develop methods of making low-cost gelatin polyps that can be used along with the higher

fidelity commercial simulators.[77] Performance on these simulators has been demonstrated to improve trainee skill acquisition early in training, and with the integration of a curriculum with progressive increase in complexity may allow these improvements to persist over time.[25,56] With respect to virtual reality (VR) simulators, the two most commonly researched simulators include the CAE EndoVR Simulator (previously AccuTouch) and GI Mentor Simulators.[78] These models are associated with the greatest financial burden but are reported to have greater functional fidelity but decreased anatomic fidelity and provide more options for clinical scenarios or modules.[79] Another advantage to VR simulation models includes their self-feedback systems which may contribute to their increased skill acquisition when compared to mechanical models.[79] Despite the advantages of various simulator models, the evidence supports the need for deliberate practice, progressive complexity and feedback associated with their use to optimize their impact on learning.[39]

Finally, faculty and trainees both acknowledge that there are significant challenges in determining competence within pediatric endoscopy. Typical metrics such as procedural volume are inadequate due to the decreased volumes of procedures within pediatrics.[40] Additionally, while there have not been formal studies evaluating learning curves in pediatric endoscopy, participants in this study suggested that competence in all aspects aside from consistent and safe completion of ileocolonoscopy may be challenging to achieve within pediatric sub-speciality training. On the other hand, competence was not strictly defined from a medical education lens, making it possible that participants were equating competence with confidence or comfort. However, evaluating this objectively will be important in the era of Competency Based Medical Education, to accelerate of the learning curve within pediatric

endoscopy training. This not only may increase both competence and confidence but may improve educational efficiency and resource utilization. In this way, development of a structured pediatric endoscopy curriculum that combines didactic teaching, simulation and structured feedback may fill in these unmet needs within sub-speciality training to facilitate competent endoscopists in the future.[25]

Strengths and Limitations

A possible limitation of this study includes selection bias. Participants in the study were recruited via email across the country; however, nearly half of the participants were from one academic centre. As such, the experiences of the participants may be shaped by the similarities in training at a single centre. It is also noteworthy that the majority of participants were female, which may affect the perceptions of endoscopy training, exposure, feedback and opportunities in the data as there are a number of studies that demonstrate differences in these experiences based on gender.[80] However, it is also possible that given this study was specific to pediatric gastroenterology training, that the predominance of females over males in the study population is reflective of the larger population – 2018 data suggest 64% of pediatric gastroenterologists are female.[81]

Additionally, this study used thematic sufficiency—stopping data collection once further data would not add meaningful depth—and information power**,** which links data relevance to smaller sample needs, to ensure rich data collection even with smaller participant volume.[82,83] As the coding was done as an iterative process and revisited throughout the interviews, the interviews were continued until subsequent interviews did not reflect new themes and the data obtained was able to meaningfully answer the research question. Further, given the study

population reflects a relatively small population (Canadian pediatric gastroenterologists), aiming to address a specific question (i.e., the challenges and gaps within pediatric gastroenterology training), and the rich conversation that was supported by the interviewer's positionality as a recent graduate with a strong appreciation for training practices, the data obtained over the course of a relatively small sample size (11 participants) was able to maintain the principles of information power and adequately answer the research questions.

Furthermore, due to the variation between Canadian programs with respect to access to adult gastroenterology trainers, endoscopy nurses and practice setting (e.g. OR, endoscopy suite) the insights and perspectives from these team members was not included this study, which may be a limitation of this study that warrants further research.[25] Along these lines, while there were individuals from different centres across Canada, not all training programs were included. Further, the participants typically included predominantly first year and early career faculty, which may affect the perceived challenges in training compared to later stage trainees and faculty.

Conclusion

In conclusion, our findings suggest that there are a number of gaps in pediatric endoscopy training including holistic training approaches to support trainees in gaining the skills required for successful completion of upper endoscopy and ileocolonoscopy in pediatrics, the challenges faced, the role of feedback and simulation, and exploration of the concepts of competence and learning curves in pediatric endoscopy training. This study highlights the complexity of pediatric endoscopy and the lack of consensus regarding optimal strategies for

endoscopic training. However, these results provide a steppingstone for the development of a pediatric endoscopy curriculum that may establish a path towards competence.

Table 1: Theme overview, definition and examples

Theme	Definition and Examples
Theme 1: Success in endoscopy is shaped not only by technical proficiency but increasingly by non-technical skills as procedural complexity increases, with faculty focusing more on the non-technical skills	Definition: This theme explores the skills required for both upper endoscopy and ileocolonoscopy, including both technical (i.e. psychomotor skills) and non-technical skills (i.e. communication and decision-making skills). Participants described similar technical skills including tip control, scope navigation, however faculty focused on skills such as procedural planning and troubleshooting skills. Examples: • *"I think that sometimes we just get a bit willy nilly. So, learning how to take good, accurate targeted biopsies is an important skill."* • *"That whole preparation piece, I think is probably the most important part of the endoscopy."* • *"Whereas an upper endoscopy you can visualize the stomach, the duodenum. It is not like you know where you are at all times basically. Where I think with the colonoscopy, I think you just got lost in like what are my looking at, where am I? What is going on?"* • *"I think sometimes it's hard to see the trees in the forest. So, for instance, recently did a colonoscopy with one of our trainees. And they were like, so close to the appendix and the, like, cecum that we couldn't see the TI because they just needed to come back to identify the landmarks"* • *"So, you know, if it's a rule out IBD in a kid who has, you know, very low hemoglobin, you're worried about like a hematoma, knowing that you may need to stop if it doesn't feel safe."*
Theme 2: Skills That Trainees Find Challenging Transition from Technical to Integrative Skills Over Time as They Gain More Experience	Definition: This theme explores the transition of skills that participants find challenging over the course of training, which tend to include integrative skills such as troubleshooting skills later in training. Examples: • *"And even have an appreciation of like okay, so if I don't tip up like how does that affect my camera view?"*

	• *"I think on one hand we have the benefit of most patients are anesthetized, so we are given that more buffer if they're sitting in the hypopharynx for a prolonged period of time or looking around."* • *"…getting around that first curve where the D1 becomes D2 can be tricky because it is difficult for me to even kind of visualize spatially what's happening. And I think if I had a better understanding of spatially what I am trying to do I could try to like position myself in a way. And I think I kind of have an idea of what I am trying to get at. I just haven't been able to put what I think I am supposed to do into translation with my hands and the torquing the scope."* • *"We might require that TI intubation more than some adults scopes that may not actually do TI intubation. Versus we kind of expect it for all of our scopes. So, I think we have a higher expectation for that intubation to happen for all procedures."* • *"That was probably my biggest challenge when I was learning. Like I could get to cecum pretty easily. And always got held up at the ileal intubation. So, I think learning different techniques for that for sure."*
Theme 2A: Limited Time, Variability in Practice, and Lower Procedural Volume Contribute to Difficulties in Developing Integrative Troubleshooting Skills	Definition: This sub-theme explores the barriers related to building troubleshooting skills which included time pressures, decreased procedural volume in pediatrics and inconsistent practices amongst trainers. Examples: • *"… depending on who you are, I think that's a challenge for sure because then some of the staff they let you, you do your own thing. And I feel that's how I like that better. Once you, you kind of know your basics because when they are in there and doing this and that they don't let you kind of experience doing what you feel feels right"* • *"…letting me you know kind of just practice using it in the colon and doing getting to where I think it should go. And letting me kind of figure out my own mistakes and problems as I navigate and correcting myself as I am going along."*

	• *"I actually had the opportunity to like to troubleshoot, right? Like to change your tension, to try to reduce, to flip the patient, to have the nurse do pressure. And like change the scope out or like, take it out and start again because nobody's like getting mad at you that you're running too late the way it is when you're a trainee."* • *"It was just different because you see that it might be easier in some respects with, you know, one person at a different hospital with a different patient population. And then you were just told to completely like not do that anymore. So, you're just like, what's the right answer?"* • *"The way I learned to scope was really, really heavy on the dials. And I have sort of since been told like, no, you really should just move up and down and do a lot more torquing. So that's something I try to do. But I find again it's like I kind of revert back to that muscle memory of like being a bit heavier on the dials."* • *"Keep doing it repeating. And yeah and of course, like stop troubleshooting and make sure that you're doing it the right way. And you're not just repeating something the wrong way. But I think that, yeah, the number of scopes, the number of colonoscopies is very important for your learning"* • *"like I compare colonoscopies to golf, right. Like uppers are usually pretty routine. But I feel like a colonoscopy like it doesn't matter how many times you hit the ball. If even if you think it's the same, each time it's gonna go somewhere completely different."*
Theme 2B: Emotions and Time Pressures Contribute to Trainees Cognitive Load	Definition: This sub-theme explores the factors that participants report increase cognitive load for trainees and act as a barrier to learning, which include the impact of trainee confidence and perceptions of time pressures during procedures. Examples: • *"And I think it really just takes time for like my brain and my fingers to figure out if I want to go say to like the 10 o'clock position, well how do I get*

	there? What do I do with my fingers to get myself there?" • *"I feel I feel for the colons, you're kind of like more quiet. I find myself I'm more quiet trying to navigate the scope."* • *"But it feels a lot more stressful or worse to be like to turn often, I think. Or to turn and then it doesn't work, and you are like oh shoot, and now I have to turn it back"*
Theme 3: Current Endoscopy Training Lacks a Structured Approach to Teaching, Feedback, and Simulation	Definition: This theme explores the variability within teaching strategies which can impact trainees' integration of feedback and use of simulation in building upon their procedural skills. Examples: • *"And then we just kind of let them usually start, see where they go. And so long as they're staying on time doing it in a safe manner, we allow them increasing responsibility to proceed through."* • *"But basically, we just did there was like this kind of stepwise algorithm that they had developed at [the participant's institution] for us to work through. We had to achieve so many goals, so many times before you would advance to different aspects of endoscopy. Obviously, starting with an upper endoscopy, then advancing the colonoscopy."* • *"I feel like it would be nice if it were a little bit more structured. And we weren't expected to just pick it up as we go along."*
Theme 3A: Integration of Didactic Teaching Sessions and a Structured Approach to Feedback Can Help Standardize Endoscopy Training	Definition: This sub-theme explores the role of didactic teaching in endoscopy training and areas for expansion that may be lacking in current practice. Examples: • *"And to be honest, I didn't know why we didn't do a ton of didactic teaching. That's something that I probably would have liked to be honest. It should have had more for sure."* • *"Like knowing that would have made things so much easier because it's not like every single scope day that you're reading up on a patient, you're having to like refigure out what you're actually*

	going to be doing based on the disease that's being looked for." • *"And I think all staffs at fellowship programs should be made to do something like that, because I don't think everyone has. And it was such a valuable experience to me that I truly regret that I wasn't able to do it as a fellow."*
Theme 3B: Simulation Training Can be an Adjunct to Endoscopic Training, But its' 'Fidelity' Limits Use	Definition: This sub-theme explores the use of simulation in pediatric endoscopy training, its benefits and its limitations which include functional fidelity of models currently in use. Examples: • *"… especially with the model of the duodenum it was also nice to see when you are doing these turns where I feel like initially you can't quite visualize you know I am turning around, I am moving my body. Like what is happening to the scope. But to be able to see like that light and where it is moving very clearly was very helpful, I think."* • *"There was one sort of model that had these like faux polyps that you could practice removing. Just to give you a sense of how to actually do it … and that was very helpful because it does actually feel like you're slicing through the stock of a polyp."*
Theme 4: Metrics for Assessment in Pediatric Endoscopy Training Lacks Clear Thresholds for Competence	Definition: This theme explores the metrics used for assessment in endoscopy and the limitations of their application in pediatrics as well as the lack of clear thresholds for competence. Examples: • *"… for them the technical skills aren't really even a question. It seems to be almost second nature to them."* • *"… cause honestly you can really push a scope, make long scope get to this cecum and reach for a biopsy. But not be short enough to like comfortably maneuver position and get into TI. So."* • *"I felt comfortable doing [balloon dilatations]. But like I would say, I still very conservative in the way I dilate like, dilate very like low and slow. And like,*

	as soon as there's a break in the mucosa, I'm like, okay, I'm done." • *"Like I had not had someone, I don't know. I hadn't had a band slip or had a bleed spontaneously during the procedure. And so, I was really stressed … Like I actually didn't feel like I was equipped to, like, deal with those complications."* • *"Or you're going to be in the community where I'm not going to be seeing like end stage liver disease or kids with vertices that require banding. Or anybody who has like a right sided polyp that needs removal. Like, that's not what I will be doing, ever. So, do I need to be skilled in that?"*

Table 2. A non-exhaustive list of common skills identified by participants for the successful completion of upper endoscopy and ileocolonoscopy.

Skills Required for Upper Endoscopy	Skills Required for Ileocolononoscopy
Technical Skills	
Equipment set up	Equipment set up
Endoscopist and patient positioning	Endoscopist and patient positioning
Esophageal Intubation	Perianal examination/DRE
Advancement and navigation through the Upper GI Tract	Scope handling including use of wheels and torque steering
Navigation into the second portion of the duodenum	Loop reduction
Retroflexion in the stomach	Navigation through the colon
Visualization of the Mucosa	Maintenance of luminal view
Targeted biopsies	Targeted biopsies
Photo-documentation	Insufflation with Air/CO2 or water
	Application of abdominal pressure
Cognitive Skills	
Knowledge of number and location of biopsies based on clinical indication	Knowledge and recognition of adequate bowel preparation
Knowledge of indications, risks, benefits and alternatives for consent	Knowledge of indications, risks, benefits and alternatives for consent
Knowledge of available equipment/sizes	Knowledge of available equipment/sizes
Communication skills (with family and team members)	Communication skills (with family and team members)
	Recognition of landmarks within the colon
	Loop Recognition
Integrative Skills	
Procedural planning and anticipation of needs	Prevention of loop formation
Safe completion of procedure	Troubleshooting challenges encountered
	Safe completion of the procedure

Appendix A: Semi-Structured Interview Guide

For Trainees:
The goal of this study is to better understand the challenges in pediatric endoscopy training to allow us to improve learning and the opportunities available for trainees. Your responses are confidential, and they will not your impact training in any way. Please speak openly about your experiences If you feel comfortable to do so. I am here as an educator and researcher wanting to learn more about your experience – skills and challenges

For all Participants:

1. What is your role in your department (staff, trainee etc.)?
2. Tell me about your training in pediatric endoscopy thus far (upper endoscopy/ ileocolonoscopy etc.)?
3. How often do you perform upper endoscopy or ileocolonoscopy procedures in your pediatric gastroenterology practice / training?

Note: When answering the following questions, please consider both technical and non-technical skills specifically during the intra-procedure stage.

The next few questions will pertain to upper endoscopy:

4. Please describe the major steps and tasks required to perform upper endoscopy in pediatrics.
5. When you perform upper endoscopy in pediatric gastroenterology, are there specific considerations you have to ensure that the procedure goes smoothly or with optimal clinical outcome? If so, what are they?
    a. *Prompts:*
    - *Communication*
    - *Teamwork*
    - *Decision making*
    - *Room set up*
    - *Knowledge*
    - *Technical skills*
        - *Intubating esophagus*
        - *Biopsies*
        - *Tip control*
        - *Navigating into duodenum*
6. In your opinion, what are the most common challenges encountered when performing upper endoscopy in pediatrics?
    a. <u>For faculty only:</u> When you perform a case with a pediatric gastroenterology trainee, which skills do you observe them struggling with? Having an easier time with? Please give specific examples
        i. Are any of these challenges related specifically to pediatrics?

   b. <u>For trainees only:</u> When you perform a case in pediatric gastroenterology, which skills do you find most challenging? Least challenging? Please give specific examples

The next few questions will be similar to the previous set but pertaining to ileocolonoscopy. Please highlight any similarities or differences between ileocolonoscopy compared to your responses for upper endoscopy

7. Please describe the major steps and tasks required to perform ileocolonoscopy in pediatrics.
8. When you perform ileocolonoscopy in pediatric gastroenterology, are there specific considerations you make to ensure that the procedure goes smoothly with optimal clinical outcome? If so, what are they?
   a. *Prompts:*
   - *Communication*
   - *Teamwork*
   - *Decision making*
   - *Room set up*
   - *Knowledge*
   - *Technical skills?*
     - *Loop recognition and reduction*
     - *Biopsies*
     - *Tip control*
     - *Navigating into TI*
     - *Asking for help*
9. In your opinion, what are the most common challenges encountered when performing upper endoscopy in pediatrics? Ileocolonoscopy?
   a. <u>For attendings only:</u> When you perform a case with a pediatric gastroenterology trainee, which skills do you observe them struggling with? Having an easier time with? Please give specific examples
      - Factors associated with taking over the scope?
      - Are any of these challenges specific to pediatric endoscopy?
   b. <u>For trainees only</u>: When you perform a case in pediatric gastroenterology, which skills do you find most challenging? Least challenging? Please give specific examples

Next, we will move on to the idea of competency within pediatric endoscopy.

10. Based on your experiences, what knowledge and skills (technical, non-technical) do you believe are necessary to be a competent pediatric endoscopist?

Lastly, we will discuss the current training practices at your institution:

11. How does your program currently train pediatric gastroenterology trainees (residents, subspecialty residents/fellows) for these procedures?
    a. *Prompts: watching videos, conferences, professional development workshops, simulation training etc.*
12. What has your experience with simulation and endoscopy been?
    a. *Prompts:*
        - *Types of simulators used for which skill*
        - *Which skills were targeted*
        - *Frequency of the sessions*
        - *Instructors*
        - *How effective do you think this training is?*
13. How is feedback on these procedural skills currently provided in pediatric gastroenterology? Are there any specific challenges associated with this? Please provide examples.
    a. *Prompts for possible challenges:*
    - *Identifying problem?*
    - *Knowing what to do?*
    - *Having the trainee understand the instruction?*
    - *Stressors/distractions in the room?*
    - *Limited time for feedback? Intra procedure vs post procedure?*
14. In your opinion, are there any unmet needs by the current pediatric gastroenterology training efforts to teach upper endoscopy and ileocolonoscopy? If yes, how might they be addressed?
15. At which stage in your pediatric gastroenterology training did you feel comfortable/competent (if at all) at performing upper endoscopy? Colonoscopy? Ileal intubation (i.e ileocolonosocpy)? Advanced procedures like banding, polypectomy or dilation?
16. Is there anything else you would like to share with me today that we haven't covered?

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CHAPTER FOUR: DISCUSSION & CONCLUSION

Discussion

The existing literature demonstrates the lack of consensus regarding pediatric endoscopy training. Despite these needs, there has been no structured approach to integration of didactic teaching, simulation, feedback, or application of magnetic endoscopic imagers within endoscopy training. Additionally, there is ongoing research required in the determination of competence within pediatric endoscopy and how this is best assessed in the context of CBD.

Summary of Findings

In the first paper of this thesis, a scoping review was conducted to explore the existing educational interventions in place for teaching endoscopy in both pediatric and adult gastroenterology, as well as in general surgery training. This review highlighted the diversity of approaches to endoscopic training and the limited research specific to pediatrics. However, across the literature, commonalities included increasing incorporation of simulation, exploration of the metrics used to assess competence, and the need for more effective teaching and feedback. Despite this, there has been little evidence to support a systematic approach to endoscopy curricula and how best to sustain the benefits of educational interventions throughout training to allow trainees to accelerate the learning curves for endoscopy. Along these lines, the scoping review highlighted the need to move away from time based and towards quality indicators and consistent use of assessment tools with established validity evidence, which can be integrated into EPAs as a part of CBD.

In the second paper of this thesis, an interpretative qualitive research study using reflexive thematic analysis methodology involved semi-structured interviews with trainees and

faculty across Canada was performed to explore the skills required for upper endoscopy and ileocolonoscopy, those that are challenging for trainees, and the perspectives of participants on the unmet needs in endoscopy training with respect to simulation, feedback, and assessment. This study was able to identify key skills for successful upper endoscopy and ileocolonoscopy, their challenges, and the need for a more structured approach to training, assessment, and feedback within pediatric endoscopy training. The following sections integrate the main findings of these two projects in the setting of the larger body of literature on this topic.

Key Skills for Upper Endoscopy and Colonoscopy

The results from the scoping review highlight that most research conducted in the field has focused on the teaching and learning of technical skills related to upper endoscopy and colonoscopy and least commonly explored integrative skills. The qualitative research conducted, on the other hand, has highlighted that while technical skills are foundational, challenges by trainees are often experienced with developing non-technical skills.[49] In particular, this work highlights the need for opportunities to build troubleshooting skills which may be limited by time and variability in practice.[84] Furthermore, the existing literature and experience of the participants included in this study suggest that formal training courses or sessions within endoscopy training have primarily been delivered at the beginning of training, and the optimal timing and frequency of these educational interventions remains unknown.

Integration of Simulation in Endoscopy Training

The findings of the scoping review and qualitative research conducted as part of this work both emphasize the potential for integration of simulation to address many of the existing gaps in endoscopy training. However, this work again highlights the benefits of endoscopic

simulation in the acquisition of basic scope handling and early skills, and the unclear effects of simulation intervention for later on in training.[85,86] Furthermore, the impact of simulation for more challenging skills, such as troubleshooting or therapeutic endoscopy, has largely been limited by the low functional fidelity of mechanical and part-task simulators and the expense associated with simulation models such as commercialized mechanical models, ex-vivo models and VR models.[16] However, this, along with the integration of simulation sessions with didactic teaching, structured feedback, and deliberate practice in a structured curriculum may be able to overcome limitations of mechanical models, which are most commonly available in training programs.

Assessment of Endoscopic Competence

Lastly, the scoping review highlighted the variability in assessment within endoscopy including the use of quality metrics, clinical indicators, and various assessment tools. Similarly, the qualitative work highlights the lack of effective assessment tools for competence given that procedural volume and completion rates are likely inadequate reflections of competence. Current training uses EPA assessments, but these are largely used as formative assessments, and no formal assessments of procedural skills target summative assessment of endoscopy training. A number of assessment tools, such as the Gastrointestinal Endoscopy Competency Assessment Tool (GiECAT), which has validity evidence in pediatrics, as well as the Assessment of Competency in Endoscopy (ACE) Tool and the Direct Observation of Procedural Skills (DOPS) Tool, have been used in the existing literature for assessment of performance before, during, and after educational interventions and closely correspond to the skills highlighted in this work for successful completion of endoscopy.[58,60,70] As such, these tools may provide the framework

for further assessment of competence as well as evaluation of proposed educational interventions.

Strengths and Limitations

In this work, while the scoping review attempted to explore the breadth of existing literature, the qualitative research conducted may be limited by selection bias as not all Canadian Pediatric Gastroenterology Training programs were represented in the sample, and the participants were largely in the earlier stages of training or independent practice. Along these lines, the lack of participants from all centres may limit its transferability across all institutions within Canada given the variations in training programs with respect to access to resources such as adult gastroenterology, simulation models or technologies (e.g. magnetic endoscopic imagers). Similarly, given that participants were recruited nationally within Canada, and literature was limited to articles in English for the scoping review, the data may be limited in its applicability on an international scale where training requirements and strategies may differ.[87]

On the other hand, this work is one of the first to qualitatively explore the skills required, and challenges associated with endoscopic training in pediatrics. By using a qualitative approach, there was greater opportunity to delve deeply into this topic that may not have been captured through surveys or quantitative research that has been attempted previously. As such, we hope the insights provided may serve as a stepping stone for future research in endoscopy teaching curricula. Similarly, despite its limitations, the findings from this study largely resonate with the existing literature, while providing depth to the exploration of the challenges faced, an area in which previous quantitative studies may have been lacking.

Future Directions for Research and Training

Comprising two interconnected, exploratory studies, this work aimed to identify the gaps in endoscopy training and serve as a needs assessment for a structured approach to teaching, simulation training, feedback, and assessment within pediatric gastroenterology training. Based on the integration of the existing literature and insights gained from this work, we highlight the following three priorities for future research:

1. Further exploration of feasible integration and evaluation of simulation sessions targeting initial scope handling skills, opportunity to troubleshoot common challenges, and exposure to infrequently encountered endoscopic procedures.
2. Implementation and evaluation of a standardized endoscopy training curriculum including didactic teaching sessions, hands-on direct observation, and simulation with structured feedback.
3. Integration of pediatric-specific endoscopy assessment tools within training and evaluation of their correlation to competence and establishment of learning curves in pediatric endoscopy training.

Conclusion

This thesis explored the current state of endoscopy training and the perspectives of Canadian trainees and faculty regarding the current needs and gaps within training. Two studies were included in the body of this thesis, including a scoping review exploring current educational interventions for endoscopy training and a second qualitative study using semi-structured interviews of trainees and faculty exploring their experiences and perspectives on the skills required for endoscopy training. Together, this work provides a comprehensive view

of current practices and the perceived needs, which may serve to generate future research on structured endoscopy curricula to accelerate learning curves and assessment of competence.

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