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ORIGINAL RESEARCH

Trauma

Decision-making for pediatric cervical spine imaging after blunt trauma: Investigating team dynamics in the emergency department

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Abstract

Objective: Cervical spine imaging decision-making for pediatric traumas is complex and multidisciplinary. Implementing a risk assessment tool has the potential to reduce variation in these decisions and unnecessary radiation exposure for pediatric patients. We sought to determine how emergency department–trauma team dynamics may affect implementation of such a tool.

Methods: We interviewed (pediatric and general emergency physicians, trauma surgeons, neurosurgeons, orthopedic surgeons and ED nurses at 21 hospitals to ascertain how team dynamics affect the pediatric cervical spine imaging decision-making process. Data were coded following a framework-driven deductive coding process and thematic analysis was used.

Results: Forty-eight physicians, advanced practice providers, and nurses from 21 hospitals (inclusive of three US regions, trauma levels I–III, and serving towns/cities of various population sizes) were interviewed. Overall, emergency physicians and trauma surgeons indicate being generally responsible for pediatric cervical spine imaging decisions. Conflict often occurs between these specialties due to differential weighting of concerns for missing an injury versus avoiding radiation exposure. Participants

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described a lack of trust and unclear roles regarding ownership for the final imaging decision. Nurses commonly described low psychological safety that prohibits them from participating in the decision-making process.

Conclusions: Implementation of a standardized risk assessment tool for cervical spine trauma imaging decisions must consider perspectives of both emergency medicine and trauma. Policies to define appropriate use of standardized tools within this team environment should be developed.

KEYWORDS

clinical decision support, imaging, pediatric trauma, teamwork

1 | INTRODUCTION

1.1 | Background

Over 40 years ago the American College of Surgeons (ACS), through the Advanced Trauma Life Support (ATLS) training and certification program,[1] advanced a standardized approach to trauma evaluation in the emergency department, which has become the practice standard in the United States[2] and globally.[3] Its systematic approach is widely taught and practiced by emergency and trauma surgery physicians. Evaluation for possible cervical spine injury (CSI) is encompassed in the ATLS evaluation. Pediatric patients have mechanisms of injury and anatomic variances from adults and require a unique approach to evaluation for CSI. While there are validated decision rules for CSI in adults, such as the National Emergency X-Radiography Utilization Study (NEXUS)[4,5] and the Canadian C-Spine Rule,[6,7] there are no validated rules for children that consider these unique charactertistics.[8] The lack of a validated clinical prediction rule for pediatric CSI has led to highly variable approaches in the use of cervical spine imaging.[9] Some practitioners may defer imaging to minimize exposing children to ionizing radiation, whereas others may default to adult trauma criteria to guide decision-making.

1.2 | Importance

The trauma evaluation process, even in the context of the structure provided by ATLS, is dynamic and collaborative, requiring cooperative evaluation and decision-making between emergency physicians, advanced practice providers (APPs), nurses, trauma surgeons, and potentially many other specialists (eg, orthopedic and neurosurgeons, respiratory therapists, pharmacists, intensivists, etc). This process leads to shared decision-making between clinicians with differing specialties, varying levels of experience, and different perspectives on caring for trauma patients. Therefore, tools to provide more support and standardization for these decisions could be beneficial, such as a CSI risk assessment tool tailored to the pediatric population. A key step in developing and planning for dissemination of such a tool is to examine current practices of the pediatric trauma team and broader

organizational context that will influence how the tool is used in practice.

1.3 | Goals of this investigation

Clinical decision-making, often considered an individual-level process, is subject to influence by a broader clinical team, the organization in which a practitioner works, and in some cases, state and regional policies or designations. In the case of decision-making about cervical spine imaging for pediatric traumas, multiple team members are often involved, such as emergency physicians and nurses, trauma surgeons, resident trainees, APPs, and depending on the context, other specialists, for example, pediatricians, pediatric emergency physicians, orthopedic surgery, neurosurgery, and so forth. This can lead to decisional conflict and serve as a barrier to implementing a CSI risk assessment tool and clinical decision support (CDS) for pediatric imaging decisions. The goal of the current study is to examine team dynamics related to evaluation of pediatric trauma patients and decision-making around cervical spine imaging and how this may affect implementation of CDS for pediatric cervical spine imaging.

2 | METHODS

2.1 | Framework

We explored this from the lens of a framework on health care teams by Gregory et al,[10] adapted from Salas et al's[11] seminal work. The Gregory et al[10] framework considers 3 team inputs: (1) a common, valued, and patient-centered goal; (2) specific roles; and (3) interdependent tasks. Processes (team member behaviors and cognitions that convert inputs to outcomes)[12] and emergent states (affective, motivational, and cognitive states of teams)[12] in the Gregory et al[10] model include psychological safety, defined as "a shared belief that the team is safe for interpersonal risk taking,"[13] conflict management, situation assessment and shared mental models (ie, development of a shared understanding of team goals, tasks, and progress), team leadership, team decision-making and planning, coordination, and backup

behavior (ie, assisting team members with tasks, including by providing feedback). Organizational conditions and communication are suggested to moderate these relationships.[10] We sought to better understand the nuances of each of these factors in cervical spine imaging decision-making in pediatric patients.

2.2 | Study design and participants

We used a qualitative phenomenological approach from a constructivist/interpretivist paradigm. Participants included pediatric and general emergency physicians, APPs, trauma surgeons, neurosurgeons, orthopedic surgeons, and ED nurses at 21 hospitals in 3 regions of the United States, including 4 state-level trauma designations representative of the trauma system in 3 regions of the United States. Participants were recruited from April 2019 until saturation (November 2019) through Pediatric Emergency Care Applied Research Network (PECARN) investigators (D.C., L.T., S.O.) and one non-PECARN investigator, M.H. These recruiters connected our research team to trauma program and emergency services administrators at hospitals throughout the United States. We purposively sampled EDs that represent the full spectrum of trauma designations, from Level I trauma centers to EDs with no trauma designation. We similarly sampled EDs based on their community population. We acknowledge EDs in the west region were overrepresented in our sample. However, our overall goal was to recruit participants from EDs in a variety of settings across the United States, with the recognized limitation that as a qualitative study, logistical constraints prevented us from conducting interviews at significantly more centers. Within-hospital, we purposively sampled by hospital role and therefore recruited participants who met these criteria and were available on the date of the interviews. Individuals who met the criteria were contacted by the hospital administrators and opted in if they wanted to participate. This study was approved by the University of Utah Institutional Review Board (#00115115) and verbal consent was obtained.

2.3 | Procedure

We conducted 40 total semistructured interviews among 48 participants, lasting 15–60-min each. Interviews were conducted in person from May—November 2019, by 1 or 2 research team members (including A.T., D.C., J.C.L.). Interviews involved primarily 1 participant but occasionally included a second participant when necessitated by logistical constraints. We conducted 2 types of interviews following separate guides (see appendices): 23 workflow interviews and 17 knowledge audit interviews. Workflow interviews focused on the processes that the emergency medicine and trauma teams followed from the time of alert of an incoming pediatric blunt trauma patient via emergency medical services (EMS) or arriving via walk-in through clinical clearance. Knowledge audit interviews were based on Militello et al.[14] and included questions about the participant's thought process around cervical spine imaging decisions when assessing and treating a

The Bottom Line

In this well-conducted qualitative study of pediatric cervical spine imaging decision-making, the investigators identified two predominant themes: 1) that spine imaging decision-making is a collaborative process between emergency physicians and trauma surgeons and 2) that team conflict regarding imaging is common due to a lack of decision support tools.

pediatric trauma case. We began data collection with workflow interviews, transitioning to knowledge audit interviews once we reached saturation in relation to workflow. We subsequently transitioned to conducting knowledge audit interviews until saturation was reached on cognitive decision-making processes. Each participant participated in only 1 interview type. All interviews were audio recorded and transcription services were provided by Hoffman Transcription. Utterances such as "um," "you know?," and so forth, were removed from quotations for this manuscript, unless they added substantive meaning. The Standards for Reporting Qualitative Research (SRQR)[15] guidelines were followed.

2.4 | Analysis

Transcripts were uploaded into MAXQDA[16] and data were analyzed using deductive thematic analysis.[17,18] An initial codebook and coding dictionary were developed by two research team members (A.T., J.C.L.). Subsequently, 4 team members (M.E.G., F.A., A.T., J.C.L.) engaged in simultaneous, group coding of the transcripts during team meetings. The codebook was continuously revised to allow for new codes to emerge, definitions to be clarified, or codes to be reorganized as needed.[19,20] A code titled "team dynamics" was used to capture vignettes that encompassed team member attitudes, behaviors, or cognitions. After this, -one team member with expertise in team dynamics (MEG) reviewed all of the vignettes coded with the initial "team dynamics" code and applied more specific teamwork sub-codes to these data. We derived teamwork subcodes using a deductive approach from the Gregory et al[10] framework. The entire authorship group, including two pediatric trauma experts, reviewed the final coding and theoretical framework for content validity.

2.5 | Reflexivity statement

Team members involved in data collection involved A.T. (a non-clinical research coordinator experienced in emergency medicine studies), D.C. (a pediatric emergency physician), and J.C.L. (a pediatric emergency physician). The coders included M.E.G. (a non-clinical researcher with expertise in health care teams), F.A. (a pediatric emergency

physician), A.T. and J.C.L. The other authors on the paper include an additional pediatric emergency physician (L.T.), a paramedic who is also an emergency medicine researcher (S.J.O.), and a pediatric orthopedic surgeon (M.H.). It is possible that these roles influenced the way the authors collected and interpreted the data. We addressed this by use of semistructured interview protocols to reduce the influence of professional biases, inclusion of a non-clinician (A.T.) in data collection, involving two non-clinical team members as coders (M.E.G., A.T.) and having a non-clinical team member (M.E.G.) engage in the analysis and integrate findings into the framework.

3 | RESULTS

3.1 | Participant characteristics

We interviewed 48 participants at 21 hospitals, including teaching ($n = 16$, 76.2%) and nonteaching ($n = 5$, 23.8%) hospitals in 3 US regions, that represented non-trauma centers as well as Level I, II, and III trauma centers. Communities ranged from small towns (19.0%) to large cities (28.6%). Participants were physicians ($n = 31$, 64.6%), including pediatric emergency physicians ($n = 4$, 8.4%), emergency physicians ($n = 14$, 29.2%), pediatricians ($n = 1$, 2.1%), and surgeons ($n = 12$, 25.0%), as well as nurses ($n = 14$, 29.2%), and APPs ($n = 3$, 6.3%), with years in practice ranging from <1 year to >10 years. See Table 1.

3.2 | Current state of team dynamics in the pediatric cervical spine imaging decision-making process

Theme 1: Pediatric cervical spine imaging decision-making is a collaboration between emergency medicine and trauma surgery physicians, whereas several others may consult on, or influence, the decision depending on clinical and organizational context. We found initial primary decision-makers always include trauma surgeons and/or emergency physicians (emergency or pediatric emergency physicians), but there is inconsistency about who is ultimately responsible for the imaging decision. In some cases, these decisions are collaborative between trauma and emergency medicine, as explained by one trauma surgeon: *"It's very collaborative. I think we know all of our emergency medicine physicians; they know all of us, the trauma surgeons, and if they happen to see someone, we'll talk about it, and sometimes I change my mind based on what they've told me. I'm like oh, that's a good idea, yeah, we should do that."* However, in other hospitals, emergency physicians defer to trauma surgeons; yet others indicate that emergency physicians are the primary imaging decision-makers (see Table 2).

Decision-making also depends on the staffing. In some institutions, particularly those that are not Level I or II trauma centers, participants indicated that neonatologists or general pediatricians may be consulted on imaging decisions if available in house, as described by a physician: *"We don't have pediatricians that would necessarily stop in, though if it's very young, then we will have our NICU [neonatal ICU] team*

here." Physicians may alternatively seek input from other consultants such as orthopedic surgery or neurosurgery and at times will seek advice from pediatric experts at a nearby children's hospital. Generally, participants reported that the primary physician caring for the patient is ultimately responsible; for example, if the orthopedic surgeon is consulted and the patient is admitted to orthopedics, the orthopedic surgeon becomes the responsible party for imaging decisions.

Some hospitals also allow others to participate in the decision-making process, including residents or APPs. In these cases, there are frequently limitations regarding type of imaging ordered and overall authority to order. For example, residents may consult an attending physician, depending on clinical context and the residents' seniority. APPs may similarly be able to make imaging decisions autonomously, particularly for plain films, but may need to consult an attending, or have a physician authorize orders. Some physicians stated that they engaged patients' families in shared decision-making regarding imaging decisions as well.

One institution had a policy requiring radiologists to approve certain imaging decisions, specifically computed tomography (CTs) and magnetic resonance imaging, and that they must be preceded by a plain film, as explained by 1 pediatric emergency physician: *"We have to have any kind of CT of the neck approved by radiology before we do it…"* Physicians at other institutions sometimes mentioned consulting with radiology on imaging decisions although the ordering provider made the final determination.

Nurses were generally unable to order any type of pediatric imaging independently, except for some types of plain radiographs (eg, extremities) in triage. However, many nurses emphasized that they would advocate for a patient to receive—or not receive—imaging, as they saw fit. This appears to be largely dependent upon psychological safety, as described later.

Lastly, some participants discussed the role of EMS in a pediatric cervical spine imaging decision. Although generally this was not a formal part of the decision-making process, EMS impression of a patient may implicitly or explicitly drive a physician toward a certain course of action. For example, some participants discussed how EMS' decision to immobilize a patient influenced their cervical spine imaging decisions (see Table 2).

Theme 2: Team conflict regarding whether to order cervical spine imaging in pediatric traumas is common, largely due to lack of decision support tools, individual preferences toward imaging versus reducing exposure to ionizing radiation, and lack of interdisciplinary trust. Participants indicated that there were times when decisional conflict was rare, such as when a child was very ill, as described by a nurse: *"The other scenario is they are more sick and time is much more valuable and there's not a whole lot of discussion, and pretty much everybody agrees on what we're doing as far as evaluating the child, being more aggressive."* However, absent these circumstances, conflict can be commonplace and multi-causal:

1. Lack of standardized risk assessment tools or CDS: For example, 1 pediatric emergency physician stated, *"We actually don't have any really clinical decision support to assist us, unfortunately."* Thus, imaging decisions appear to be highly variable between individuals. This

TABLE 1 Demographics of participating hospitals and participants.

Variable	Level	n (%)
State-level trauma designation		
	Level I	7 (33.4%)
	Level II	6 (28.6%)
	Level III	4 (19.0%)
	Non-trauma	4 (19.0%)
Region of the United States		
	West	15 (71.4%)
	Northeast	5 (23.8%)
	Midwest	1 (4.8%)
Community		
	Small town (2500 to 24,999 people)	4 (19.0%)
	Medium town (25,000 to 74,999 people)	3 (14.3%)
	Large town (75,000 to 149,999 people)	5 (23.8%)
	Mid-sized city (150,000 to 500,000 people)	3 (14.3%)
	Large city (500,001 or more people)	6 (28.6%)
Profession		
	Physician	31 (64.6%)
	Attending, pediatric emergency medicine	4 (8.4%)
	Attending, general emergency medicine	14 (29.2%)
	Attending, pediatrician	1 (2.1%)
	Adult general surgery	5 (10.4%)
	Pediatric general surgery	3 (6.3%)
	Adult neurosurgery	1 (2.1%)
	Pediatric neurosurgery	1 (2.1%)
	Adult orthopedic surgery	1 (2.1%)
	Adult trauma surgery	1 (2.1%)
	Advanced practice providers: advanced practice nurse/physician assistant	3 (6.3%)
	Nurse	14 (29.2%)

Note: Two facilities are free-standing children's hospitals: One with pediatric Level I trauma designation and one with pediatric Level II trauma designation.

is described by a surgeon: *"Now, if you look at my entire group, it's sort of a, you know, bell curve. Some of them scan everybody head to toe and others do more selective scanning…"*. Importantly, there is currently not a universally accepted or validated pediatric cervical spine imaging decision rule, and thus physicians tend to default to adult practice, or apply an inconsistent case-by-case assessment. In lieu of this, some indicated that they, individually, followed rules such as NEXUS[5] (validated for adults), but this was not a hospital-wide practice (see Table 3). As a result, the decision appears to come down to individual opinions and disagreements occur.

2. Individual preferences for imaging: As stated by 1 pediatric emergency physician, *"Some people are very judicious in their decisions for what to scan and how to scan, and some are very liberal."* Many commented that this was related to specialty, with trauma physicians obtaining imaging more frequently, as suggested by the following

physician: *"I worked with a trauma surgeon in residency, that if they got a fender bender at 3 miles an hour. It doesn't matter. You get a full trauma imaging panel. There was no decision-making whatsoever with him."* In a similar vein, a trauma surgeon at another institution indicated that the difference between emergency medicine and trauma imaging decisions primarily comes down to the confidence each specialty has in physical exams. It was also common to attribute imaging decision preferences to when a physician trained, with more recent trainees tending to err on the side of not imaging.

3. Lack of interdisciplinary trust: Occasionally, physicians mentioned that they felt the need to double-check and make their own decision due to lack of trust in another discipline (eg, trauma double-checking their emergency medicine colleagues' exams). An emergency physician had a similar sentiment regarding lack of full

TABLE 2 Roles of various professions in imaging decisions for pediatric traumas.

Profession	Role in pediatric cervical spine imaging decision	Example quotation
Emergency/pedicatric emergency physician	Usually involved; may act independently, may consult with trauma and/or other surgical specialties, or may defer to trauma, depending on institutional norms and clinical context	*"Mostly it's going to be emergency medicine [making imaging decisions]. They'll occasionally, sort of we'll do it together, like 'what do you think? Should we scan a kid?,' or whatever, but we're just talking about a handful of cases per year."*—Trauma surgeon
Trauma surgeon	Usually involved when there is a trauma team activation; may act independently, may consult with emergency medicine, or may defer to emergency medicine, depending on institutional norms and clinical context	*"Ultimately, the trauma surgeons sort of have the last word."*—Emergency physician
Emergency medicine, pediatric, or trauma trainee/resident physician	May be involved if available at the institution; depending on experience and clinical context, may act independently or consult attending physician	*"I think [residents are] still gonna make decisions, what they want to do… If you're 80 years old and having chest pain, they're going to get a chest X-ray, but I'm sure if it's a 3-year-old with neck pain after a fall, they're going to ask the attending first what to do or what to image."* -Emergency physician
Advanced practice providers	May be involved if available at the institution; may make decision independently but orders usually need to be authorized by a physician; may consult with physician depending on self-efficacy and clinical context. May be limited in types of imaging they can order.	*"A lot of our children's ER PAs are ours, so they've worked with us long enough that they feel comfortable and they kind of know what we are asking for or what we would be thinking or, so a lot of times. I mean, I think they're comfortable doing X-rays."* -Pediatric emergency physician
Orthopedic surgery or neurosurgery	May be consulted depending on clinical context	*"If there is anything concerning on the X-ray, then we'll go to CT scan and then we'll admit them for observation and see if they can go back to baseline and then clear the collar without scanning. If not, then we'll scan or we'll consult neuro. Like we have a spine service. So, it's orthopedics sometimes or neurosurgery and then they will make the decision if they want a scan or not to scan."* - Pediatric emergency physician
Pediatrics or neonatology	May be consulted if available at institution	*"…we sort of huddle between the emergency department, peds, and trauma, to determine what our next steps are as far as imaging plans."* -Pediatric emergency physician
Radiology	May be consulted if desired by physician or may choose to contact physician to discuss imaging order; at some institutions, has authority to approve/deny orders	*"There is a protocol that we have for X-ray first, and these X-rays have to be done and have to be discussed with the radiologist to get further CT or MRI imaging."* -Pediatric emergency physician
Nurse	Cannot order imaging; however, may advocate for a particular decision, depending on self-efficacy, assertiveness, and physician reputation (e.g., may be hesitant to speak up to physician who is known for being non-receptive)	*"I'm not being asked for my opinion, but again I would prompt, or I would try to clarify why are we doing? 'You're scanning this child's head, chest, abdomen and pelvis. What are we doing? Why are we doing all this?' But not so much as 'what do you think? Do you think we should get a scan or not?'"*- Emergency medicine nurse
External children's hospital	May be consulted on decision if physician would like pediatric expertise, and/or if patient is being transferred. Occasionally, children's hospital radiology may read and interpret imaging.	*"If they are not stable, we will directly communicate with our pediatric colleagues at [local children's hospital] as to how to best address the issue."* -Neurosurgeon
Patient's family	May be consulted by physician to engage in shared decision-making around imaging.	*"We always have parents back here when we can… And the trauma surgeon…or the pediatric surgeon or PICU attending, start talking to the parent, 'So this is what we're doing. This is why. He seems to be looking very good right now. We don't like to give children a lot of radiation. We would like not to scan him right now. Maybe we can just watch him in the children's ER.' And some parents are adamant, you know, 'I want to get.' 'Well, let's see how he does in the ER.' They try to really lead them away from that if it's appropriate."* -Emergency nurse
Emergency medical services	Assessment may influence physicians' imaging decision	*"Well, I mean we have pretty good paramedics… I think if I have paramedics coming in and saying 'oh this person's really sick, we think that there's something really wrong with them,' I wouldn't just take them off the board and pan scan him, you know what I mean."*- Emergency physician

Abbreviations: CT, computed tomography; ER, emergency room; MRI, magnetic resonance imaging; PA, physician assistant; PICU, pediatric ICU.

TABLE 3 Clinical decision support mentioned by participants to assist with pediatric imaging decisions.

Type of CDS	Examples mentioned	Noted teamwork-related challenges to use and implementation	Example quotation
Evidence-based adult standardized risk assessment tools	NEXUS	Typically described as a physician individually choosing to use this tool, not required by hospital and not systematically implemented	*"So, for me we did a lot of NEXUS stuff, but I think some people just aren't and we've got some older docs who are primarily internal medicine trained and I'm not sure that there's the same comfort level."*-Emergency physician
Hospital-wide guidelines	Decision support cards	Challenges to buy-in when perceived as developed without specialty input	*"It's kind of a sore point between the emergency department and trauma surgery because… I could grab a [decision support] card for you… It's just certain mechanisms that the trauma surgery service has unilaterally decided on meet, some sort of criteria."* - Emergency physician
Specialty guidelines	ATLS guidelines, supported by ACS, used by trauma surgeons	Conflicts between various specialty guidelines (eg, more frequent imaging recommendations for trauma vs. emergency medicine)	*"Usually if the kid's wiggling around and moving around, I'm pretty comfortable that they're not guarding or protecting and things like that. And the surgeon will say, 'well, it was a rollover.' So regardless of ejection or anything else. A lot of times, I feel like it comes down to 'ACS [American College of Surgeons] says this, ACS says that,' versus the clinical presentation or taking the whole package in."* - Emergency physician

Abbreviations: ACS, American College of Surgeons; ATLS, Advanced Trauma Life Support; CDS, clinical decision support; NEXUS, National Emergency X-ray Utilization Study.

TABLE 4 Sources of emergency medicine/trauma physician conflict in pediatric cervical spine imaging decision-making.

Source of conflict	Explanation	Example quotation
Confidence in physical exams	Emergency physicians appear to weigh reassuring physical exam findings more heavily than trauma physicians; trauma may be less trusting of a physical examination finding to rule out a specific diagnosis without supporting imaging.	*"It's a difference in the literature and then the belief, like emergency room providers feel like 'oh, we can clear all this stuff with physical exam and all,' but for us surgeons, physical exam is pretty useless in the trauma bay… From my standpoint, X-ray is not a bad thing, so, if there's any concern, then you scan them."* -Trauma surgeon
General risk aversion/fear of missing injury	Trauma may be more risk-averse than emergency medicine, leading to more imaging. This is supported by their professional guidelines (eg, ACS).	*"Or [surgeons are] just more conservative. They're more risk-averse, as far as, you know, as far as, missed injuries and that kind of stuff."*- Emergency physician
Concern for radiation exposure	Emergency physicians seem to have more concern about exposing patients to radiation as compared to trauma surgeons.	*"I think now, we try to be very judicious. Our surgeons are not so much, but they're coming around."*-Emergency physician
When physicians trained	More recent trainees may generally be more judicious about imaging as compared to those who trained more distally.	*"I have noticed the senior residents now will say 'we shouldn't do this' or 'there's no need for this,' like as part of their education as interns, they've grown up in the 'do not scan a kid' mode."* -Pediatric surgeon

Abbreviation: ACS, American College of Surgeons.

trust in EMS personnel, stating, *"There have been instances where the medics have been a little bit cavalier or they've missed a criteria … so I don't know if it's skeptical or cautious or whatever, about the EMS decision to clinically clear."*

Table 4 summarizes these findings.

This conflict is resolved in various ways. Some indicated that, if they do not feel strongly, after attempting to negotiate, they defer to their colleagues. Alternatively, if all parties in the negotiation do feel strongly, the decision may be moved up the chain of command. The prior emergency medicine physician continued, *"one of my colleagues a month ago got into this argument with a trauma surgeon, refused to do the imaging. The trauma surgeon ended up, kind of escalated it kind of up the chain of command."* If conflict is occurring with a trainee or APP, the discussion can be escalated up to the attending level, as described by a PEM physician: *"Occasionally one person will say I want CT, the other will*

TABLE 5 Summary of potential teamwork-related barriers to pediatric cervical spine imaging decisions.

Dimension from Gregory et al.[10]	Description of barrier	Example quotations
Common, valued, patient-centered goal	Different specialties have different goals (avoiding radiation exposure vs. minimizing risk of missed injury)	"…They can get heated…because, like I said, some of the surgeons will fall back on ACS or they'll… just bluntly say, 'I don't care, I want [the imaging].' And we say, 'Then you put the order in.' It becomes kind of a battle…" - Emergency physician
Situation assessment and shared mental models	Not always clear to team members when the physician is making imaging decisions	"Some doctors would be fine with the nurses bringing [a standardized risk assessment tool for pediatric cervical spine imaging] up, and some would be annoyed because they're like, 'I already made that decision.' You know, the nurses don't know when we're thinking about it. So it might not flow right." - Emergency physician "With an adult trauma, we know what we're doing, we know why we're doing it, we anticipate everything that the surgeons and the doctors are going to order, and with the pediatricians and the pediatric traumas run by our ER doctors, we are not quite sure what the next step is going to be. That's probably because it's pediatric trauma, right? We're not sure if we're going to do imaging or not or, you know, how aggressive they're going to become especially if the patient is pretty stable." -Nurse
Specific roles	Not always clear whose role it is to make imaging decision; this role may change depending on trauma level, profession, specialty, self-efficacy, clinical context, logistics/availability of team members, time of day, etc.	"During daytime, like 11A to 11P, when we have the peds ED side open, it may not be sent there. It may be kept on the main ED for the adult ED physicians because the back, where we have our little six-bed pediatric ED is actually staffed by general pediatricians, so it's more like a pediatric urgent care than true emergency care."— Emergency physician "No, [residents] generally get the imaging, because it's just more, while I'm on my way or if I'm in the OR something like that, they will get some X-rays first, and depending on how senior the resident is, generally they'll make recommendations."-Orthopedic surgeon
Team leadership	Not always clear who leader is for imaging decision, or if there should be shared leadership for imaging decision	"I think that the ER's impression of how much autonomy they have is different than what they actually have. So a Level I or a Level II, immediately after they're done assessing the patient, they call me." -Orthopedic surgeon
Team decision-making and planning	Often many parties are involved in imaging decision: emergency medicine, trauma, consultants (eg, pediatrics, neonatology, neurosurgery, orthopedics) regional pediatric hospital, radiology, patient's family	"We would work with the trauma team as well as our pediatric hospitalist group, so we always get an attending or a resident or fellow… down that would come from the Peds service to assist from that perspective. So they are looking at the pediatric side and doing all the history and talking to family and trying to figure out that, in working in conjunction with the trauma EM to facilitate care. So between all three of them, they determine plan of care, what is appropriate, what tests need to be done, and how we can go forward." - Emergency nurse
Psychological safety	Not always present	"As far as empowered, it definitely depends on the nurse and experience and which physician it is and how approachable they are." - Emergency nurse
Backup behavior	Non-physician team members may choose not to advocate or speak up in absence of psychological safety. Further, physicians may choose not to accept the input from these team members.	"…We definitely have some [nurses] who are more timid and if they're paired with an attending physician that is much more harder to approach, then I could see that not do as well, whereas, I feel like in general we have some amazing outspoken nurses who would definitely, who wouldn't have any trouble saying 'you sure about this?' and wouldn't mind bringing it up. I think a lot of our attending physicians would listen to that, but I think there are some that would shoot them down and say, 'no, I'm the physician, this is what I want'." -Pediatric emergency physician "I think that [nurses] feel comfortable [speaking up about pediatric imaging recommendations], but I don't know if we would necessarily follow it." -General surgeon
Conflict management	Most do not have a standardized way to resolve imaging decision conflict, various individual-level approaches are taken (eg, negotiate, defer, escalate to chain of command)	"I mean, it's almost kind of a negotiation now… And so, I guess it just kind of comes down to … how strongly do we feel about getting less imaging? And so, if we're kind of on the fence and they're pushing for it, then you kind of say, 'okay, fine, it's not worth the fight'."- Emergency physician

(Continues)

TABLE 5 (Continued)

Dimension from Gregory et al.[10]	Description of barrier	Example quotations
Coordination	Trauma workflow can be chaotic. Workflow varies depending on trauma level, walk-in versus EMS transfer, clinical context, and other factors; not always a standard time when imaging decision occurs	*"Like in the middle of a trauma with 20 people there… you have to pick and choose your times when you want to negotiate stuff like [imaging], so I'm a little bit more selective about when I go, 'Are you sure you want to do that?'"* -Pediatric emergency physician *"… probably the biggest hang-up is there's a ton of people and a lot going on…"* -Pediatric emergency physician
Interdependent tasks	Sometimes lack of trust leads physicians to duplicate exams before making imaging decision	*"So, the emergency room provider will do [the neck examination] first. And then we go back and, you know [do a second neck examination]. Yeah, we don't believe them, ever."* -Trauma surgeon

Abbreviations: ACS, American College of Surgeons; ED, emergency department; EMS, emergency medical services; ER, emergency room; OR, operating room.

say X-ray. When that happens, we just kick it up to the trauma attending and then it will be an attending-to-attending discussion as far as what imaging should be obtained." Similarly, one nurse explained, *"Especially for head scans, I've been in a situation where I have literally… gotten in an argument with the… PAs [physician assistants] or NPs [nurse practitioners] … I've literally like gone into CT and been like, 'do not scan this kid…this is not going to happen, they don't meet criteria, they don't need to be exposed to radiation.' And at that point, I just get an ER physician involved."*

Summary of current state. We have mapped the aforementioned challenges onto the Gregory et al.[10] (2021) framework for health care teamwork (Table 5).

3.2.1 | Potential teamwork-related barriers to effective standardized pediatric cervical spine imaging risk assessment tool implementation and recommendations to address barriers

Addressing teamwork-related barriers to effective implementation of pediatric imaging guidelines. As noted previously, participants mentioned that guidelines or protocols would be beneficial to streamlining and standardizing pediatric cervical spine imaging decisions and reducing conflict. One physician exemplified this when discussing use of the MDCalc tool (a web-based tool that provides point-of-care CDS) to inform team decision-making more broadly: *"I open MDCalc and put it through… like if the APP is presenting to me about a kid… we can look at it together and say, 'Okay, that's low-risk, let's do a six-hour obs.' And so that they can read it and we're not at disagreement and everyone sees the same thing."* However, our work has uncovered that several teamwork-related barriers may stand in the way of a successful implementation of CDS for many hospitals. We summarize these barriers and propose recommendations for solutions in Table 6.

4 | LIMITATIONS

Although interviews were primarily focused on pediatric cervical spine imaging decisions, several participants expanded their discussion to include other types of pediatric imaging decision-making practices.

Although we included a wide variety of settings and professions, these findings are not necessarily representative of all hospitals and individuals. Future work should expand this research, particularly in areas underrepresented in our sample, such as the southern and midwestern United States, and with more lower level trauma centers. Further, it is unclear to what extent the findings generalize outside of the United States. Additionally, biases of the research team could have influenced the interviews and coding. Future research should focus on validating these findings in other settings using quantitative research methods.

5 | DISCUSSION

The pediatric cervical spine imaging decision-making process is complex, unstandardized, and varies widely between institutions and physicians. Prior work has noted similar challenges, with a survey of 25 institutions finding that general/trauma surgeons were the primary service responsible for pediatric cervical spine clearance in 44% of cases, with 33% being a "rotating schedule" of orthopedic and neurosurgery.[9] This study also found that less than half of the institutions reported using a written, standardized pediatric cervical spine clearance protocol.[9]

The collaborative, yet unstandardized, approach to pediatric cervical spine imaging decision-making and associated conflict appear to largely be a result of unclear roles and team leadership between emergency medicine and trauma in this context, as well as lack of interdisciplinary trust, differing goals (avoiding ionizing radiation vs. missing an injury), and often the consultation of additional disciplines in the team decision-making process (eg, orthopedics, pediatrics or neonatologists, neurosurgery, external hospitals, etc.). Further complicating the process is the influence of others, such as APPs, EMS, and nurses, who may attempt to weigh in on cervical spine imaging decision-making when they feel psychologically safe to do so. These factors in the context of a chaotic trauma workflow, with no relevant decision support, lead to frequent challenges that which may result in either over- or underimaging, unnecessary exposure to ionizing radiation, or missed injuries.

A teamwork approach is clearly needed to address these issues; yet, the role of teamwork in risk assessment tool implementation is

TABLE 6 Teamwork-based barriers and associated recommendations for implementing a pediatric cervical spine imaging standardized risk assessment tool.

Barrier	Example quotations	Recommendations
Specialties and individuals have different opinions on how judicious to be regarding imaging; may not all buy-in to new recommendations	*"You know what you'd have to do. You'd have to send a trauma surgeon there with the research and present [the tool]… I think if it comes from emergency medicine, I think that they're a little bit more resistant to it. I think if it came from trauma surgery, they would kind of see that as like, you know, their cultural contribution to the endeavor rather than kind of something being imposed on them…"* - Emergency physician *"Some of the older docs… would be like 'I haven't needed to use this [tool] for my whole career, blah, blah, blah.'… they don't want to change their practice."* - Emergency physician	Provide hospital-wide education to physicians on risks and benefits of imaging for pediatrics, co-led by emergency medicine and trauma physicians Guidelines should be co-developed between emergency medicine and trauma to ensure all viewpoints are represented and increase buy-in Guidelines should be studied for compliance (ie, audited) or failures on a regular basis after implementation to facilitate re-evaluation and adaptation if necessary
Unclear roles related to pediatric imaging decision-making; who is involved and who has the final say varies	*"…While I'm on my way, or if I'm in the OR something like that, they will get some X-rays first, and depending on how senior the resident is, generally they'll make recommendations. So anything that was aimed at guidelines would also really need to be made aware… the residents are kind of like first line, that order all these kinds…"* -Orthopedic surgeon	Hospital should consider policy of use of the tool by initial trauma team leader Guidelines should define when clinical consult from specialist should be obtained and delineate who is the ultimate decision-maker
Lack of psychological safety	*"Plus you're asking a nurse to look back at a bunch of physicians, going, 'the computer says you're not doing it right.' I think that's a hard conversation for the nurse to be able to do, so I'm not sure I would necessarily pin it on them to be the ones to break the news to us."* -Pediatric emergency physician	Hospitals and teams should strive to develop a culture wherein non-physicians are empowered to collect the information needed to populate the decision aid. In absence of this, physicians should be charged with consulting the tool, instead of nurses. Hospitals should evaluate how CDS is being used and seek to understand rationale for physicians' deviations from risk assessment tool recommendations
Trauma workflow varies widely depending on clinical context and can be chaotic; not always a standardized point in time when imaging decisions occur	*"Just the way that our workflow works in the EMR is that we're often times documenting and ordering after the fact because it doesn't… We're given verbal orders. And then back filling it afterwards. So, if it were really to be decision support in the moment of clinical decision-making, it would need to be… everybody to remember there's this thing and then have it somewhere posted…"* -General surgeon *"I am just thinking about how a trauma flows and…because truly, [the surgeons] don't have anything in front of them, they're not using electronics, there literally just standing because, especially the education part of it, the surgical resident is there, they are running the trauma so… it's kind of tough, because there's no real break in their continuum of care that you can stop and say, hey this says. Especially if it's a really ill or injured child they are not stopping for much."* -Nurse *"We have 30 min to be there. [EM is] not going to wait on us for imaging if they think they need imaging, they'll get it. Otherwise, we're usually here within 10 min or so, and then we help with imaging."* -Trauma surgeon	Risk assessment tool should be available in multiple formats that are widely available and easy to access at all points of care (eg, wall poster, decision card, mobile app, intranet) To ensure use at all possible points of care, risk assessment tool should be readily available to multiple specialties (emergency medicine, trauma, radiology, neurosurgery, orthopedics, pediatrics, and neonatology), multiple roles (nurses, residents and APPs) and in multiple points of care (eg, triage, emergency medicine, trauma bay, radiology department)

Abbreviations: APP, advanced practice provider; CDS, clinical decision support; EMR, electronic medical record; OR, operating room.

understudied.[21] In relation to the Gregory et al[10] framework, our data suggest that different specialties do not typically share a *common goal* nor *shared mental models*, with emergency medicine physicians tending to emphasize reduced radiation exposure, and trauma physicians tending to emphasize more frequent imaging to reduce missed injuries.

There also tends to be *unclear roles* and *unclear leadership*, such it is not always clear who (ie, emergency medicine or trauma) was ultimately responsible for the decision. Physicians' lack of trust in other specialties also has implications for challenging *task interdependence* and *coordination*, as duplicate examinations add to the confusion of the trauma

environment and prolong the decision-making process. This also impedes effective *team-decision making and planning* regarding imaging decisions. Finally, nurses often feel it is important to provide *back-up behavior* to support the imaging decision-making process by advocating for or against imaging. However, some mentioned a lack of *psychological safety* that precluded them from speaking up. Altogether, these factors lead to the *conflict* described previously and suggest that the current environment for teamwork in pediatric traumas will serve as a potential barrier to successful implementation of a risk assessment tool.

Overall, to effectively implement a risk assessment tool for pediatric cervical spine imaging, guidelines should be co-developed and introduced to collaboratively by both emergency and trauma physicians.[22] This will help to ensure that guidelines reflect priorities from both specialties and demonstrate to each specialty that the tool is supported by their respective groups. Next, we propose that hospitals implementing this tool should consider creating policies around the individual responsible for using the tool who would ultimately make the final decision on pediatric cervical spine imaging. Such a policy would reduce role conflict and unclear leadership. Further, results suggest that teams should not prescribe the role of tool consultation to team members such as nurses or APPs, as they often feel a lack of psychological safety to speak up to the physician. Physicians should also ideally be trained to show that they are open and accepting of team members' opinions.

This study found that the pediatric cervical spine image decision-making process is unstandardized and involves multiple stakeholders. This, combined with lack of trust and differing goals between disciplines, leads to frequent conflict about whether or not to image a patient. A standardized CSI risk assessment tool tailored to the pediatric population would likely reduce this conflict. Our study indicates the importance of involvement of both emergency medicine and trauma in the development and implementation of such a tool in order to ensure it reflects different perspectives and achieves buy-in for both groups, who are the primary decision-makers in this context.

AUTHOR CONTRIBUTIONS

CONFLICTS OF INTEREST STATEMENT

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APPENDIX A: INTERVIEW GUIDE 1- ED PROVIDERS' WORKFLOW

Task prompts—focus who, what, where, when, why, how?

1. **Please tell us about your role.**
   a. **Prompts**
      (i) Describe your clinical practice
      (ii) What percent of your practice is pediatrics based?

2. **Take a moment and think about a recent blunt trauma case you worked on.**
   ***Stay workflow oriented.
   a. How is the typical blunt trauma patient evaluated at your center?
      ***If they have trouble, ask to describe a specific case **OR SAY**
      (i) Think of the patient's care as a timeline. Can you walk me through it from start to finish? **OR SAY**
      (ii) Walk me through the workflow when a child comes in with a blunt trauma injury.

> If they struggle with describing a scenario:
> - What was the mechanism?
> - How did the patient present to the ED?
> - Why does this scenario come to mind?

Who is involved?

b. What other clinicians are involved and what are their roles responsibilities
c. Physician extenders—what all can they do?

Major decision points:

d. What were the major decision points?
e. Who made them?
f. Where- physical location?
g. Why?
h. How?
i. When?

> Additional prompts throughout interview:
> - When did you become involved in the patient's care?
> - Can you highlight decision points?
> - What are the different blunt trauma situations or scenarios you are experienced with, for example, how the patient arrives (EMS), whether or not they arrive with a cervical collar, trauma…?
> - Of the five general scenarios which one or two do you feel most familiar with?
>   1. Walk in triage
>   2. EMS arrival—triage
>   3. EMS arrival roomed without spine immobilization
>   4. EMS Arrival—roomed with spine immobilization
>   5. EMS arrival—level 1 trauma

3. **If a patient arrives without spine immobilization in place/ tool/ resources prompts**:

   a. Describe your work flow if a patient **presents without spine immobilization**
      (i) Who evaluates them? Sequence of caregivers?
      (ii) Where are you when evaluating?
      (iii) Using what resources/tools/examinations?

   b. Do you have any resources to guide the decision to use spine immobilization? (policy documents, training, pathways…)
      (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
      (ii) What are the resources?
      (iii) Where are they located?
      (iv) How do you access them?
      (v) What medium are they (electronic, paper-based etc.)

   c. If a new tool was created, what would be the best way to make it known it was available to you?

   d. Where would it most efficiently be placed in your workflow

4. **If a patient arrives with spine immobilization in place/ tool/ resources prompts**:

   a. Describe your work flow if a patient presents **with spine immobilization in place**
      (i) Who evaluates the patient?
      (ii) Who makes the decision to keep it in place or remove it?
      (iii) Where is the evaluation being done?
      (iv) At what point in their care are they being evaluated to keep or remove spine immobilization?

   b. Do you have any resources to guide the decision to remove spine immobilization? (policy documents, training, pathways…)
      (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
      (ii) What are the resources?
      (iii) Where are they located?
      (iv) How do you access them?
      (v) What medium are they (electronic, paper-based etc.)

   c. If a new tool was created, what would be the best way to make it known it was available to you?

   d. Where would it most efficiently be placed in your workflow

5. **Imaging prompts**:

   a. At what point in the work flow are you deciding to order imaging?
      (i) Who makes this decision?
      (ii) Any collaboration?
      (iii) Where are you located?

   b. How do you obtain the information you need to decide on the use of imaging?
      (i) How often do you have missing information when deciding how to proceed with imaging?

   c. Who is inputting the orders and where?

   d. How do you obtain the information you need to decide on the use of imaging?
      (i) How often do you have missing information when deciding how to proceed with imaging?

   e. Do you have any resources/ pathways that guide your decision-making?
      (i) If so, when do you consult it?
      (ii) How do you access it?
      (iii) What does it look like (physical characteristics)?
      (iv) Where is it located?
      (v) Where are you located?

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6. Prompts if don't bring up c-spine, clearing the spine, spine immobilization etc.

a. Are there certain injuries you always screen for?
   (i) Are there injuries that are a liability if you miss?
      (1) Are there certain mechanisms that influence your decision to screen for certain injuries?

b. Does arrival by EMS influence which injuries you screen for?

Knowledge prompts:

1. **Knowledge augmentation prompts**:

   a. Roughly how often do you encounter a pediatric patient with blunt trauma?

   b. Outside of your clinical training (med school, residency…) have you had any additional education or training regarding care for children with blunt trauma

2. **Spine immobilization decision-making/ resources/ tool prompts**:

   a. If a patient arrives via **EMS with spine immobilization**, what information do you have about EMS's decision to remove spine immobilization?

   b. What information is required in the decision to keep or remove spine immobilization?

   c. How do you obtain the information you need to decide on the removal of spine immobilization?
      (i) How often do you have all the information you need?
      (ii) How do you deal with information that is not available?
      (iii) Are there findings that weigh more heavily in the decision?

   d. Do you have any resources to guide the decision to remove spine immobilization? (policy documents, training, pathways…)
      (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?

   e. How does the clinical team discuss the removal of spine immobilization?

   f. Describe the consistency of decision-making on spine immobilization in your organization?
      (i) What might improve the decision-making?

3. **Spine immobilization decision-making/ resources/ tool prompts**:

   a. If a patient arrives **via EMS without spine immobilization**, what information do you have about EMS's decision to use spine immobilization?

   b. What information is required in the decision to use spine immobilization?

   c. How do you obtain the information you need to decide on the use of spine immobilization?
      (i) How often do you have all the information you need?

(ii) How do you deal with information that is not available?

(iii) Are there findings that weigh more heavily in the decision?

d. Do you have any resources to guide the decision to use spine immobilization? (policy documents, training, pathways…)

   (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?

e. How does the clinical team discuss the use of spine immobilization?

f. Describe the consistency of decision-making on spine immobilization in your organization?

   (i) What might improve the decision-making?

4. **Imaging prompts**:

a. What information guides your decision to obtain cervical spine imaging in children who experience blunt trauma?

b. How do you decide what images to get?

   (i) Head, neck, both?

   (ii) x-ray, CT, MRI?

c. Are there certain findings that stand out the most to you?

d. What could come up that would make you stop and immediately image?

e. How do you obtain the information you need to decide on the use of imaging?

   (i) How often do you have all the information you need?

   (ii) How do you deal with information that is not be available?

   (iii) Are there findings that weigh more heavily in the decision?

   (iv) Do you have any resources to guide the decision of image orders? (policy documents, training, pathways…)

   (v) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?

f. Describe the consistency of decision-making on CSI imaging in your organization?

   (i) What might improve the decision-making?

Closing remarks/questions:

5. **Shared decision-making**:

a. Do you ever use shared decision-making when deciding whether or not to obtain cervical spine imaging in children who have experienced blunt trauma?

b. If so, can you walk me through what that looks like?

   (i) What resources do you have available?

   (ii) Are there materials you use to show the family?

      1. How do you present those materials to the family?

6. **What is your overall impression on the care of children with blunt trauma at your organization?**

   Prompts:

a. What, if anything, could be improved?

   (i) Education, EHR, training…?

b. If there is little need for improvement, how did your organization achieve this level?

c. Do you feel you are familiar with the most recent findings and guidelines?

d. Is CSI ever the topic of discussion in your department, among your colleagues…?

7. **Is there anything we did not ask that you feel is important to care of blunt trauma injuries in children?**

Abbreviations: CSI, cervical spine injury; CT, computed tomography; ED, emergency department; EHR, electronic health record; EMS, emergency medical services; MRI, magnetic resonance imaging.

APPENDIX B: INTERVIEW GUIDE 2- NURSES' WORKFLOW

Task prompts—focus who, what, where, when, why, how?

1. **Please tell us about your role.**

   Prompts

   a. Describe your clinical practice

   b. Describe your responsibilities

   c. What percent of your practice is pediatrics based?

2. **Take a moment and think about a recent blunt trauma case you worked on.**

   ***Stay workflow oriented.

   a. How is the typical blunt trauma patient evaluated at your center?

   ***If they have trouble, ask to describe a specific case **OR SAY**

   (i) Think of the patient's care as a timeline. Can you walk me through it from start to finish? **OR SAY**

   (ii) Walk me through the workflow when a child comes in with a blunt trauma injury.

If they struggle with describing a scenario:

• What was the mechanism?

• How did the patient present to the ED?

• Why does this scenario come to mind?

PROMPTS for how blunt trauma patient is evaluated:

a. Are there any variations from the typical workflow you can describe?

b. Can you describe your process for triaging a child with an injury?

c. Who is triaging the child?

d. Where are they during the triage process?

   (i) Who determines how the patient is triaged?

   (ii) At what point in the child's care is it determined a child is a trauma activation?

   (iii) How is their acuity level determined?

   (iv) Nurses mental checklist/ by mechanism/ injury/self- reported pain?

Who is involved?

f. What other clinicians are involved and what are their roles responsibilities

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Major decision points:

What were the major decision points?

g. Who made them?
h. Where–physical location?
i. Why?
j. How?
k. When?

Additional prompts throughout interview:
- When did you become involved in the patient's care?
- Can you highlight decision points?
- What are the different blunt trauma situations or scenarios you are experienced with, for example, how the patient arrives (EMS), whether or not they arrive with a cervical collar, trauma…?
- Of the five general scenarios which one or two do you feel most familiar with?
  - Walk in triage
  - EMS arrival—triage
  - EMS arrival roomed without spine immobilization
  - EMS arrival—roomed with spine immobilization
  - EMS arrival—level 1 trauma

---

2. **If a patient arrives without spine immobilization in place**:
   a. Describe your work flow if a patient presents without spine immobilization
      (i) Who evaluates them? Sequence of caregivers?
      (ii) Where are you when evaluating?
      (iii) Using what resources/tools/examinations?
   b. Do you have any resources to guide the decision to use spine immobilization? (policy documents, training, pathways…)
      (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
      (ii) What are the resources?
      (iii) Where are they located?
      (iv) How do you access them?
      (v) What medium are they (electronic, paper-based etc.)
   c. If a new tool was created, what would be the best way to make it known it was available to you?
   d. Where would it most efficiently be placed in your workflow

If a patient arrives with spine immobilization in place:
   e. Describe your work flow if a patient presents with spine immobilization in place
      (i) Who evaluates the patient?
      (ii) Who makes the decision to keep it in place or remove it?
      (iii) Where is the evaluation being done?
      (iv) At what point in their care are they being evaluated to keep or remove spine immobilization?
   f. Do you have any resources to guide the decision to remove spine immobilization? (policy documents, training, pathways…)

(i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
(ii) What are the resources?
(iii) Where are they located?
(iv) How do you access them?
(v) What medium are they (electronic, paper-based etc.)
   g. If a new tool was created, what would be the best way to make it known it was available to you?
   h. Where would it most efficiently be placed in your workflow

3. **Imaging prompts**:
   a. What is your involvement in the decision-making process to order imaging?

If they state involvement:
- Who makes this decision?
  - Any collaboration?
  - Where are you located?
- How do you obtain the information you need to decide on the use of imaging?
  - How often do you have missing information when deciding how to proceed with imaging?
- Who is inputting the orders and where?
- Do you have any resources/ pathways that guide your decision-making?
  - If so, when do you consult it?
  - How do you access it?
  - What does it look like (physical characteristics)?
  - Where is it located?
  - Where are you located?
- Do you have resources/ tools/ pathways that guide decisions to image?
  - What do they look like?
  - How do you access them?
  - Where are you when you access them?
  - Where are the resources located?

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4. **Prompts if don't bring up c-spine, clearing the spine, spine immobilization etc.**

   c. Are there certain injuries you always screen for?
      i. Are there injuries that are a liability if you miss?
         1. Are there certain mechanisms that influence your decision to screen for certain injuries?
   b. Does arrival by EMS influence which injuries you screen for?

Knowledge prompts:

8. **Knowledge augmentation prompts**:
   a. Roughly how often do you encounter a pediatric patient with blunt trauma?
   b. Outside of your clinical training (nursing school) have you had any additional education or training regarding care for children with blunt trauma?

9. **Spine immobilization decision-making/ resources/ tool prompts**:
   a. If a patient arrives via **EMS with spine immobilization**, what information do you have about EMS's decision to put spine immobilization in place?
   b. Are you involved in the decision to keep or remove spine immobilization?
      (i) If so, what information is required in the decision to remove spine immobilization?
      (ii) How do you obtain the information you need to decide on the removal of spine immobilization?
         1. How often do you have all the information you need?
         2. How do you deal with information that is not available?
         3. Are there findings that weigh more heavily in the decision?
   c. Do you have any resources to guide the decision to remove spine immobilization? (policy documents, training, pathways…)
      (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
   d. How does the clinical team discuss the removal of spine immobilization?
   e. Describe the consistency of decision-making on spine immobilization in your organization?
      (i) What might improve the decision-making?
   f. If NOT involved in the actual decision to keep or move spine immobilization- what is their role at this point in time for the patient's care?

10. **Spine immobilization decision-making/ resources/ tool prompts**:
   a. If a patient arrives **via EMS without spine immobilization**, what information do you have about EMS's decision not to use spine immobilization?
   b. What information is required in the decision to put a patient in spine immobilization?
   c. How do you obtain the information you need to decide on the use of spine immobilization?
      (i) How often do you have all the information you need?
      (ii) How do you deal with information that is not available?
      (iii) Are there findings that weigh more heavily in the decision?
   d. Do you have any resources to guide the decision to use spine immobilization? (policy documents, training, pathways…)
      (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
   e. How does the clinical team discuss the use of spine immobilization?
   f. Describe the consistency of decision-making on spine immobilization in your organization?
      (i) What might improve the decision-making?

11. **Imaging prompts**:
   a. Please describe your involvement in the decision to obtain cervical spine imaging in children who experience blunt trauma?

If they state involvement in imaging decision-making:
- What information guides your decision to obtain cervical spine imaging in children who experience blunt trauma?
- How do you decide what images to get?
  ○ Head, neck, both?
  ○ x-ray, CT, MRI?
- Are there certain findings that stand out the most to you?
- What could come up that would make you stop and immediately image?
- How do you obtain the information you need to decide on the use of imaging?
  ○ How often do you have all the information you need?
  ○ How do you deal with information that is not be available?
  ○ Are there findings that weigh more heavily in the decision?
  ○ Do you have any resources to guide the decision of image orders? (policy documents, training, pathways…)
  ○ Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
- Describe the consistency of decision-making on CSI imaging in your organization?
  ○ What might improve the decision-making?

Closing remarks/questions:

1. **Shared Decision-Making**:
   a. Do you ever use shared decision-making when deciding whether or not to obtain cervical spine imaging in children who have experienced blunt trauma?
   b. If so, can you walk me through what that looks like?
      (i) What resources do you have available?
      (ii) Are there materials you use to show the family?
         1. How do you present those materials to the family?
2. **What is your overall impression on the care of children with blunt trauma at your organization?**
   Prompts:
   a. What, if anything, could be improved?
      (i) Education, EHR, training…?
   b. If there is little need for improvement, how did your organization achieve this level?
   c. Do you feel you are familiar with the most recent findings and guidelines?
   d. Is CSI ever the topic of discussion in your department, among your colleagues…?
3. **Is there anything we did not ask that you feel is important to care of blunt trauma injuries in children?**

Abbreviations: CSI, cervical spine injury; CT, computed tomography; ED, emergency department; EHR, electronic health record; EMS, emergency medical services; MRI, magnetic resonance imaging.

APPENDIX C: INTERVIEW GUIDE 3- SURGEONS' WORKFLOW

Task prompts—focus who, what, where, when, why, how?

1. **Please tell us about your role.**
   a. Prompts
      (i) Describe your clinical practice
      (ii) What percent of your practice is pediatrics based?
2. **Take a moment and think about a recent blunt trauma case you worked on.**
   ***Stay workflow oriented.
   a. How is the typical blunt trauma patient evaluated at your center?
      ***If they have trouble, ask to describe a specific case **OR SAY**
      (i) Think of the patient's care as a timeline. Can you walk me through it from start to finish? **OR SAY**
      (ii) Walk me through the workflow when a child comes in with a blunt trauma injury.
   b. Can you walk me through the difference between these two situations: when a child comes in as a trauma activation versus when you are called to consult during an injury?
      (i) When did you become involved?
      (ii) Can you highlight decision points?
      (iii) By the time you see the patient will they have already been imaged?
      (iv) If not, are you part of the decision-making to image?
      (v) If so, do you ever require additional imaging?
   c. Are there any variations from the typical workflow you can describe?

Who is involved?

a. What other clinicians are on your surgical team?
   (i) What are their roles and responsibilities?
      (1) What decisions can they make autonomously?
   (ii) In what order do they evaluate the patient?
b. Is there a collaboration between your surgical team and the ED team?
   (i) Who makes the decision on cervical spine imaging?
   (ii) Is the decision already made before you get there?

FOR SPINE SURGEONS: Who makes the orders to image? How do they make the orders?

Major decision points:

a. What were the major decision points?
   (i) Who made them?
   (ii) Where- physical location?
   (iii) Why?
   (iv) How?
   (v) When?

ONLY ASK FOR TRAUMA SURGEONS:
3. **If a patient arrives without spine immobilization in place/ tool/ resources prompts**:
   a. Describe your work flow if a patient presents **without spine immobilization**
      (i) Who evaluates them? Sequence of caregivers?
      (ii) Where are you when evaluating?
      (iii) Using what resources/tools/examinations?
   b. Do you have any resources to guide the decision to use spine immobilization? (policy documents, training, pathways…)
      (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
      (ii) What are the resources?
      (iii) Where are they located?
      (iv) How do you access them?
      (v) What medium are they (electronic, paper-based etc.)
   c. If a new tool was created, what would be the best way to make it known it was available to you?
   d. Where would it most efficiently be placed in your workflow?

   If a patient arrives with spine immobilization in place/tool/ resources prompts:
   e. Describe your work flow if a patient presents **with spine immobilization in place**
      (i) Who evaluates the patient?
      (ii) Who makes the decision to keep it in place or remove it?
      (iii) Where is the evaluation being done?
      (iv) At what point in their care are they being evaluated to keep or remove spine immobilization?
   f. Do you have any resources to guide the decision to remove spine immobilization? (policy documents, training, pathways…)
      (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
      (ii) What are the resources?
      (iii) Where are they located?
      (iv) How do you access them?
      (v) What medium are they (electronic, paper-based etc.)
   g. If a new tool was created, what would be the best way to make it known it was available to you?
   h. Where would it most efficiently be placed in your workflow?

4. **Imaging prompts**:
   a. At what point in the work flow are you deciding to order imaging?
   b. Who makes this decision?
   c. Any collaboration?
   d. Where are you located?
   e. How do you obtain the information you need to decide on the use of imaging?
      (i) How often do you have missing information when deciding how to proceed with imaging?
   f. Who is inputting the orders and where?
   g. How do you obtain the information you need to decide on the use of imaging?
      (i) How often do you have missing information when deciding how to proceed with imaging?
   h. Do you have any resources/ pathways that guide your decision-making?
      (i) If so, when do you refer to it?
      (ii) How do you access it?
      (iii) What does it look like (physical characteristics)?
      (iv) Where is it located?

(v) Where are you located?

i. Do you have resources/ tools/ pathways that guide decisions to image?

   (i) What do they look like?

   (ii) How do you access them?

   (iii) Where are you when you access them?

   (iv) Where are the resources located?

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5. **Prompts if don't bring up c-spine, clearing the spine, spine immobilization etc.**
   a. Are there certain injuries you always screen for?
      (i) Are there injuries that are a liability if you miss?
         1. Are there certain mechanisms that influence your decision to screen for certain injuries?
   b. Does arrival by EMS influence which injuries you screen for?

Knowledge prompts:

12. **Knowledge augmentation prompts**:
   a. Roughly how often do you encounter a pediatric patient with blunt trauma?
   b. Outside of your clinical training (med school, residency…) have you had any additional education or training regarding care for children with blunt trauma?

ONLY ASK FOR TRAUMA SURGEONS:

13. **Spine immobilization decision-making/ resources/ tool prompts**:
   a. If a patient arrives via EMS with spine immobilization, what information do you have about EMS's decision to remove spine immobilization?
   b. What information is required in the decision to keep or remove spine immobilization?
   c. How do you obtain the information you need to decide on the removal of spine immobilization?
      (i) How often do you have all the information you need?
      (ii) How do you deal with information that is not available?
      (iii) Are there findings that weigh more heavily in the decision?
   d. Do you have any resources to guide the decision to remove spine immobilization? (policy documents, training, pathways…)
      (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
   e. How does the clinical team discuss the removal of spine immobilization?
   f. Describe the consistency of decision-making on spine immobilization in your organization?
      (i) What might improve the decision-making?

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14. **Spine immobilization decision-making/ resources/ tool prompts**:
   a. If a patient arrives via EMS without spine immobilization, what information do you have about EMS's decision to use spine immobilization?
   b. What information is required in the decision to use spine immobilization?
   c. How do you obtain the information you need to decide on the use of spine immobilization?
      (i) How often do you have all the information you need?
      (ii) How do you deal with information that is not available?
      (iii) Are there findings that weigh more heavily in the decision?
   d. Do you have any resources to guide the decision to use spine immobilization? (policy documents, training, pathways…)
      (i) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
   e. How does the clinical team discuss the use of spine immobilization?
   f. Describe the consistency of decision-making on spine immobilization in your organization?
   g. What might improve the decision-making?

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15. **Imaging prompts: – If they say they are involved**
   a. What information guides your decision to obtain cervical spine imaging in children who experience blunt trauma?
   b. How do you decide what images to get?
      (i) Head, neck, both?
      (ii) x-ray, CT, MRI?
   c. Are there certain findings that stand out the most to you?
   d. What could come up that would make you stop and immediately image?
   e. How do you obtain the information you need to decide on the use of imaging?
      (i) How often do you have all the information you need?
      (ii) How do you deal with information that is not be available?
      (iii) Are there findings that weigh more heavily in the decision?
      (iv) Do you have any resources to guide the decision of image orders? (policy documents, training, pathways…)
      (v) Are any resources available to you during patient care (EHR or other technology, paper-based tools…)?
   f. Describe the consistency of decision-making on CSI imaging in your organization?
      (i) What might improve the decision-making?

Closing remarks/questions:

16. **Shared Decision-Making**:
   a. Do you ever use shared decision-making when deciding whether or not to obtain cervical spine imaging in children who have experienced blunt trauma?

b. If so, can you walk me through what that looks like?

  (i) What resources do you have available?

  (ii) Are there materials you use to show the family?

    1. How do you present those materials to the family?

17. **What is your overall impression on the care of children with blunt trauma at your organization?**

   Prompts:

a. What, if anything, could be improved?

  (i) Education, EHR, training…?

b. If there is little need for improvement, how did your organization achieve this level?

c. Do you feel you are familiar with the most recent findings and guidelines?

d. Is CSI ever the topic of discussion in your department, among your colleagues…?

18. **Is there anything we did not ask that you feel is important to care of blunt trauma injuries in children?**

Abbreviations: CSI, cervical spine injury; CT, computed tomography; ED, emergency department; EHR, electronic health record; EMS, emergency medical services; MRI, magnetic resonance imaging.

APPENDIX D: INTERVIEW GUIDE 4 – KNOWLEDGE AUDIT

Knowledge Audit

- I'd like to start by walking through an example of a workflow diagram we created based on interviews with providers at other hospitals. While looking at this diagram, I'd like for you to highlight key decision points, and walk through your thought process at that time.
- As we review the workflow, please describe any variance at your institution.
- Please rank in order which workflow junctures and decisions have the most variation in your practice.

Walking through the workflow:

1. When you learn of an inbound blunt trauma (1 or 2) what types of questions are you asking and/or thoughts are you having?
   a. Are you referencing any CDS, guidelines, pathways at this point?
2. Patient arrival- walk me through your thought process at this point.
   a. What are major symptoms you're looking for?
   b. What are symptoms that stop you in your tracks and elevate their level immediately or change your course of action from the typical trauma workflow?
3. Where and when does your examination of the neck/spine occur?
   a. What types of things are you looking for?
   b. How are you making decisions regarding C-spine stabilization, immobilization, and clearance?

4. When in the process of evaluating a trauma patient do you have enough information to make a decision on imaging?
5. When do you start to think about imaging? How does that thought process change over the course of your evaluation?
6. What information is critical in making the decision of whether or not to image?
   a. And if the decision is to image, what type of imaging?
7. Does the information you've collected from your examination correspond with your decision to image?
   a. For example- do you feel like you have already made up your mind before your evaluation is over?
8. What factors do you base your decision to image off of?
9. Imaging decisions- who is involved in this decision-making at your institution?
   a. Is there collaboration?
      (i) Who has the final say in decisions to image or not?
10. What happens if there is a disagreement between yourself and another provider about what imaging should be obtained?
    a. What do you base your decision on?
       (i) Past experiences, trainings, evidence-based articles, CDS/guidelines/pathways?
       (ii) Strategies for example, pros/cons list–if so, what's on these lists
    b. Are you using any CDS/guidelines/pathways etc.?
    c. Once you decide to image, is there an imaging workflow (always X-ray then CT?) how does MRI fit in?
       (i) Do you ever feel pressure to get a CT on a child?
       (ii) What influences your decision to CT multiple regions of the body, not just the one you are most concerned about? How do you decide what region to CT?
    d. Would you use CDS for imaging c-spine if available?
       (i) At what point during your workflow would CDS be most useful?
       (ii) What type of CDS would be most useful in the context of a trauma evaluation?
       (iii) Would the CDS differ if it were used in a non-trauma context?
       (iv) What medium would be most effective in your workflow for imaging CDS?
          1. EHR, poster, pocket card, app?
          2. Who would be the most influential person to push it out to?
11. Are there constraints or barriers to the imaging you can order?
    a. Do you need to input rationale for ordering specific types of images?
    b. What are some examples of rationale you would use for ordering CT scans?
12. Order entry- How does order entry play into imaging decision-making?
    a. For example, if a nurse documenter or resident is inputting orders in real time and a popup comes up that says "Per PECARN C-SPINE rule, do not image"- would they speak up?

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b. If they did speak out, how does that conversation go? How do providers on different hierarchical levels agree on imaging decisions?

c. Would physicians in your institution take well to that?

Walk through specific case(s) using the workflow diagram- have them note areas of variance in their workflow and areas of decision-making.

- Female, age 9 is climbing tree, falls 15 ft to ground, comes via EMS as level 2 trauma, not in c-collar or on backboard
- Male, age 16 comes in as a walk-in after wrestling practice with a sore neck
- Female, age 5 comes in via EMS as level 1 trauma after MVC in c-collar
- Infant with NAT comes in as walk-in

Abbreviations: CSI, cervical spine injury; CT, computed tomography; EHR, electronic health record; EMS, emergency medical services; MRI, magnetic resonance imaging; NAT, non-accidental trauma.

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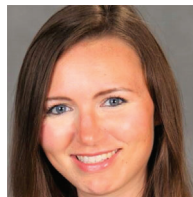
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