

Emergency Medical Service Personnel Recognize Pediatric Concussions

Joshua N. Speirs, MD^{1,*}, Matthew I. Lyons, MD^{1,*},
and Bert E. Johansson, MD, PhD^{1,2}

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Abstract

Concussions are a major cause of morbidity in pediatrics. Many concussions occur during activities with emergency medical service (EMS) providers present to determine if a higher level of care is needed. Data are limited on how capable these providers are. We assessed the ability of EMS providers to recognize pediatric concussions. Fifty-six total responses were included, 38 from EMS and 18 from our MD/RN (medical doctor/registered nurse) group. No statistical differences were found between the 2 groups when adjusted for age, gender, number of years in practice, and number of pediatric concussions managed. This first of its kind pilot study was designed to assess EMS personnel's ability to recognize and triage pediatric concussions. Our findings show EMS providers are statistically identical in their ability to recognize and triage concussions to physicians. The performance of our MD participants was lower than expected. Larger studies are needed to further investigate EMS providers' ability to recognize a concussion.

Keywords

concussion, pediatric, assessment, emergency medical service personnel (EMS), education, sports, head trauma

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Introduction

There are approximately 1.6 to 3.8 million concussions diagnosed each year in the United States.¹ These figures are estimated to understate the total number of concussions, accounting only for patients who seek medical care.² Thirty-eight million children and adolescents play in organized sports in the United States, a known risk factor for concussions.^{3,4} Concussion symptoms are often misinterpreted by patients and their families as the symptoms are nonspecific in nature.⁵ If a concussion is suspected, many athletes report not seeking medical attention assuming the injury is not severe or trying to avoid being pulled from the game. McCrea et al suggest that a significant number of pediatric concussions go either unrecognized or untreated, increasing the risk of serious long-term consequences.⁶ Additionally, there is a misperception that pediatric athletes are more resilient to head injury; however, as their brains are still developing, children are more susceptible to the effects of head trauma.¹ And despite common belief, it has been shown that concussions are more common in high school than in collegiate athletic activities.⁷ It is clear that untreated concussions can potentially have both short- and long-term effects. Failure to remove a concussed player from

a game can lead to second-impact syndrome, or diffuse cerebral edema secondary to a second head injury prior to full recovery.⁸ Studies have shown that there are long-term deleterious effects to concussions as well. These include postconcussion syndrome, presenting with the persistence of fatigue, poor sleep, headaches, dizziness, and mood and personality disturbances.⁹ Additionally, it has been shown that patients with concussions have persistent deficiencies on neurophysiological testing and poorer academic achievement.^{10,11}

Due to the potential sequelae of concussions, it is critical to make an early diagnosis and initiate appropriate management. Early symptom recognition allows for appropriate treatments, including removal of the patient from the game/sport until symptoms resolution and completion of the appropriate return to play regimen.¹²

¹Texas Tech University Health Sciences Center, El Paso, TX, USA

²El Paso Children's Hospital El Paso, TX, USA

*The authors contributed equally to this work.

Corresponding Author:

Joshua Speirs, Department of Orthopaedic Surgery, Loma Linda University, 11406 Loma Linda Drive, Suite 213, Loma Linda, CA 92354, USA.
Email: jspeirs@llu.edu



For this to occur it is critical for physicians and first responders properly recognize the signs and symptoms of pediatric concussion.

No prior study has assessed emergency medical service (EMS) personnel's ability to recognize and triage pediatric concussions. The purpose of this study is to serve as a pilot study to assess El Paso EMS personnel's comprehension of pediatric concussions and knowledge of appropriate early management practices.

Methods

An assessment tool was developed to assess comprehension of the Centers for Disease Control and Prevention criteria for clinical diagnosis of concussion and of initial treatment steps.⁵ This survey included demographic questions, questions assessing the respondent's confidence in managing pediatric concussions, and questions assessing the respondent's ability to recognize pediatric concussion presentations, symptoms, severity, and their ability to appropriately triage pediatric concussions. Eight case presentations were provided, requiring respondents to determine if a concussion was present and if the patient needed further evaluation. Presentations included both scenarios where a concussion was present and was not present. Four questions asked the surveyed to identify symptoms of concussion from multiple choices. A response of "I don't know" was not included as an answer choice option as clinical situations require a decision to be made. We used the "Sports-Related Concussion in Children and Adolescents," from the American Academy of Pediatrics (AAP); Centers for Disease Control and Prevention "What are the Signs and Symptoms of Concussion"; and "Concussion Guidelines Step 1: Systematic Review of Prevalent Indicators" from Carney et al to build evidence-based case presentations and questions where the correct answer could clearly be elicited using the AAP guidelines.^{1,5,13} The survey is provided in the appendix. The assessment was administered using Qualtrics, an online survey tool distributed by email.

With permission from the El Paso Fire Department's medical director, the survey was emailed to all registered fire department EMS personnel, including EMT-Bs, EMT-As, and EMT-Ps, who are the 911 emergency responders in the El Paso, Texas, area. Additionally, the survey was distributed to emergency medicine physicians at Texas Tech University Health Science Center El Paso Paul L. Foster School of Medicine as well as to pediatric physicians and nurses at El Paso Children's Hospital. We obtained institutional review board approval from each institution included in this study.

The results of the study were analyzed with the primary goal to compare the responses of our EMS personnel to our physician/nurse cohort that was trained in concussion recognition and diagnosis. All statistical analyses were performed by the Texas Tech Biostatistics Department. Continuous data were described using mean and standard deviation (SD), while categorical data were described using frequency and proportion. Continuous data were compared according to profession (EMS, MD/RN [medical doctor/registered nurse]) using unpaired *t* test. Categorical variables were compared according to profession using Fisher's exact test. Results with *P* value less than or equal to .05 were considered as statistically significant. Statistical analyses were conducted using SAS version 9.4 (Cary, NC).

Results

Participants

Of the approximately 950 surveys emailed, 56 (5.6%) were received in total, with 38 from our EMS group and 18 from our MD/RN group. The EMS group included 20 EMT-Ps, 1 EMT-A, and 17 EMT-Bs. Our MD/RN group included 10 MDs (6 pediatricians, 1 pediatric emergency medicine physician, and 3 emergency medicine physicians) and 8 RNs. Both groups had similar characteristics (Table 1), with the exception of the EMS group responding entirely as male. The mean respondent age was 41.49, had an average of 13.55 years in practice, and managed an average of 6.36 pediatric concussions per year. Fifty-eight percent of physicians and 65% of EMS personnel reported receiving prior education on concussions. The EMS group did report greater self-rated ability to both treat and manage pediatric concussions at 6.68 and 6.94, respectively, as compared to our MD/RN group at 4.29 and 4.75 ($P < .05$, $P < .05$).

Concussion Recognition and Response

Respondents in both groups correctly answered an average of 8.19 of the 12 concussion recognition and response questions, with no statistically significant difference between the EMS and MD/RN groups ($P = .9428$). Individual analysis of each question is provided in Table 2. There were no statically significant differences between the 2 groups on any individual question except question 7, where 5.26% of the EMS group and 57.89% of the MD/RN group appropriately recognized and responded to a positive concussion case scenario ($P \leq .013$). Additionally, on the two questions with the lowest correct response rates, questions 1 and 11, correct response rates were 21.05% and 36.84%, respectively,

Table 1. Comparison of Variables According to Profession, Using EMS, MD, and RN Survey Data (n = 57).

Variable	Total (N = 56)	EMS (n = 38)	MD/RN (n = 18)	P
Age, mean (SD)	41.49 (8.45)	41.47 (7.94)	41.53 (9.63)	.98
Gender, n (%)				
Female	13 (23)	0	13 (68)	<.0001
Male	44 (77)	38 (100)	6 (32)	
Years in practice, mean (SD)	13.55 (7.97)	13.73 (7.43)	13.21 (9.14)	.82
# of pediatric concussions managed per year, mean (SD)	6.36 (15.55)	3.25 (3.44)	12.94 (26.31)	.15
Self-rated ability diagnose pediatric concussion, mean (SD)	5.43 (2.25)	5.76 (2.09)	4.75 (2.46)	.14
Self-rated ability treat pediatric concussion, mean (SD)	5.88 (2.8)	6.68 (2.67)	4.29 (2.39)	.003
Self-rated ability manage pediatric concussion, mean (SD)	6.24 (2.63)	6.94 (2.45)	4.75 (2.44)	.004
Received education on concussion, n (%)				
No	21 (37)	13 (34)	8 (42)	.57
Yes	36 (63)	25 (66)	11 (58)	
Overall correct response, mean (SD)	8.19 (1.29)	8.18 (1.18)	8.21 (1.51)	.94

Abbreviations: EMS, emergency medical service; MD/RN, medical doctor/registered nurse cohort.

with no statistically significant differences between the 2 cohorts ($P = .732$, $P = 1$). There were no differences between the 2 groups in how severe concussions were rated.

Adjusted Differences

We looked at adjusted association between profession and overall corrected responses on pediatric concussion shown in Table 3. When examining the impact of age, gender, number of years in practice, previous concussion education, and number of pediatric concussions managed per year, and progression (MD/RN vs EMS), there were no statistically significant factors corresponding with overall corrected responses to our questions. Age and previous concussion education approached statistical significance ($P = .1001$, $P = .1262$, respectively), but the effects were small (regression coefficient [RC] = 0.047, RC = 0.625, respectively).

Discussion

Current literature has shown that early diagnosis of concussion in pediatric patients is critical to initiating early treatment and preventing possible devastating sequelae.

As concussions frequently occur during sporting events, often it is the parents, coaches, and athletic trainers who are the first to assess an injured child. Prior surveys of parents, coaches, and athletic trainers have shown that many lack knowledge of concussion symptoms and treatment, showing a need for additional concussion-related education.^{14,15} Additionally some surveys have shown that only 37.5% of coaches referred their concussed players to an emergency department,¹⁶ likely due to poor on-field concussion assessment and management leading to many missed concussions.¹⁷ Among physicians, a study in 2015 reported that pediatric emergency physicians “diagnosed concussion less often relative to international consensus-based guidelines” leading to concussions being underdiagnosed.¹⁸ When medical students were surveyed, most reported never having had any formal didactic education on concussion and lacked clinical exposure to concussion management.¹⁹ Although the data on how EMS providers perform on similar measures is limited, it would not be unreasonable to think that they would mirror emergency medicine physicians in the underdiagnoses of pediatric concussions. There seems to be a global lack of education with regard to concussions in children.

Our study showed that 58% of the physician/nurse group and 65% of the EMS group have had prior education on concussions ($P = .57$). Although this may be concerning

Table 2. Comparison of Specific Case Questions (Q1-8) and Symptom Recognition Questions (Q9-12).

Question	Total (N = 56)		EMS (n = 38)		MD/RN (n = 18)		P
	n	%	n	%	n	%	
Q1 (Negative for concussion)							
Wrong	45	79	29	76	16	84	
Correct	12	21	9	24	3	16	.73
Q2 (Positive for concussion)							
Wrong	2	4	0	0	2	11	
Correct	55	96	38	100	17	89	.11
Q3 (Positive for concussion)							
Wrong	1	2	0	0	1	5	
Correct	56	98	38	100	18	95	.33
Q4 (Positive for concussion)							
Missing	1	2	1	3	0	0	
Wrong	6	11	4	10	2	11	
Correct	50	87	33	87	17	89	1
Q5 (Positive for concussion)							
Wrong	6	11	2	5	4	21	
Correct	51	89	36	95	15	79	.09
Q6 (Positive for concussion)							
Missing	1	2	1	3	0	0	
Wrong	24	42	18	47	6	32	
Correct	32	56	19	50	13	68	.26
Q7 (Positive for concussion)							
Wrong	47	82	36	95	11	58	
Correct	10	18	2	5	8	42	.001
Q8							
Missing	1	2	1	3	0	0	
Wrong	4	7	1	3	3	16	
Correct	52	91	36	94	16	84	.11
Q9							
Wrong	17	30	13	34	4	21	
Correct	40	70	25	66	15	79	.37
Q10							
Wrong	14	25	8	21	6	32	
Correct	43	75	30	79	13	68	.52
Q11							
Wrong	36	63	24	63	12	63	
Correct	21	37	14	37	7	37	1
Q12							
Wrong	12	21	7	18	5	26	
Correct	45	79	31	82	14	74	.51

Abbreviations: EMS, emergency medical service; MD/RN, medical doctor/registered nurse cohort.

for medical educators, it is encouraging that the EMS personnel report having had statistically similar levels of exposure to concussion education as their hospital colleagues. This prior education likely played a role in the overall ability of our EMS cohort to diagnosis and triage pediatric concussions when assessed. In this study, EMS responders correctly recognized the signs of concussion and chose the appropriate initial course of action, with

comparable results to the physician-nurse cohort. Additionally, it is interesting that although EMS personnel report seeing less than 25% of the concussion volume that physicians and nurses report treating, they expressed increased confidence in their ability to treat and manage concussions. These findings may be related to an increase in efforts to disseminate concussion awareness and education in the medical community.

Table 3. Adjusted Association Between Profession and the Overall Corrected Response on Pediatric Concussion.

Variable	RC	95% CI		P
		Lower	Upper	
Age	0.047	−0.009	0.104	.10
Gender, male vs female	1.086	−0.657	2.828	.22
Number of year in practice	−0.013	−0.073	0.048	.68
Previous concussion education (yes vs no)	0.625	−0.183	1.432	.13
Number of pediatric concussions managed annually	−0.009	−0.04	0.021	.54
Profession (MD/RN vs EMS)	0.884	−0.718	2.486	.27

Abbreviations: RC, regression coefficient; CI, confidence interval; EMS, emergency medical service; MD/RN, medical doctor/registered nurse cohort.

These findings suggest that in El Paso, Texas, both prehospital and hospital providers alike are able to recognize and triage pediatric concussions when assessed and that emergency response personnel are being well trained on concussion management. This is reassuring as physician coverage at sporting events is limited, and EMS providers are often the first to assess many sports-related injuries. These findings suggest that prior educational efforts directed to this cohort improve awareness of concussions and early recognition. Additionally, our findings suggest that the presence of emergency response personnel at sporting events may lead to more accurate triaging of concussions and lead to fewer missed diagnoses.

This study adds to the growing body of evidence that physicians continue to miss symptoms of traumatic brain injuries. When looking only at the ability of the physician (MDs) cohort to recognize symptoms of a concussion, only 40% of physicians correctly answered all 4 questions requiring correct identification of a symptom of a concussion, with 25% of all physician response incorrect on these 4 questions. This seems to expose an area of weakness in both the initial and continuing education of physicians and posits that current pediatric physicians in this cohort may not be keeping pace with current medical literature. Zonfrillo et al published similar findings concluding that providers “may not have adequate training or infrastructure to systematically diagnose and manage” concussed patients.²⁰ These findings are alarming as they likely support the growing evidence that children with concussions are being undiagnosed, untreated, and at being placed at risk for significant life altering consequences.

Our study has certain limitations. As with any study relying on individual’s willingness to complete a voluntary survey, there is the potential for an uncorrected selection bias. Due to the limited number of surveys completed, the study was potentially underpowered, limiting our ability to better define potential differences

among our study groups. Additionally, this study relied on an assessment that had not previously been validated.

Conclusion

This is the first study to assess the knowledge of concussions among emergency response personnel. The El Paso, Texas, region, like many other areas, lacks an adequate number physicians, leading to increased dependency on other provider types. Our data serve as a pilot for further investigations and to show that with concussion education, paramedics and other emergency service personnel can accurately triage pediatric concussions and respond accordingly. A follow-up investigation into the reliability and validity of our EMS provider’s concussion recognition could potentially illuminate more in this area. Additionally, further investigation and action may be necessary to improve continued medical education efficacy on current pediatric practices.

Appendix

Pediatric Concussion Assessment Tool

Joshua N. Speirs, MD, Matthew I. Lyons, MD, Bert E. Johansson, MD, PhD

This survey is a part of a research study being conducted to assess medical professionals’ understanding of pediatric sports injuries. The survey is anonymous, completely voluntary, and that by responding to the questions, the survey taker is consenting to be in the study. The survey and study will have no effect on grades, evaluations, or employment status. The survey should take 15 to 20 minutes. You can only take the survey once and will NOT be allowed to edit your responses once you have progressed to the next page.

What is your age?

What is your gender (Male, Female, etc)?

Where is your practice located (City, State)?

Where did you train (School Name, Country)?

Did you receive education on concussion during your training?

- Yes
- No

What is your profession (EMT-B, EMT-I, EMT-P, MD, DO, NP, PA, RN, Medical Student, etc)?

What is your specialty (Only if applicable)?

How many years do you have in practice since completing professional school?

Question 1: You are attending a game of a local high school football team. During the game, the running back takes a particularly forceful hit and is tackled for a loss on a first down. The player is slow to get up after the play. A timeout is called and the player is able to walk back to the sidelines. The team's coach is concerned and asks you to evaluate the player. You rule out any physical injuries. The player denies any headache, dizziness, or tinnitus. He denies loss of consciousness and double vision. He is anxious to rejoin his team on the field during your exam. What should you do next?

1. Allow return to play
2. Hold from play and further evaluation

Question 2: You are attending a cheerleading competition as the medical professional for a local school. One of the cheerleaders takes a bad fall after a failed attempted toss. She is slow to get up and the team coach asks you to evaluate her. You rule out any physical injuries. The cheerleader denies loss of consciousness, but seems to not understand your question, and stumbles when waking to get a drink. She complains of a headache, which she attributes to hitting her head on the ground. A teammate asked, "Are you okay? You're acting weird." What should you do next?

1. Allow return to play
2. Hold from play and further evaluation

Question 3: You are at a D1 College Track and Field Championship meet. The 5-km steeplechase is almost done. You notice a player trip over the water barrier. The runner slowly pulls herself out of the water and walks off and sits down. Twenty minutes later the runner enters the training room for a minor abrasion to the left lower leg that occurred during the race. While cleaning and dressing the wound you notice the runner is acting really

tired. The runner stumbles as she walks slowly to get some water. You ask the patient if she is feeling OK. She slowly replies, "Yeah, I'm fine my vision is just a little off, I must be dehydrated." You ask the patient what happened when she tripped and she responds, "Not sure, I don't remember." She begins to cry and states that she feels really weak and tired and is not sure if she can run her next race. What should you do next?

1. Allow return to play
2. Hold from play and further evaluation

Question 4: A 17-year-old male is slow to get up after being hit in the head the side of the head with a soccer ball during the last 10 minutes of the game. Trainers evaluated the athlete and send them to the nearest hospital ED (emergency department) for evaluation. The ED evaluation was unremarkable and CT (computed tomography) scan was read as negative. Three days later the patient reports to his mother that he gets headaches in class and his soccer coach has noticed he seems to not be playing like he used to. What is the best course of action?

1. Allow return to play
2. Hold from play and further evaluation

Question 5: You are called to evaluate a 14-year-old baseball player who collided with a fence in the outfield while running to field a fly ball. There are no abnormalities noted during the exam when you first arrive and he is allowed to stay in the game. Later during the game the player vomits one time and his coach notices the player seems "out of it." What's the next best step in caring for this patient?

1. Allow return to play
2. Hold from play and further evaluation

Question 6: The parents of an 18-year-old female are concerned about recent changes in her behavior. She's had trouble concentrating in school and seems forgetful. Additionally she's been more irritable lately, becoming argumentative with her parents. Her basketball coach of 4 years has also noticed a change, saying that their player has struggled remembering their team plays and sometimes looks lost during a game. She previously was a successful player with a reputation for tenacious play and never having missed a game, despite often having to play "banged-up." She has no significant past medical history or family history. What could have prevented her current presentation?

- A. Screening for depression and bipolar
- B. Screening for anemia

- C. Screening for drugs
- D. Screening for concussion
- E. Screening for thyroid disease

Question 7: Just before halftime at a high school football game, a 17-year-old boy who plays wide receiver is undercut by a tackler while leaping to catch a pass. He drops the ball and, after getting to his feet, is confused and walks to the opposing team's side of the field. He remains confused while walking into the locker room for halftime but then seems normal by the start of the second half. However, he continues to have some amnesia for the details of the play in which he was tackled. Of the following, the recommendation you are MOST likely to make as health practitioner is

- A. Daily neurologic examinations for 2 weeks
- B. Emergency department evaluation and clearance before returning to play
- C. Return to play at the start of the second half
- D. Return to play in 30 minutes if symptoms resolve
- E. Return to play in 7 to 10 days if symptoms resolve

Question 8: A 16-year-old girl presents to your office following an injury she sustained playing soccer. One week ago, another player hit her in the chest, causing her head to snap back. She had near-immediate onset of a diffuse frontal headache and mild nausea that lasted several hours after the injury. She did not lose consciousness. Her mother reports that the girl has seemed more forgetful and has been having trouble sleeping since the injury. She has not played soccer since the injury. Of the following, you are MOST likely to tell the girl and her mother that this injury was

- A. A concussion and she can return to soccer since it has been 1 week since the injury
- B. A concussion and she can return to soccer since she no longer has headache
- C. A concussion and she should continue to rest from all physical activities
- D. Not a concussion because she did not get hit in the head
- E. Not a concussion because she did not have loss of consciousness

Question 9: Which of the following answer choices is a sign or symptom of concussion?

- A. Slurred speech
- B. Loss of vision
- C. Paresthesias
- D. Difficulty concentrating

Question 10: Which of the following answer choices is a sign or symptom of concussion?

- A. Nonreactive pupils
- B. Blurred vision
- C. Excessive lacrimation
- D. Nystagmus

Question 11: Which of the following answer choices is a sign or symptom of concussion?

- A. Weakness
- B. Tinnitus
- C. Hearing Loss
- D. Emotional Lability

Question 12: Which of the following answer choices is a sign or symptom of concussion?

- A. Constricted affect
- B. Nightmares
- C. Increased energy
- D. Difficulty sleeping

How many pediatric concussions do you manage a year?

On a scale from 1 to 10, with 1 being very limited competency and 10 being exceedingly competent, how would you rate your ability to diagnose pediatric concussions?

_____ Ability to Diagnose Pediatric Concussions

On a scale from 1 to 10, with 1 being very limited competency and 10 being exceedingly competent, how would you rate your ability to treat pediatric concussions?

_____ Ability to Treat Pediatric Concussions

On a scale from 1 to 10, with 1 being very uncomfortable and 10 being exceedingly comfortable, how would you rate your comfort in managing pediatric concussions?

_____ Comfort in Managing Pediatric Concussions

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Author Contributions

JNS: Contributed to conception and design; contributed to analysis; drafted the manuscript; gave final approval; agrees to

be accountable for all aspects of work ensuring integrity and accuracy.

MIL: Contributed to conception and design; contributed to analysis; drafted the manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

BEJ: Contributed to conception and design; contributed to analysis; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

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