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SPECIAL REPORT

WHEN SHOULD EMS CALL A CHILD A SMALL ADULT: DISPARITIES IN PROTOCOL DEFINITIONS

Elise Solazzo, BA, EMT-B*[1]; Kerry McCans, BS, EMT-P[2]; Sylvia Owusu-Ansah, MD, MPH, FAAP[3]; Kenneth A. Williams, MD, FACEP, FAEMS[4]

Author Affiliations: 1. Department of Emergency Medicine, Warren Alpert Medical School, Brown University, Providence, RI, USA; 2. Department of Pediatrics and Emergency Medicine, University of Pittsburgh School of Medicine, Pittsburgh, PA, USA; Department of Pediatrics and Emergency Medicine, University of Pittsburgh, School of Medicine; EMS Medical Director, UPMC Children's Hospital of Pittsburgh; Pittsburgh, PA, USA. 4. Department of Emergency Medicine, Warren Alpert Medical School of Brown University, Providence, RI, USA; LifePACT Critical Care Transport, Rhode Island Hospital, Providence, RI, USA

**Corresponding Author*: elise_solazzo@alumni.brown.edu

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ABSTRACT

Understanding age-related patient differences is important to those providing care in the prehospital environment, yet there is currently no research evaluating how emergency medical services (EMS) systems across the US categorize patients as pediatric. The US Health Resources and Services Administration's Maternal Child Health Bureau (HRSA MCHB) through their Emergency Medical Services for Children (EMSC) program has coordinated a focus on pediatric EMS care. However, there is a wide variety of age and other categorizations used to define the pediatric EMS population. In order to start discussion on this variation, this paper reviews the current state of pediatric EMS categorization from several sources, including national-level agencies and organizations, EMS Protocols, and other sources, and provides an overview of the anatomic, physiologic, and behavioral parameters that are generally expected within the range of pediatric ages. We found that, of 32 states publishing statewide EMS protocols online, there was great variability in the definition of a pediatric patient. The age at which states identified the transition from pediatric to adult patient ranged from 12-18 years old, and several states used non-aged-based definitions. Consistent definitions of pediatric patients across regional or national boundaries may provide a base for future research on pediatric outcomes and interventions and may allow for better development of evidence-based pediatric EMS protocols.

INTRODUCTION

19.1% of US emergency department visits and 13% of EMS patient transports involve patients generally defined as pediatric (Moore et al., 2017; Shah et al., 2008). The US EMSC effort began in its current form in 2016 ("About EIIC", n.d.), after the realization that US ambulances, EMS personnel, and emergency departments often lacked at least some of the equipment, training, and other resources necessary to provide optimal pediatric care. Despite this extensive effort, one missing feature is a universally accepted and implemented definition of the age when a child becomes a small adult. Indeed, this debate continues far beyond

the world of EMS. While the American Academy of Pediatrics now discourages formal age limits, it defines adolescence as the period from 12-21 years old (Hardin et al., 2017). While not an official definition of "pediatric", the American College of Surgeons 2021 revised trauma triage criteria includes vital sign categories for patients aged 0-9, 10-64, and 65+ (Newgard et al., 2017). This is an especially salient data point, as traumatic injury remains the leading cause of death for those aged 0-14 years in the United States (Centers for Disease Control and Prevention, 2023). The National Association of State EMS Officials (NASEMSO) model EMS guidelines define pediatric patients as "those patients who weigh up to 40 kg or up to 14 years of age, whichever comes first" (National Association of State EMS Officials). Disparities between individual state protocols' definitions of pediatric span a 6-year time range and include variations on the methodology used to determine which patients are considered pediatric.

This paper reviews the current state of this situation to begin discussions regarding the varied definitions of pediatric patients and reviews some of the anatomical, physiological, and behavioral aspects of EMS patients at various ages to serve as a streamlined reference point. This paper is divided into 2 sections: Section 1 is a descriptive study of the currently available pediatric EMS definitions from national organizations and from an available sample of EMS protocols; Section 2 reviews developmental anatomy, physiology, and behavior as a reference for EMS clinicians to inform future discussions regarding the definition of a pediatric patient in EMS.

SECTION 1

Methods

Our research project was exempt from IRB review. To assess the EMS protocol landscape nationally, we used an internet search to locate all available EMS protocols that apply to an entire US state and are available for detailed review online, as there is no centralized database for state or local EMS protocols. We read these protocols, searching for criteria that identify patients as pediatric or adult, including a narrative definition of pediatric, age-based criteria, anatomic or physiologic criteria, or a combination of the above.

Findings

We located 32 states with available statewide EMS protocols. After review and analysis, we identified large variations in the definition of a pediatric patient between states, and sometimes within a single state's protocols. The distribution of ages (for states that identify a transition age) or other criteria that define pediatric patients in each state protocol is shown in Figures 1 and 2 below. A full list of specific protocols and where to find them can be found in Supplemental Spreadsheet 1.

Additionally, six states explicitly enable EMS clinician judgment in their statewide protocols, shown in Figure 3, allowing paramedics to select the most appropriate pediatric or adult protocols for the specific patient encounter.

SECTION 2

There are many important physiologic and psychological differences between pediatric and adult patients. In this paper, we will highlight the important differences in pediatric shock, airways, vital signs, injury patterns, and psychosocial development to provide

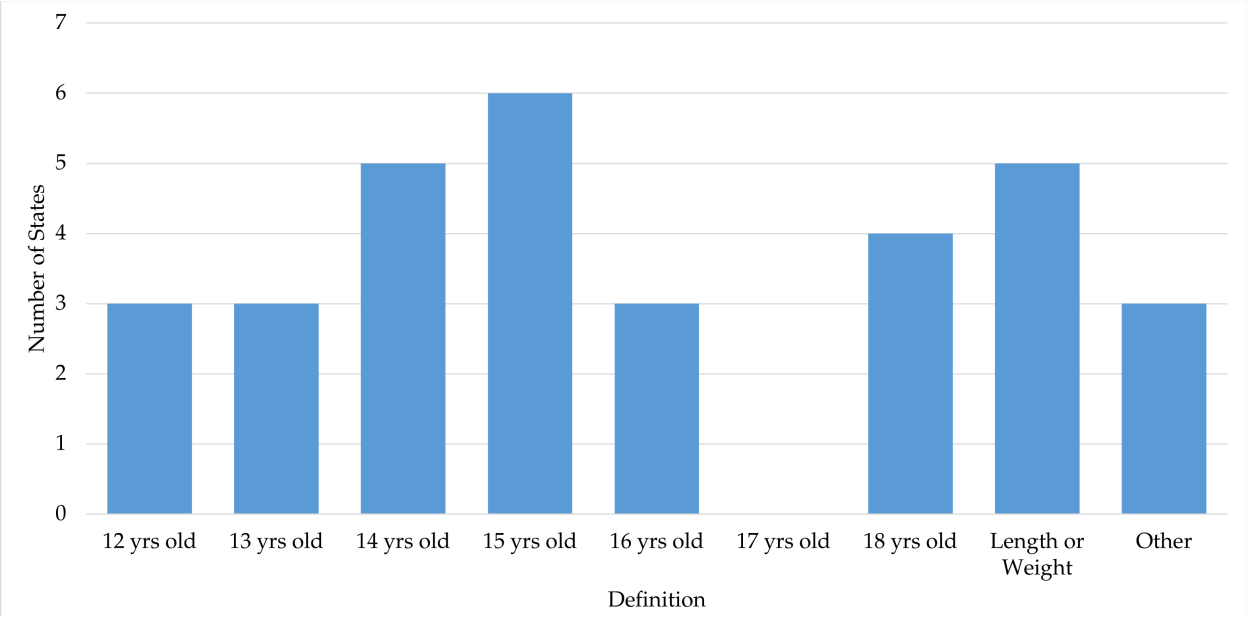

Figure 1. Distribution of pediatric definition criteria.

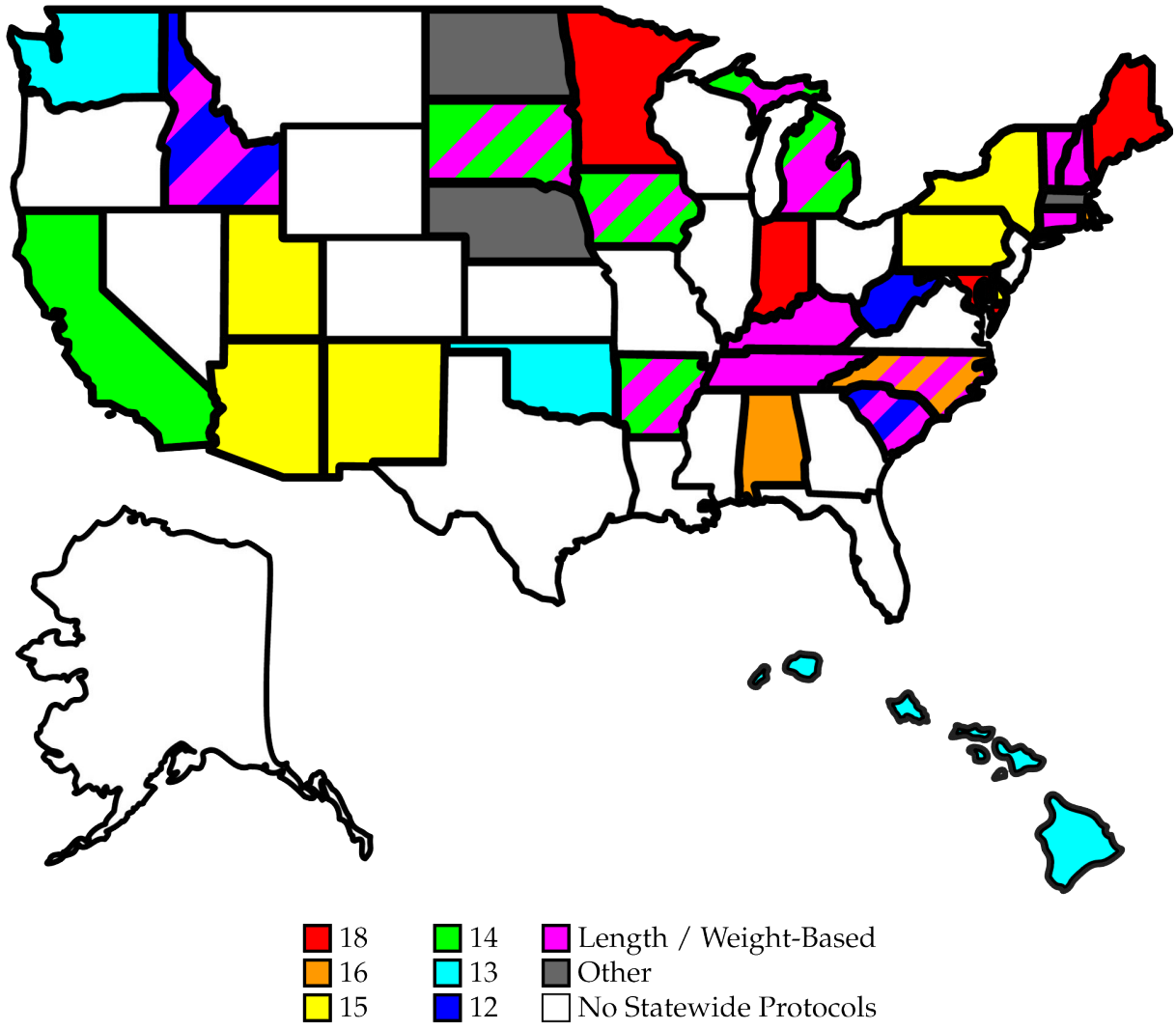

Figure 2. Pediatric definitions by state.

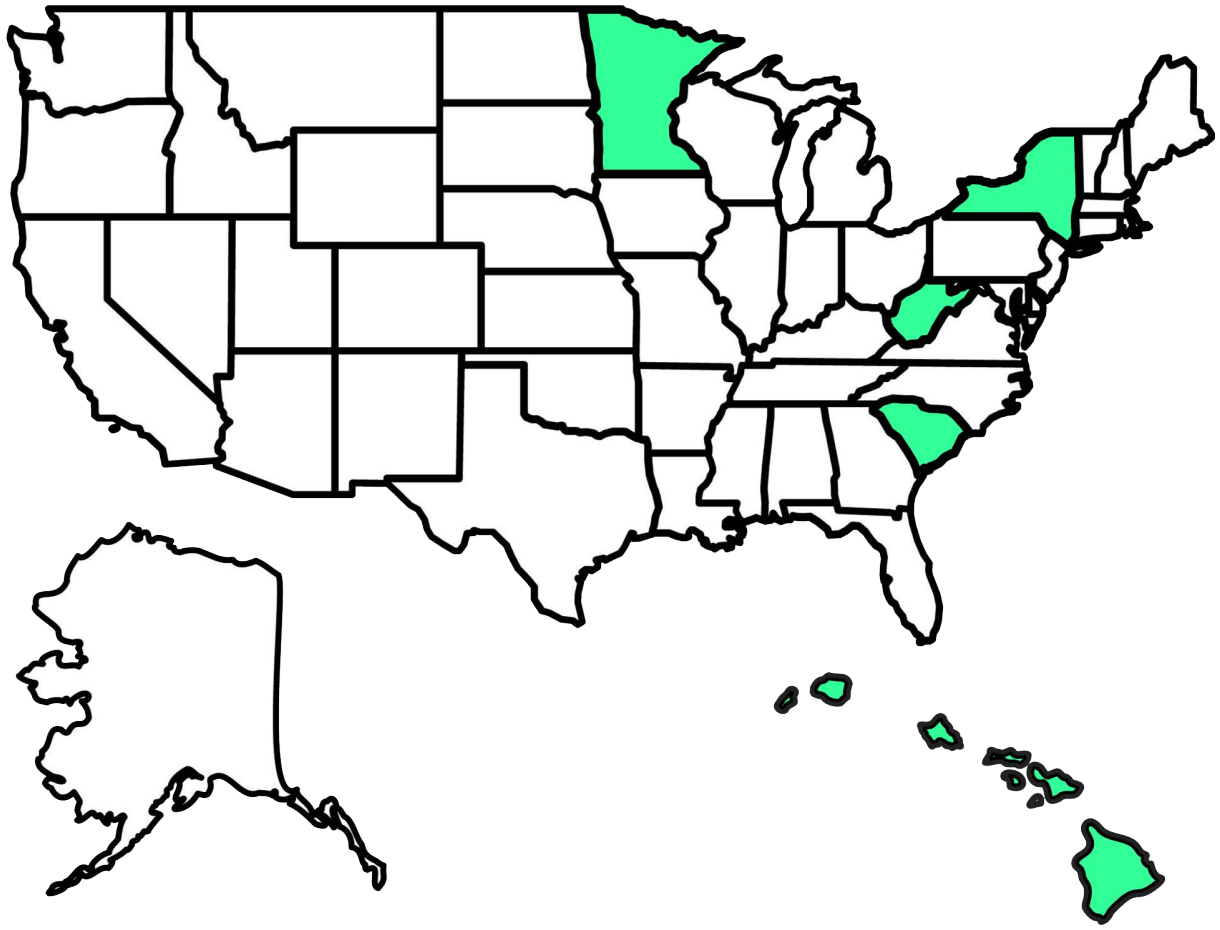

Figure 3. States enabling EMS clinician judgement.

points of reference for future discussions regarding a more standardized definition of pediatric patients.

State	Pediatric Definition
Massachusetts	Determination is different for different protocols. 20 kg for "Diabetic Emergencies" (Protocol 2.3P) 25 kg for "Bronchospasm/Respiratory Distress" (Protocol 2.6P) 25 kg for "Pain & Nausea Management" (Protocol 2.13)
Nebraska	Newborn to 1 year is determined as an infant for resuscitation. 1 year to onset of puberty is defined as a child for resuscitation.
North Dakota	Length/Weight-based dosing for most protocols, with age-based differentiation for anaphylaxis, 12-lead EKG obtainment, and LUCAS application.

Table 1. Elaboration of statewide protocol definitions of "pediatric" for selected states.

Shock

The ability to identify a patient in shock, especially during the early compensated phase, is a vital skill for prehospital clinicians. Pediatric patients in shock have a similar course to adult patients in shock; they will progress from compensated to decompensated shock, then to coma and/or death without recognition or intervention. However, the physical exam findings for children in shock can be more subtle and potentially ignored by practitioners unfamiliar with them. Early recognition of shock is key to improved survival (Evans et al., 2018). Thus, EMS protocols must pay attention to the differences between pediatric and adult presentations of shock, providing clear guidance for EMS clinicians. Here we outline signs of shock in a pediatric patient progressing from early to late signs,

with the information summarized in Appendix 1. Children rely on heart rate to boost cardiac output more than adults (Peitzman, 2008), with tachycardia being an early sign (Mendelson, 2018). They may also show subtle signs like delayed capillary refill (>2 sec) or mild irritability (Kleinman et al., 2010). As shock worsens, orthostatic vital sign changes can occur (Peitzman, 2008). EMS personnel trained in Pediatric Advanced Life Support (PALS) are better at recognizing pediatric shock (Baker et al., 2009). Note that 2020 PALS guidelines define infants as patients up to approximately 1 year old and children as patients between 1 year old and the onset of puberty, defined as "breast development in females and the presence of axillary hair in males" (Topjian et al, 2020).

If compensated shock is not noticed or corrected, it progresses. Tachypnea worsens as a respiratory response to metabolic acidosis. Capillary refill further delays (>4 sec), and extremities become pale, cool, or mottled due to peripheral vasoconstriction. Hypotension is an ominous sign (Kleinman et al., 2010). Children can maintain normotension until significant blood loss (Wolfson et al, 2009). Their smaller baseline circulating volume exacerbates this (Howie et al 2011).

Decreased perfusion leads to altered mental status, coma, abdominal distention, decreased bowel sounds, constipation, and reduced urine output. Dyspnea, tachypnea, and cyanosis may result from an inflammatory response (Wolfson et al, 2009). Bradycardia in decompensated shock indicates ischemic cardiac muscle. Neurogenic shock may present with bradycardia (Peitzman, 2008). Pediatric patients are more prone to hypothermia due to their body size and thermoregulation (Kleinman et al, 2010).

Vital Signs

A review of the normal vital signs in patients of different ages is included in Tables 2 and 3. This is especially important to note, as previous research indicates that most pediatric categories had reduced odds of complete vitals documentation, pain score documentation was lower in children after trauma (Ramgopal et al, 2018), and oxygen saturation documentation was lower in children with respiratory complaintsÐ effectively demonstrating that EMS personnel tend to assess pediatric patients less thoroughly than their adult counterparts.

Age	HR	RR
Neonate	120-160	40-60
<1 yr	100-160	30-60
1-2yrs	90-150	24-40
2-5yrs	80-140	22-34
>6-12yrs	60-100	12-16

Table 2. Normal pediatric vital signs (Freeborn et al, 2021, Lindh, 2006).

Airway

Pediatric airways are notoriously different from those of adults. One 2015 retrospective study found a rate of 1 pediatric intubation per 2,198 EMS responses; 44% of which were for patients in cardiac arrest and 66% of which were intubated on the first attempt. The most common challenge identified by this study was bodily fluids obstructing the laryngeal view (Prekker et al, 2016). Table 2 summarizes the anatomical changes of pediatric patients' airways as they age, which may be of use in reaching a more unified definition of pediatric patients for EMS clinicians.

Age (yrs)	Systolic	Diastolic
1	74-100	50-70
3	80-112	50-80
6	82-110	50-78
10	84-119	54-80
17	94-119	62-88

Table 3. Normal pediatric blood pressure (Lindh, 2006).

Age	Oro-pharynx	Larynx	Epiglottis	Glottis	Cricoid	Chest Wall
Neo-nate	Degree of relative microg-nathia	Cephalad and more com-pressed Making it ap-pear anterior at direct laryn-goscopy	<id-level of C1 45-degree position-ing and contact with soft palate allows for sucking and breathing simulta-neously and protects from aspiration but makes visualization of larynx difficult	Mid C3	Superior border of C4	Weak intercostal and diaphragmat-ic muscles (lack of type 1 fibers), horizontal ribs and a protuberant abdomen results in earlier onset of fatigue and less efficient ventilation. Chest wall-specific compliance is higher, and intercostal or sternal recession is readily visible with in-creased respiratory effort or airway obstruction.
Year 4-5		similar laryn-geal view to adults by year 4–5	mid C3	C4–C5 interspace	Mid C5	
puber-ty				Mid C5	C6–C7 interspace	

Table 4. Summary of anatomical changes of the pediatric airway (Westhorpe, 1987, Wilton and Hack, 2021).

Psychosocial Development

It is important for prehospital clinicians to be familiar with milestones and their time-line to properly assess mental status, tone, and social needs. These milestones may help differentiate certain categories of patients (e.g. "toddler") within the broader category of pediatric patients. Here, we discuss some of the more important and easily remembered milestones. More can be found in Appendix 2 (Zubler et al, 2022). Knowing develop-mental milestones aids in assessing mental status, tone, and social needs. By the age of 2 months, infants should be soothed easily and track movement (Zubler et al, 2022). At 4 months, they become more interactive and coo. By 6 months, they recognize familiar people and may put objects in their mouth. At 9 months, stranger anxiety develops. At 1 year, children become more interactive and start basic language. At 15 months, they follow instructions with gestures. By age 2, they respond to others' emotions. At 3, they ask questions and state their name. At 4, vocabulary and fine motor skills improve. Around 5, vocabulary expands, including time-related words (Zubler et al, 2022). These milestones have variability as to when children reach them; however, clinicians should have general expectations for how a healthy patient of that age should present in order to recognize a sick child.

Injury Patterns

Pediatric injury patterns differ from adults due to musculoskeletal differences. The dis-tribution of these injury patterns may also be important for defining pediatric patients for EMS categories or defining specific categories therein. Children are more prone to bony injuries than ligamentous or tendinous injuries (Marzi et al, 2023). There's also a risk of cervical spine displacement in young children. Hip dislocation is rare and suspi-cious. Scapular fractures are rare but concerning. Pelvic injuries are worrisome, with or without fractures. Lung contusion can occur without rib fractures. "Nursemaid's elbow" is common in young children, usually due to sudden arm pulling. Head size changes affect the estimation of burn injury severity (Table 5).

Finally, as children's relative head size decreases as age increases, the % Body Surface Area (BSA) in each part of the body changes with age, impacting the estimation of severity of burn injuries. This is summarized in Table 5.

Area	Birth to 1 year	1 to 4 years	5 to 9 years	10 to 14 years	Adult
Head	9.5	8.5	6.5	5.5	4.5
Neck	1	1	1	1	1
Trunk	13	13	13	13	13
Upper arm	2	2	2	2	2
Forearm	1.5	1.5	1.5	1.5	1.5
Hand	1.25	1.25	1.25	1.25	1.25
Thigh	2.75	3.25	4	4.25	4.5
Leg	2.5	2.5	2.5	3	3.25
Foot	1.75	1.75	1.75	1.75	1.75
Buttock	2.5	2.5	2.5	2.5	2.5
Genitalia	1	1	1	1	1

Table 5. Percent BSA of Body Parts by Age (Strobel et al 2018, Murari and Singh, 2019).

DISCUSSION

As children's development varies, so too does the definition of a pediatric patient across EMS systems in the United States. The variation in protocols does not seem to follow significant regional patterns. This is clearly a highly complex and multifactorial issue where more standardization appears to be needed. As a point of comparison, geriatric patients are widely understood to be those patients aged 65 and up, allowing for clinicians and researchers to have a common understanding when discussing these patients and develop evidence-based guidelines for the treatment of these patients. Some situations, such as medication dose, may benefit from a weight-based definition, while others, such as equipment choice, may make better use of a length-based definition. Age of legal adulthood for purposes of consent may require an age-based definition. Therefore, different definitions may make sense within a set of protocols, but wide definition variation between states likely does not serve patients or EMS professionals well. As discussion of these standards occurs in the appropriate forums, we highly encourage EMS systems to establish more consistent, logical, and applicable definitions.

CONCLUSION & RECOMMENDATIONS

The authors recommend further discussion at a national level to determine a consistent definition of pediatric patients. Consensus regarding the definition of pediatric patients will allow for enhanced monitoring of patient care trends at regional or national levels and will better inform future research regarding and care of pediatric patients. The authors acknowledge that there may not be a singular definition of pediatric that is suitable for all patients and presentations. We encourage future investigation as to whether different definitions for certain presentations (e.g., traumatic injury, airway emergencies, acute psychiatric emergencies, etc.) may be most appropriate, as some states have already elected to include in their statewide protocols. However, the authors recognize the difficulty that these differing definitions may impose on EMS clinicians and researchers. While no single definition of a pediatric patient seems eminently available, increased national concordance regarding the definition of pediatric patients is of paramount importance for future development of EMS protocols and pediatric EMS research.

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APPENDICES

Early (compensated) Shock		Late (uncompensated) Shock	
signs/symptoms	**physiology**	**signs/symptoms**	**physiology**
tachycardia	Increased cardiac output; compensation for decreased stroke volume	Bradycardia (sign of impending cardiac arrest)	Ischemic heart unable to match demand/ compensate for decreased stroke volume
Mild tachypnea	To meet oxygen demand of under perfused organs	Increased tachypnea	Compensatory respiratory alkalosis for increasing metabolic acidosis
Slightly delayed capillary refill	Due to peripheral vasoconstriction to maintain core organ perfusion (may not be true in some cases of septic shock)	Increasingly delayed capillary refill (>4sec) Mottled or pale skin with cool extremities	Severe peripheral vasoconstriction to shunt blood to brain, kidneys, and heart
Orthostatic BP	Decreased circulating volume causes orthostatic changes	hypotension	Failure of compensatory measures to maintain a perfusing pressure Note: unlike adults, children maintain an almost normal blood pressure until 25% to 35% of their circulating blood volume is lost
Orthostatic pulse changes	Decreased circulating volume causes orthostatic changes		
Mild irritability		AMS progressing to coma	Decreased brain perfusion
		Oliguria	Decreased cardiac output and vasoconstriction cause renal ischemia
		Abdominal distension and decreased motility	Gastrointestinal ischemia due to decreased perfusion
		Dyspnea, tachypnea, and cyanosis refractory to oxygen therapy	massive systemic inflammatory response to ischemia causes endothelium damage and allows fluid into alveolar space

Appendix 1. Summary of pediatric presentation of shock.

Age	Social-emotional	Language	Cognitive	Motor
2 months	Calms down when spoken to or picked up Looks at your face Seems happy to see you Smiles when you talk to or smile at them	Makes sounds other than crying Reacts to loud sounds	Watches you as you move Looks at a toy for several seconds	Holds head up when in prone position Moves both arms and legs Opens hand briefly
4 months	Smiles to get your attention Chuckles (not yet a full laugh) Looks at you, moves, or makes sounds to get or keep your attention	Makes sounds like "oooo" and "aahh" (cooing) Makes sounds back when you talk to them Turns head toward the sound of your voice	If hungry, opens mouth when the breast or bottle is seen Looks at own hands with interest	Holds head steady without support Holds a toy when put in hand Uses arm to swing at toys Brings hands to mouth Pushes up onto elbows/forearms from prone position
6 months	Knows familiar people Likes to look at themself in the mirror Laughs	Takes turns making sounds with you Blows "raspberries" (sticks tongue out and blows) Makes squealing noises	Puts things in mouth to explore Reaches to grab a toy Closes lips to show they does not want more food	Rolls front to back Pushes up with straight arms when in prone position Leans on hands to support self when sitting
9 months	Is shy, clingy, or fearful around strangers Shows several facial expressions, like happy, sad, angry, and surprised Looks when name is called Reacts when you leave (looks, reaches for you, or cries Smiles or laughs when you play peek-a-boo	Makes different sounds like "mamamama" and "babababa" Lifts arms up to be picked up	Looks for objects when dropped out of sight Bangs 2 things together	Gets to a sitting position without assistance Sits without support Uses fingers to "rake" food toward self Moves things from one hand to the other
12 months	Plays games with you, like pat-a-cake	Waves "bye-bye" Calls a parent "mama" or "dada" or another special name Understands "no" (pauses briefly or stops when you say it)	Puts something in a container, like a block in a cup Looks for things he sees you hide, like a toy under a blanket	Pulls up to stand Walks, holding onto furniture Drinks from a cup without a lid, as you hold it Picks things up between thumb and pointer finger, like small bits of food
15 months	Copies other children while playing, like taking toys out of a container when another child does Shows you an object that they like Claps when excited Hugs stuffed doll or other toy Shows you affection (hugs, cuddles, or kisses you)	Tries to say 1 or 2 words besides mama or dada, like "ba" for ball or "da" for dog Looks at a familiar object when you name it Follows directions given with both a gesture and words. For example, gives you a toy when you hold out your hand and say, "Give me the toy." Points to ask for something or to get help	Tries to use things the right way, like a phone, cup, or book Stacks at least 2 small objects, like blocks	Takes a few steps on their own Uses fingers to feed self
18 months	Moves away from you, but looks to make sure you are close by Points to show you something interesting Puts hands out for you to wash them Looks at a few pages in a book with you Helps you dress them by pushing arm through sleeve or lifting up foot	Tries to say ≥3 words besides mama or dada Follows 1-step directions without any gestures, like giving you the toy when you say, "Give it to me."	Copies you doing chores, like sweeping with a broom Plays with toys in a simple way, like pushing a toy car	Walks without holding onto anyone or anything Scribbles Drinks from a cup without a lid and may spill sometimes Feeds self with their fingers Tries to use a spoon Climbs on and off a couch or chair without help
24 months	Notices when others are hurt or upset, like pausing or looking sad when someone is crying Looks at your face to see how to react in a new situation	Says at least 2 words together, like "More milk." Points to at least 2 body parts when you ask Uses more gestures than just waving and pointing, like blowing a kiss or nodding yes	Holds something in 1 hand while using the other hand, for example, holding a container and taking the lid off Tries to use switches, knobs, or buttons on a toy Plays with >1 toy at the same time, like putting toy food on a toy plate	Kicks a ball Runs Walks (not climbs) up a few stairs with or without help Eats with a spoon

Appendix 2. Summary of pediatric developmental milestones.

Age	Social-emotional	Language	Cognitive	Motor
30 months	Plays next to other children and sometimes plays with them Shows you what they can do by saying, "Look at me!" Follows simple routines when told, like helping to pick up toys when you say, "It's clean-up time."	Says ≥2 words, with 1 action word, like "Doggie run." Says around 50 words Names things in a book when you point and ask, "What is this?" Says words like I, me, or we	Uses things to pretend, like feeding a block to a doll as if it were food Shows simple problem-solving skills, like standing on a small stool to reach something Follows 2-step instructions, for example, "Put the toy down and close the door." Shows that they know at least 1 color, like pointing to a red crayon when you ask, "Which one is red?"	Uses hands to twist things, like turning doorknobs or unscrewing lids Takes some clothes off by themself, like loose pants or an open jacket Jumps off the ground with both feet Turns book pages, one at a time, when you read to them
3 years	Calms down within 10 minutes after you leave, like at child care drop off Notices other children and joins them to play	Talks with you in conversation using at least 2 back-and-forth exchanges Asks who, what, where, or why questions, like "Where is mommy/daddy?" Says what action is happening in a picture when asked, like running, eating, or playing Says first name when asked Talks well enough for others to understand, most of the time	Draws a circle when shown how Avoids touching hot objects, like a stove, when warned	Strings items together, like large beads or macaroni Puts on some clothes by themself, like loose pants or a jacket Uses a fork
4 years	Pretends to be something else during play (teacher, superhero, dog) Asks to go play with children if none are around, like "Can I play with Alex? Comforts others who are hurt or sad, like hugging a crying friend Avoids danger, like not jumping from tall heights at the playground Likes to be a "helper" Changes behavior on the basis of location (place of worship, library, playground)	Says sentences with four or more words Says some words from a song, story, or nursery rhyme Talks about at least one thing that happened during the day, like "I played soccer." Answers simple questions, like "What is a coat for," or "What is a crayon for?"	Names a few colors of items Tells what comes next in a well-known story Draws a person with three or more body parts	Catches a large ball most of the time Serves food or pours water , with adult supervision Unbuttons some buttons Holds crayon or pencil between fingers and thumb (not in a fist)
5 years	Follows rules or takes turns when playing games with other children Sings, dances, or acts for you Does simple chores at home, like matching socks or clearing the table after eating	Tells a story that was heard or made up with at least two events, like a cat stuck in a tree and a firefighter saving it Answers simple questions about a book or story after you read or tell it to them Keeps a conversation going with more than three back-and-forth exchanges Uses or recognizes simple rhymes (bat-cat, ball-tall)	Counts to 10 Names some numbers between one and five when you point to them Uses words about time, like yesterday, tomorrow, morning, or night Pays attention for 5–10 minutes during activities, for example, during story time or making arts and crafts (screen time does not count) Writes some letters of their name Names some letters when you point to them	Buttons some buttons Hops on 1 foot

Appendix 2 (continued). Summary of pediatric developmental milestones.

Injury	Ages more common	Anatomical/ physiological reasoning	Bones most affected	Mechanism of Injury	Notes
Stress fractures	2-4 years Puberty		Tibia, fibula, tarsus, and femur Proximal tibia or the metatarsals	Young children learning to walk or run Excessive sports activity	
Osseous, chondral, or periosteal ligament tears	10-12 years	Ligaments are more stable than their attachments			
Avulsion or growth plate injuries	Children with open epiphyseal junctures (~<12years)	Tendons and ligaments are not directly connected to the growing skeleton in childrenbut are attached to the cartilage or the growth region. The high elasticity and plastic deformability of the tendons and ligaments in children often lead to bony injuries and not to intra-ligamentous/intra-tendinous ruptures			
Ligament rupture	> 12 years	After the growth phase, laxity described above decreases and risk of ligament rupture is increased			
Muscle tendons tear/ bone avulsion	Adolescents	Hormonal influence	Humeral medial epicondyle, anterior iliac spines, lesser trochanter	Increased risk at adolescence due to hormonal changes and increased sports stress	
Greenstick (Classic)		Pediatric periosteum has a higher fat content, increased vascularization and is thicker than that of adults	Shaft of forearm long bones is most common	Fall on outstretched arm or other blunt trauma	High refracture risk
Greenstick (Compressed)	<5				Not associated with healing problems
Greenstick (Bowing)	Late childhood/ adolescence				
Shoulder Dislocation	> 10-12 years				
Posterior Hip Dislocation				A result of high speed trauma	High index of suspicion for other injuries
Physiological anterior displacement of C2 on C3 or C3 on C4 with the potential for pseudo-subluxation	Up to age 8	Greater elasticity of pediatric spine			
Muscle contusions/ sprain	Adolescents playing sports (rare in young children)			Sports related	
Scapular fractures	Rare			High speed traffic accident or falls from height	Suspect concomitant rib and/ or vertebral fxfractures
Supracondylar humerus fracture	Peaks at age 5		Metaphysis of distal humerus	Fall on outstretched, hyperextended arm (breaking a fall)	
Transcondylar humerus fractures (Medial condyle)	Peaks at 12 years			Fall onto outstretched hand; sometimes direct trauma	Often seen with elbow dislocation
Transcondylar humerus fractures (Lateral condyle)	4-5 years				Missed lateral condyle fractures can lead to significant function deficit/ deformity and ulnar nerve irritation
Transcondylar humerus fractures (T-fractures)					
Elbow dislocation	> 10 years			Fall on outstretched hand leads to posterolateral dislocation; rarely, a direct fall on the posterior elbow will lead to anterior dislocation	
Subluxation of proximal radius "Nursemaids elbow"	< 4 years more common in girls and left arm	Annular ligament's distal attachment to proximal radius strengthens as child ages	Proximal radius slips out of the annular ligament when the muscles cannot counter-stabilize the joint	Abrupt force, often an adult pulling up or twisting an extended arm	Presents holding the injured elbow in moderate extension and pronation
Proximal Forearm		Supinator and biceps muscles pull the proximal fragment into supination and flexion. The pronator quadratus and teres muscles pronate the distal fragment	Radius and ulna		Immobilize in supination to approximate fracture

Appendix 3. Summary of pediatric musculoskeletal injury patterns.

Injury	Ages more common	Anatomical/ physiological reasoning	Bones most affected	Mechanism of Injury	Notes
Mid shaft forearm	Ages 6-8; more common in boys	Pronator teres and the supinator neutralize each other, leaving only the biceps acting to flex the proximal fragment	Radius and ulna	Fall onto the outstretched hand	Immobilize in neutral or mild supination
Distal Forearm	Age 10	Supinates due to pull of the brachioradialis muscle	Usual distal third of radius and ulna		Immobilize in slight pronation
Carpal injuries	10-15 year	Carpal complex consists almost entirely of cartilage; as bones ossify injury patterns similar to adults is seen	Generally of scaphoid, lunate, and capitate bones	Fall from bike or while skating	Often in combination with distal radius fracture
Hip (Proximal femur)		Bone is more robust than adults		Massive trauma	Must suspect concomitant injuries; complicated healing due to vascular supply
Hip (Femur shaft)	Younger children/ infants	Femoral shaft diameter increases with increasing cortical diameter during growth, while canal diameter proportionally decreases.; bone less stable		Consider child abuse; falls from changing tables	Consider shock from blood loss, vascular, and nerve injury; evident from swelling, shortening, and rotation of affected leg
Hip (Distal femur)				Often sports related, can be from high-speed trauma or falls	Assess for vascular damage
Lower leg			Tibia only (70%) Tibia and fibula (30%)		High-risk for compartment syndrome
Talus				Severe force trauma	High index for other injuries
Pelvis		Strong ligaments and multiple cartilaginous growth centers can absorb significant force without fracturing	Isolated ring fracture possible due to elasticity of hemipelvis	High energy trauma: traffic accident and fall from height; approx 25% of children with a fracture will have associated traumatic brain injury	High incidence of additional injuries; high- risk of organ injuries without fracture; evaluate for perianal and scrotal hematomas; transport to center with pediatric surgery/ trauma highly encouraged

Appendix 3 (continued). Summary of pediatric musculoskeletal injury patterns.