



Hazard/Threat Vulnerability Analysis Workgroup Final Report

Executive Summary

The Assistant Secretary for Preparedness and Response (ASPR) awarded the Eastern Great Lakes Pediatric Consortium for Disaster Response (EGLPCDR) a grant to harness and develop best practices around disaster preparedness and response to be shared with other children's and non-children's hospital entities in the region. Each children's hospital partner has filled key roles to accomplish the organization structure to begin to address the activities and strategies in the workplan. The partners established 16 workgroups with respective leads to address the items outlined in the workplan, including the Hazard / Threat Vulnerability Analysis (HVA) Workgroup. (See Appendix C for members and sites.)

Background

Children under 18 years old comprise approximately 25% of the United States population and are one of the country's most vulnerable groups.¹ The unique anatomic, physiologic, and developmental features of children cause them to be disproportionately affected by disasters.² To prepare for and mitigate against disasters, emergency managers and hospitals create hazard vulnerability analyses (HVAs). HVAs seek to identify various hazards, their probability of occurrence, their hazard's potential impact, and how prepared a given community or hospital is for such an event.^{3,4}

Ideally, HVAs account for population-specific characteristics (i.e. age, medical needs, health conditions) and population-specific vulnerability to different disasters.⁵ HVAs differ based on location, population, and vulnerabilities; for example, California's HVAs would likely include wildfires and earthquakes, while Florida's HVAs would include hurricanes.

Although HVAs have become a standard practice in regions and hospitals across the US, they often exclude pediatric-specific considerations, despite the large number of children in the population and their disproportionate risks during a disaster.⁶

The Workgroup's action plan was highlighted as part of Activity A, Strategy 1, to help define the core elements of a pediatric disaster care capability and identify the respective contributions of

regional partners and other available assets. The HVA Workgroup specifically focused on the following areas within that larger effort:

- Regional disaster coordinator survey tool for Ohio and Michigan
- Assessment of pediatric inclusion in HVA tools
- Evaluation of publicly available databases for pediatric implications of hazards
- Creation of a visual aid for Regional Disaster Coordinators (RDC) pediatric disaster preparedness efforts by hazard
- Development of a pediatric-specific disaster framework for use in HVAs

Results of the Workgroup Activities

Regional Disaster Coordinator (RDC) Survey Tool for Ohio & Michigan

In October 2019, the Workgroup created and deployed a survey of the 16 RDC within Ohio and Michigan. The Workgroup identified the following items as being critical assessment metrics within each region both with respect to specific pediatric preparedness efforts as well as general emergency management information:

- Number of children under age 18 in the region
- Number of schools and daycares
- Number of hospitals
- HVA tools used by hospitals
- HVA top 5 hazard (Ohio only)
- Triage tools—regional
- Use of children in disaster drills (regional/hospital)
- Pt tracking systems—regional
- Reunification plans—regional
- Hospital notification systems—regional
- Electronic medical record systems—hospital
- Equipment stockpiles (pediatric)—regional
- Mental health resources/Critical incident stress debriefing (CISD)—regional

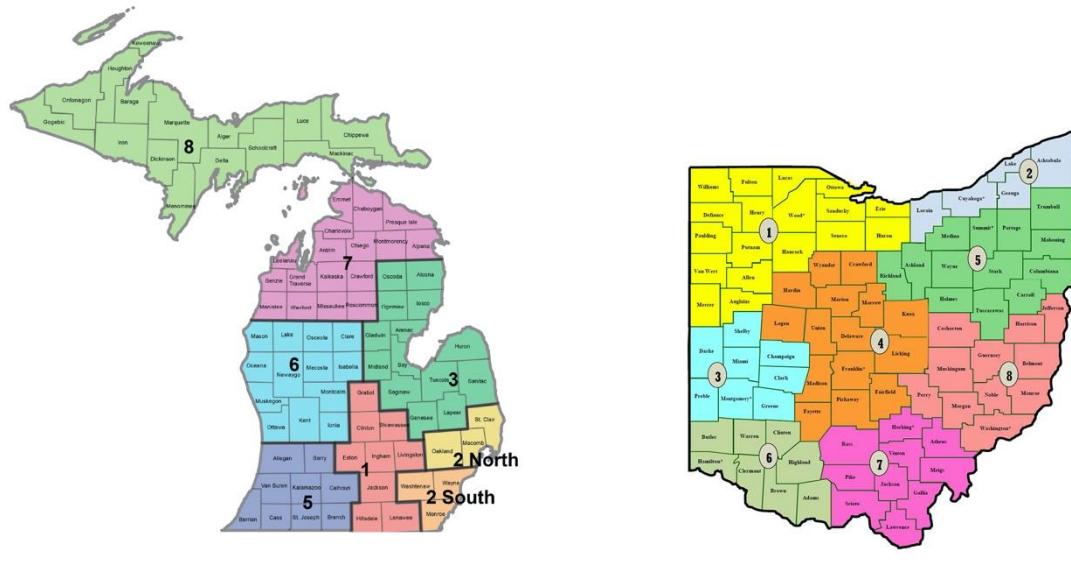
The results of the survey were compiled in a centralized database on the Eastern Great Lakes (EGL) share drive, making it available for other Center Workgroups, including Metrics, Children's Hospital Survey, Asset Map, Behavioral/Mental Health, and EMS. Responses were received from Regional Disaster Coordinators representing 7 of 8 geographic zones in the State of Michigan and 7 of 8 geographic zones in the State of Ohio (see Figure 1, below).

The information was also shared with the RDCs for integration into the Pediatric Emergency Plan Annex in 2020 as part of the Regional Hospital Collaboration's overall Emergency Operations Plan within the States of Ohio and Michigan. These plans were created as part of ASPR's efforts to ensure pediatric preparedness efforts occur within regional emergency plans. The Michigan and Ohio Departments of Health were responsible for the oversight of these

plans and the pediatric information compiled with the survey helped fill in gaps within those plans.

Additionally, survey results were used to inform the recommendations within this white paper, and the development of a newly proposed HVA toolkit.

Figure 1: Emergency Response / Healthcare Coalition Regions of Michigan and Ohio



Michigan

Ohio

Both Michigan and Ohio are divided into eight geographic regions of emergency preparedness and healthcare coalitions. Each region's disaster coordinator was surveyed on a range of pediatric-specific preparedness topics as well general emergency management topics.

Figures taken from [Ohio Department of Health](#) and [Michigan State Police](#).

Recommendations for Next Steps

- Create a standardized model for a pediatric annex within the Michigan and Ohio regions.
- Formalize an annual review process of pediatric annexes to be conducted by pediatric disaster experts.
- Maintain on-going relationships between EGL members and RDCs to promote pediatric preparedness efforts.

Assessment of Pediatric Inclusion in Regional and Hospital Hazard Vulnerability Analyses

Pediatric-specific considerations are often excluded from regional and hospital HVAs, despite the fact that 83% of all children in the US are seen in adult or community Emergency Departments (EDs), as opposed to pediatric EDs.⁷ Nationally, only 47% of all hospitals (and 67% of high-volume hospitals) have disaster plans that include pediatric needs; the majority of hospital disaster reports do not consider pediatric-specific equipment, family reunification procedures, or pediatric standards during crises.^{8, 9, 10} Less than 50% of hospitals routinely conduct disaster drills with pediatric patients, while only 32% of hospitals have plans incorporating pediatric surge capacity.¹¹

Through the Technical Resources, Assistance Center, and Information Exchange (TRACIE) website, ASPR provides hospitals and regional managers with an array of HVA frameworks, resources, and examples.¹² ASPR TRACIE also offers many HVA templates¹³ that offer a methodological approach to classifying hazards and hazard impacts, as well as way for organizations and localities to gauge preparedness and vulnerability to individual disasters.

Some of the most commonly used HVA toolkits are the Kaiser Permanente (KP) framework,¹⁴ Pennsylvania Public Health Risk Assessment Tool (PHRAT),¹⁵ and Threat/Hazard Assessment Module (THAM).¹⁶ All three of these frameworks provide examples of hazards (e.g. thunderstorms, cyber-attack), allow organizations to assess the risk of each hazard occurring, and gauge the predicted internal and external response to each hazard.

- The KP template is primarily targeted at hospitals and healthcare organizations and classifies hazard impact along *human* (death and/or injury), *property* (physical damages), and *business* (service interruption) dimensions.¹⁷ It does not allow for additional stratification of at-risk populations or impacts within each dimension.
- Like the KP tool, the PHRAT framework also assesses hazard risk and establishes planning priorities, yet the PHRAT also incorporates an in-depth population impact analysis alongside specific threats.¹⁸ The sizes of at-risk populations (e.g. children 18 and under, seniors age 65 and older,) as well the procedures to care for these populations during disasters can be incorporated into the PHRAT.
- THAM is a new HVA modality that was recently released by HHS as a part of the agency's risk identification and site criticality (RISC) toolkit.¹⁹ THAM contains built-in data to help organizations identify hazard risk based on geographic location and other inputs. The other modules of RISC analyze site impact in terms of operations, business, and additional categories according to each hazard. Like the Kaiser tool, THAM does not allow users to input specific population impacts per hazard.

Regional and hospital-based emergency managers across the country use these three frameworks to inform their own HVAs, with little to no modification of the original templates. Unfortunately, these templates fail to incorporate the pediatric considerations necessary for managing children during disasters. For example, the KP and THAM tools do not allow for any specific population inclusions, while the PHRAT framework does not allow for detailed pediatric inputs (it only contains one category to describe the impact on all children 18 and under).

Even if a region or hospital wanted to incorporate pediatric considerations into their existing HVAs, however, they would struggle to find accessible and integrable ways to do so. Many disaster resources that are available online do not detail the essential pediatric factors to include in HVAs; instead, they focus on helping children and families cope with disasters.^{20 21 22}

The NIH offers a literature search tool to explore individual hazards, although the resulting scientific journals may not succinctly detail the hazard's impact on children in a way that can be incorporated into a HVA.²³ Other resources from the CDC offer guides to prepare for surge events and to create action plans, yet even these lack a streamlined approach to including children into existing HVAs and emergency response plans.²⁴

As a result, without a model that simply frames the inclusion of children in threat preparedness and hazard vulnerability analyses, regional and hospital-based emergency managers across the country may struggle to incorporate pediatric risks and disaster impacts into their work.

Recommendations and Next Steps

- Broaden current HVA templates to include pediatric-specific implications. 'Human Impact' as described within the Kaiser Permanente framework could be expanded to include relevant impact by age.
- Create pediatric-specific HVAs that highlights implication of all hazards on children.
- Hospital accreditation agencies should incorporate pediatric-specific hazard assessments during hospital surveys.

Evaluation of Publicly Available Database Assessment for Pediatric Implications of Disasters

Baseline metrics are needed in order to inform a pediatric-specific hazard/threat vulnerability assessment, in order to understand the implications for the pediatric population. Yet, information regarding pediatric injuries, mortality, morbidity, hospitalizations, and other pediatric-specific outcomes after disasters strike are not available in any publicly accessible database.

FEMA compiles reports from all declared disasters; however, there is little (if any) pediatric information within the agency's database. Instead, emergency management planners need to access the literature for case reports and case series specifically related to disasters in order to understand implications on children.

To address this challenge, the Workgroup developed a database of literature by hazard-type, which highlights acute and long-term implications for children. Interestingly, there is no similar database for the "adult" population related to hazards. Once again, the data are only available through literature search for case reports and case series.

Recommendations and Next Steps

- Create a publicly available database that provides pediatric-specific implications for all hazards. This would include but not limited to data on: hospitalization, injury patterns, morbidity, and mortality.
- Highlight this pediatric-specific data within HVA templates for hospitals and regional planners.

Creation of a Visual Infographic Hazard Aid for Regional Disaster Coordinators

Many websites have pediatric-specific information related to the preparedness and response to disasters. These include information from the CDC, FEMA, and the National Child Traumatic Stress Network. Accessing this information can be daunting, however. Moreover, the data are not specific by state or region.

To address this challenge, the Workgroup established a process to incorporate mitigation / preparedness / response efforts that are specific to hazards outlined by Regional Disaster Coordinators in Ohio and Michigan for distribution to these regional leaders, in order to improve regional situational awareness. (See next page.) This information was directed to regional disaster healthcare planners as well as incorporated into the EIIC website for more global distribution and review.

Children and Disaster Emergency Management: Threat Assessment, Hazard Identification, and Risk

Over 4.7 million children live in Michigan and Ohio

Michigan	Ohio
0-10: 28%	0-10: 28%
11-17: 31%	11-17: 31%
18-24: 17%	18-24: 17%
Total Michigan Child Population 2019: 2,143,933	Total Ohio Child Population 2019: 2,578,019

Source: National KIDS COUNT Child Population By Age Group (Percent) datacenter.kidscount.org
● 0-10 ● 11-17 ● 18-24 ● 25-34

Children are a high-risk vulnerable population and are consistently left out of hospital & regional threat and hazard assessments.

Including children in threat and hazard assessments creates opportunities to avoid, control, and reduce community impacts as well as promote whole community engagement & capability

National pediatric readiness scores for hospitals in Michigan/Ohio was 66/67 out of 100 in 2014. While these scores fall within the national average, higher scores are known to be associated with improved pediatric care outcomes.

A Center for American Progress 2020 analysis reported that 30% of the Ohio/Michigan Health Care workforce have children <14 years old. Planning with childcare and schools preserves local and regional health provider workforce.

According to KIDS COUNT Data Center in 2019 18% of Ohio and Michigan children live in poverty. Planning for children is essential for shelter & food assistance programs. Disaster events increase the need for food and shelter assistance and have lasting community impacts.

Child-Centric Disaster Readiness
Sources: American Academy of Pediatrics, FEMA & CDC

- Community resilience begins with teaching children to be disaster ready.
- Children are able to engage parents in disaster readiness learned in schools.
- Children & youth are capable to become disaster leaders.
- Children & families who are disaster ready experience less long term impacts.

Pediatric Disaster Readiness = Whole Community Readiness

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Children and Disaster Emergency Management: Threat Assessment, Hazard Identification, and Risk

Regional Healthcare Coalition 2020 Top 5 Hazard Vulnerabilities

1 Blizzard Snow

- Awareness:** Children are at greater risk of injury and death due to severe weather events. Pediatric admissions to hospitals associated with frostbite, hypothermia, and carbon monoxide poisoning should be anticipated.
- Preparedness:** Workforce with children may travel long distances to and from their children impacting their ability to respond to disasters.
- Response:** Families with children who are dependent on medical devices are known to seek assistance from 911 and hospitals during a severe weather power outage.
- Mitigation:** Children rely on their families, childcare providers, and schools to prepare and gather supplies prior to freezing winter storms.

2 Active Shooter

- Awareness:** There were 70 school shootings in Michigan and 55 in Ohio in 2020. Most shootings occur within proximity to schools.
- Preparedness:** Active shooter drills in schools were associated with a 42% increase in anxiety & stress and 39% in depression. The American Academy of Pediatrics recommends that drills be conducted in a manner that does not traumatize children.
- Response:** PsYSTART Triage assists providers in allocating mental health resources to children and adults after the event. Limiting children's media exposure when an incident occurs reduces anxiety. Practice age-appropriate community messaging to reassure children.
- Mitigation:** Stop-the-bleed training is for everyone, including middle and high school students. Hospitals need to ensure there is a practiced plan for family reunification and unaccompanied children.

3 Chemical Exposure

- Awareness:** Children have a greater risk of respiratory failure and acute toxicity. Children breathe more air per kilo and have a higher body surface area that increases the absorption of toxins. Agents of the highest concern include nerve, blistering, asphyxiants, and disabling agents.
- Preparedness:** Childcare, schools, and families should have plans for sheltering in place. Prehospital providers and Hospitals decontamination equipment and PPE.
- Response:** Anticipate the decontamination of children within a short period of time. Prevent hypothermia using warmed water for decontamination. Prepare for pediatric medical countermeasure administration.
- Mitigation:** Communities should have reliable mechanisms to alert the community to a toxic exposure and how to shelter in place.

4 Mass Casualty

- Awareness:** Only 13% of communities have a mass casualty plan that includes children. Trauma accounts for approximately 20% of pediatric EMS encounters under normal conditions. Children are at greater risk of blunt chest and abdominal trauma, including traumatic asphyxia.
- Preparedness:** Adopting a single standard for pediatric triage such as JumpSTART or SALT improves on-scene triage between responders.
- Response:** Children with critical trauma or burns require a regional coordinated system of response. EMS transport mutual aid, including air transport to distant pediatric regional centers, should be anticipated.
- Mitigation:** Promote Stop-the-Bleed Programs. Place stop-the-bleed kits with public access defibrillators.

5 Cyber

- Awareness:** Every year thousands of children become victims of cybercrime. The National Center for Missing and Exploited Children (NCMEC) Cyberipline reports included over 69 million images, videos, and other files related to child sexual exploitation.
- Preparedness:** Secure computer networks in schools, libraries, and other areas where children gather. Train caretakers in the signs of child cybercrime.
- Response:** As children move to online learning the need to monitor and report cybercrime events against children through appropriate law enforcement channels including the NCMEC.
- Mitigation:** Promote programs known to reduce the risk of cybercrime of children from the FBI and National Center for Missing and Exploited Children.

EASTERN GREAT LAKES CONSORTIUM FOR PEDIATRIC DISASTER RESPONSE 2020

The Workgroup created an infographic on *Children and Disaster Emergency Management: Threat Assessment, Hazard Identification and Risk*, designed to provide essential facts and

figures informing disaster preparedness efforts for children living in Ohio and Michigan. The top vulnerabilities in 2020, as identified by Eastern Great Lakes Regional Healthcare Coalitions, are described; awareness, preparedness, response, and mitigation efforts that are unique to children are detailed.

Subsequently, the Workgroup utilized a similar approach to produce an All-Hazard Children and Disaster Hazard Awareness quick guide. This guide highlighting Awareness, Preparedness, Response and Mitigation. A portion of the infographic follows, and provides stakeholders (i.e., community members, hospital staff, public health representatives, policy makers, and first responders) with awareness, preparedness, response, and mitigation information that is unique to children and associated with 24 hazards. The full infographic is available at the EIIC EGL website at: <https://emscimprovement.center/domains/preparedness/asprcoe/eglpcdr/hva/>.



Children and Disaster Hazard Awareness



Hurricane

- **Awareness:** In 2020 the US experienced 30 hurricanes affecting large portions of the US. Millions of children are impacted since children are on average 25% of the population. Evacuations commonly occur requiring evacuation and sheltering.
- **Preparedness:** Hurricanes are "noticed events" and allow families with children to move out of harm's way. Children at the most risk are homeless children, families without transportation or money, children with complex medical conditions. Use AAP Hurricane Preparedness: Tips for Families materials.
- **Response:** Families with children who cannot evacuate may seek shelter, power, and support at hospitals during a hurricane. Children may become separated in mass evacuations and require reunification.
- **Mitigation:** Promote child-centric preparedness programs like Ready.gov-Kids. Assure families with children with complex needs have plans and resources to prepare.



Tornado

- **Awareness:** Most tornados occur during April and May while children are in school. Injuries and deaths to children are associated with trauma due to fractures and brain injuries due to flying/falling debris. 50% of tornado-related injuries occur during rescue, cleanup, and post-tornado activities. Children experience anxiety and fear during these events.
- **Preparedness:** Children rely on school personnel to shelter in place during a tornado. Mass casualty events involving children may occur. Facilities should prepare accordingly.
- **Response:** First medical response will rely on community responders. Facilities should expect surges of self-transported children with their families after a tornado. Secondary surges of children should be anticipated with and without parents.
- **Mitigation:** Tornados are short notice events. Children, families, and communities need to know how to rapidly seek shelter and deal with power and housing failures.



Flood

- **Awareness:** 37% of fatalities associated with flooding in the US occurred in children < 19 in 2020. Young children and those with autistic disorders may be drawn to water and are at high risk for drowning. Children may go towards a threat due to their curiosity.
- **Preparedness:** Childcare, schools, and families should have plans for flood emergencies that include sufficient food, water, and medication. Flooding is typically a noticed event and families should monitor local communications for evacuation warnings.
- **Response:** Avoid separating children during evacuation. Keep children away from rising water. Prepare to follow boil water notices. Do not let children participate in flood cleanup due to contaminated water and mold.
- **Mitigation:** Prepare children and their families that flooding disrupts power, housing, transportation and increases the risk of infectious disease. Families should know not to drive through floodwaters. Six inches of water can knock you down and two feet of water can sweep a vehicle away.

Recommendations and Next Steps

- Expand this infographic to provide state-based data across the US.

- Recruit hospital and regional emergency management leaders to assess how best to incorporate these documents into their planning.

Development of a Pediatric-Specific Disaster Framework for use in Hazard Vulnerability Analyses (HVAs)

The Ohio and Michigan RDC surveys revealed that the majority of hospitals and agencies across the two States employed a HVA that was based off of either the Kaiser Permanente or HHS' THAM templates. None of the regional coordinators surveyed reported receiving county or hospital HVAs with pediatric-specific considerations.

In response, and to provide regional and hospital emergency managers with a flexible way to include children in their disaster preparedness efforts, the Workgroup developed a novel pediatric HVA template that can be used on its own or alongside existing frameworks (e.g. KP, PHRAT). The pediatric HVA template allows managers to determine a hazard's impact on children and the probability of that hazard occurring, in order to establish their region's or hospital's overall pediatric vulnerability to a given hazard (see Appendix A: Pediatric HVA Template).

The template allows regional and hospital managers to consider how disasters affect children and how prepared their regions and respective hospitals are for the pediatric consequences of those disasters. It is not meant to be a thorough checklist of preparation (i.e. the details, coordination, and policies of sheltering children during a displacement event) but, instead, to spur the inclusion of general pediatric considerations into HVAs. The template equips regional managers to think about children in disasters across multiple dimensions (e.g. acute and long-term health impacts, family reunification) and can be applied to all types of hazards.

The pediatric HVA template allows emergency managers to determine a hazard's impact on children, how vulnerable the region and/or hospital is to the hazard, and the risk of each hazard based on existing preparedness efforts. The impact score is determined by assigning categories a value—from 1, indicating low risk, to 3, indicating high risk—using the accompanying impact score key. The vulnerability score then incorporates hazard likelihood, which can be obtained by examining the frequency of past hazard occurrences. Finally, after assigning preparedness categories a rank—from 1, indicating low preparedness, to 3, indicating high preparedness—using the accompanying preparedness key, the overall risk of a hazard can be obtained. The overall hazard risk is a final determination that incorporates the hazard's impact, likelihood, and existing preparedness efforts.

Emergency managers can then input currently existing disaster cycle efforts (e.g. mitigation, preparedness) to ascertain the relative risk to their respective region. The template's construction provides managers with both the pediatric-specific impact across various categories (as in the PHRAT template) and the simplicity of a final relative risk score (as in the KP template). The hazards listed in the Workgroup's template were carefully chosen and based upon those found in the KP, PHRAT, and THAM templates.

The most novel aspect of the Workgroup's HVA template is the hazard impact / severity measure—this is the first time an HVA has employed pediatric-specific categories to determine a hazard's impact (see Figure 2, below). The template mirrors the PHRAT's classifications and is broken into *human impact*, *healthcare system impact*, and *community safety infrastructure*. Each of these sections is then further divided into categories that uniquely involve children. For example, the *community safety infrastructure* measure asks managers to consider how displaced children will be brought back to their families (*family reunification*), how school and daycare closures will affect children's safety and hospital workforces (*school / childcare*), as well as how a disaster threatens the shelter and food needs of children in the community.

Figure 2: Impact / Severity Measure Within the Pediatric HVA Template

Hazard Impact / Severity Measures								
Human Impact		Healthcare System Impact			Community Safety Infrastructure			
Acute Pediatric Morbidity	Long-Term Pediatric Morbidity	Hospital	Public Health	Emergency Medical Services	Family Reunification	School/Childcare	Shelter/Food	IMPACT SCORE
1 - Low 2 - Medium 3 - High	Weighted score of hazard impact alone							

The template asks managers to assign each category an impact score—where 1 indicates low impact, and 3 indicates high impact. To assist with these score determinations, the template includes an *impact score key* that assigns each category descriptions and examples across low, medium, and high impacts (see Figure 3, below). The impact score key provides the many different considerations of each impact / severity category. These considerations align across impacts, thereby allowing managers to easily assign a score. For example, within *acute pediatric morbidity*, the physiologic impact across age distributions is classified as mild across all ages (low impact), mild to moderate across all ages and/or severe across 1-2 distributions (medium impact), or significant across all ages and/or lethal across 1-2 distributions (high impact).

Although the scoring key is comprehensive, managers have wide latitude in assigning scores, due to the fact that each category contains multiple components. Consider the *hospital* category (within *healthcare systems impact*), which asks managers to examine, among other things, the number of hospitals a hazard impacts, hospital capacity, patient flow, and the pediatric-specific equipment a given hazard necessitates. Within a given category, most hazards will have components with different impacts, thereby allowing a manager to decide which aspects are most influential in the category's final impact score. For example, within the *hospital* category, a biologic attack on one community might be low-impact in that it affects a small number of hospitals, but high-impact in that it necessitates more pediatric-specific equipment than the region can provide.

Figure 3: Impact Score Key

Impact Scoring Key					
IMPACT OF IDENTIFIED HAZARD	Human Impact Preparedness	Domain	Impact is Low (1)	Impact is Medium (2)	Impact is High (3)
		Acute Pediatric Morbidity		Small number of children affected; isolated incident	Potential for moderate number of children impacted across multiple locals
		Minimal types and low number of predicted pediatric acute injuries from hazard		Increasing severity and numbers of pediatric injuries predicted	Large number of children impacted, potentially state or nationwide
		Age-based physiology makes children marginally more vulnerable to the hazard		Age-based physiology makes children moderately more vulnerable to the hazard	Very severe types and numbers of pediatric injuries predicted
	Long-Term Pediatric Morbidity	Mild physiologic impact across all pediatric age distributions*		Mild to moderate physiologic impact across all age distributions and/or 1-2 age distributions significantly impacted*	Age-based physiology makes children significantly more vulnerable to the hazard
		Little to no long-term pediatric injuries predicted from hazard		Increasing severity and types of long-term pediatric injuries predicted	Significant physiologic impact across more than 1 pediatric age distribution and/or 1-2 age distributions lethally impacted*
		Long-term effects do not adversely impact youngest age distributions*		Mild to moderate long-term effects adversely impact youngest age distributions*	Lifelong and severe hazard effects adversely impacting youngest age distributions*
	Healthcare Systems Impact Preparedness	Hospital	Long-term mental health and/or rehabilitation needs met by existing system		Long-term mental health and/or rehabilitation needs bring system to capacity; may need to expand beyond current mental health resources
			Small number of hospitals impacted		Multiple regional hospitals impacted
			Patients arrive to ED in 1 low-volume wave or low-volume evenly distributed waves†		Patients arrive in 1 moderate-volume wave or many low-volume waves; ED capacity reached‡
			Patient surge below hospital bed capacity§		Hospital capacity reached by surge of patients§
			Minimal utilization of pediatric-specific equipment; met by hospital resources		Increasing amount of pediatric-specific equipment needed based on age*; often exceeds hospital resources
		Patient surge does not affect hospital's ability to treat non-hazard patients§; surge does not cause equipment shortages		Patient surge affects hospital's ability to treat non-hazard patients§; equipment needs of hospitalized patients stressed due to surge	Significant amount of pediatric-specific equipment needed based on age*; often exceeds state/national resources
		Limited hospital operational impact or loss of hospital business		Isolated loss of operational capacity and/or moderate impact on multiple operational units	Patient surge prevents hospital from treating non-hazard patients§; equipment needs of hospital exceeded due to surge
		Limited impact on total organizational performance		Moderate impact on total organizational performance	Significant loss of operational capacity
		Isolated hazard without public health ramifications		Large or prolonged hazard that requires local/regional public health support	Severe impact on total organizational performance
		Hazard has no impact on at-home children with medical complexity		Hazard impacts ability of children with medical complexity from receiving at-home resources	State or nationwide hazard that affects basic community health functions
	Community Safety Infrastructure Preparedness	Emergency Medical Services	Isolated hazard that only requires local EMS personnel and resources		Hazard prevents children with medical complexity from receiving at-home resources
			Number of children involved minimal; local EMS can treat all affected children		Large regional hazard that often exceeds local EMS personnel and resources
		EMS able to transport patients without issue		Number of children involved increasing; local EMS struggles to treat all affected children	Large number of children involved; EMS cannot treat all affected children
		Isolated local hazard with minimal displacement		Hazard moderately affects EMS ability to transport patients	Hazard prevents or severely limits EMS ability to transport patients
		Family Reunification	Reunification can occur at the hospital level		Regional hazard with moderate displacement
		School/Childcare	Isolated local hazard with minimal school/child care impact		Reunification usually requires regional and outside organizational assistance
		Hospital staffing can absorb employees that must remain home with their children		Prolonged local hazard or region-wide hazards with moderate school/child care impact	Displacement across states, requires nationwide governmental coordination and outside organizational assistance
		Shelter/Food	Isolated hazard that does not affect local food supply		Hospital staffing burdened due to employees that must remain home with their children
		Local resources can supply shelter for those affected by environmental hazard		Prolonged severe state or nationwide hazard with significant school/child care impact	Hospital staffing severely affected by employees that must remain home with their children
		Hazard does not cause pediatric displacement		Region must provide shelter for those children displaced by hazard	Significant or prolonged hazard requiring state or nationwide efforts to ensure food supply
					Regional resources for supplying shelter from environmental hazard exceeded
					State or nationwide efforts needed to provide shelter for those children displaced by hazard

Additionally, some parts of the *impact score key* ask managers to review their regional pediatric demographics and surge capabilities, a space for which is included next to the score key (see Figure 4, below). Some components of the impact score key (e.g. hazard morbidity, patient flow, hospital capacity) require managers to consider a holistic assessment of their region's capabilities. This provides a means for emergency managers to identify broad areas of potential vulnerabilities, such as if their region lacks pediatric intensive care beds or contains a pediatric population with an uneven distribution (e.g. large percentage of 0–2-year-olds). Dividing the pediatric population into separate age ranges prompts managers to appreciate how specific hazards affect pediatric physiology differently, depending on age. It also provides a more holistic assessment of a region's pediatric capabilities, as older children can likely be cared for in adult hospital beds during a surge event.

Figure 4: Regional Demographics and Capabilities Within the Impact Score Key

Regional Pediatric Demographics and Capabilities

*** Regional Pediatric Population**

Age	0-2 yo	3-5 yo	6-10 yo	11-13 yo	14-17 yo	All ages
Total						

Number of Pediatric Emergency Department encounters/yr

Annually	Monthly	Weekly	Daily	15% Surge	20% Surge	30% Surge	40% Surge

Regional Pediatric Beds

Pediatric Acute Care Beds (from PICU/NICU)	Pediatric Intensive Care Unit (PICU) Beds	Neonatal Intensive Care Unit (NICU) Beds	Adult ICU Beds (for children 14 and older)	Flexible Pediatric Surge Beds

To help illustrate how an emergency manager might use the *impact score key* in our pediatric HVA template, we have included two examples of hazards broken down into impact / severity categories. Appendix B. (Impact/Severity Examples Using the Impact Score Key) presents impact examples for a winter storm/blizzard as well as a chemical attack/exposure, which were created using the detailed classifications within the impact score key. Each category is assigned a score based on the components within the *impact score key*, with an reasoning provided for why that score was chosen.

For a region or hospital to understand its actual vulnerability to a given hazard, it needs to know both the impact the hazard will have on children as well as the likelihood of the hazard realistically occurring. Building off of decades of risk management theory (where in the simplest form, $\text{risk} = \text{impact} \times \text{probability}$)²⁵ and mirroring several other HVA templates, managers can assign a *likelihood score* to each hazard from 0 (implausible; no documented historical events) to 4 (high likelihood of occurring; 1-2 events every 5-10 years). A weighted calculation then incorporates a hazard's impact and likelihood to provide a vulnerability score.

The final step in the Workgroup's pediatric HVA template incorporates existing hazard preparedness efforts in order to produce an overall *risk score*: a final determination of the risk/exposure to the hazard based on hazard impact, likelihood of occurrence, and preparedness.

Hazard preparedness mirrors the broad *hazard impact/severity* categories and is separated into *human impact*, *healthcare system impact*, and *community safety infrastructure*. It asks emergency managers to assign a score—where 1 indicates low preparedness and 3 indicates high preparedness—in each section for a given hazard.

To assist with these score designations, the Workgroup included a *preparedness scoring key* that provides each preparedness section and score with descriptions and examples. Similar to the *hazard scoring key*, the *preparedness scoring key* is meant to serve as a guideline to emergency managers who are ultimately able to assign scores based on their individual determinations. In Figure 5, below, the preparedness scoring provides examples / descriptions of low, medium, and high levels of preparedness. The preparedness categories (*human impact preparedness*, *healthcare system preparedness*, and *community safety infrastructure preparedness*) align with the hazard impact/severity categories.

In using the *preparedness scores* to produce a final *hazard risk score*, the Workgroup HVA template considers both the numerical degree of hazard impact as well as in which section a manager assigns a *preparedness score*. Preparedness in any one section (e.g. *human impact preparedness*) only mitigates the impact in the corresponding hazard impact section (e.g. *human impact*). For example, if a hazard is predicted to have a significant *healthcare systems impact* (by affecting hospitals, public health, and emergency medical services) on a region, and the emergency manager indicates that the region has high *human impact preparedness* yet low *healthcare system preparedness*, the overall risk for that hazard will be much higher than if the region has low *human impact preparedness* and high *healthcare system preparedness*.

Figure 5: Preparedness Scoring Key

Preparedness Scoring Key				
		Preparedness is Low (1)	Preparedness is Medium (2)	Preparedness is High (3)
PREPAREDNESS FOR IDENTIFIED HAZARD	Human Impact Preparedness	Staffing, beds, and resources ill-equipped to handle unique hazard-specific injuries and/or age distributions affected by the hazard.	Staffing, beds, and resources can handle some, but not all, of unique hazard-specific injuries. Can treat most of the age distributions affected by the hazard.	Staffing, beds, and resources in place that allows for the treatment of all ages of affected children with various types of hazard-related injuries.
		Coordination among fatality agencies, poison control, and biohazard units has not yet been established	Coordination among fatality agencies, poison control, and biohazard units is not well-established.	Coordination among fatality agencies, poison control, and biohazard units is strong.
		No clear plans or regional coordination among pediatric and adult hospitals to accommodate older children.	Preliminary plans and/or regional coordination among pediatric and adult hospitals to accommodate older children exists, however, it is unclear if it will be successful.	Regional coordination among pediatric and adult hospitals to accommodate older children is well-established and has been stress-tested.
		Current staffing and resources ill-prepared to address long term impacts of hazard, including mental health and/or rehabilitation.	Current staffing and resources somewhat prepared to address long-term impacts of hazard, including mental health and/or rehabilitation.	Staffing and resources in place to address long-term impacts of hazard, including mental health and/or rehabilitation.
	Healthcare Systems Impact Preparedness	Hospital and/or regional plans do not exist to address the physiologic impact of hazard across multiple age distributions. No hazard-specific drills or routine trainings have occurred.	Hospital and/or regional plans exist to address the physiologic impact of hazard, yet minimal to no hazard-specific drills or routine trainings have occurred.	Hospital and/or regional plans exist to address the physiologic impact of hazard across multiple age distributions. Periodic hazard drills have been conducted and routine training occurs.
		Hospital and/or region is poorly equipped to handle surge of patients due to hazard; EDs will be overwhelmed and hospital beds filled. Limited to no regional and statewide coordination to direct overflow patients and assist with treatments.	Hospital and/or region is somewhat equipped to handle surge of patients due to hazard. EDs can handle most of patient surge, with some patients unable to be treated due to hospital bed capacity. Moderate, yet unproven, regional and statewide coordination exists to direct overflow patients and assist with treatments.	Due to hospital and regional ED/bed surge capacity, as well as regional and statewide coordination, able to successfully treat all children impacted by the hazard.
		Hospital and/or region has limited amounts of equipment to treat uniquely hazard-impacted children of all ages.	Hospital and/or region has most of the equipment needed to treat uniquely hazard-impacted children of all ages.	Hospital and/or region has all necessary equipment to treat uniquely hazard-impacted children of all ages, including PPE, CBRNE prophylaxis, etc.
	Community Safety Infrastructure Preparedness	Limited or no plans exist to transport patients between regional hospitals and restore hazard-impacted community health functions. Limited or no drills for these functions have occurred.	Plans exist, yet have not been fully stress-tested, to transport patients between regional hospitals and restore hazard-impacted community health functions. While some drills for these functions have occurred, there is no continued education.	Comprehensive plans exist and drills have been conducted involving the transportation of large amounts of patients between hospitals and the successful restoration of community health functions. Continued hazard education occurs.
		EMS is overwhelmed by the number of children impacted and the hazard-specific injuries; EMS cannot transport and treat all children. No pediatric-specific training for local/regional EMS and no regional/statewide EMS coordination.	EMS has the resources and coordination to transport and treat most, but not all, of the children impacted and the hazard-specific injuries. Regional and statewide EMS coordination exists but is unproven. Some pediatric-specific training for local/regional EMS exists, without regular drills.	EMS is able to treat and transport all affected children, both through their own resources as well as through regional and statewide coordination. Pediatric-specific training for EMS is robust with regular drills and mass-casualty incident protocols.
		Limited or no mitigation and preparedness efforts are in place to blunt the loss of operational capacity and impact on organizational performance due to hazard.	Some mitigation and preparedness efforts are in place to blunt the loss of operational capacity and impact on organizational performance due to hazard.	Proven mitigation and preparedness efforts are in place to significantly blunt the loss of operational capacity and impact on organizational performance due to hazard.
		Hospital and/or region has limited reunification procedures. Limited to no plans to provide temporary shelter for displaced children. State and nationwide coordination for large-scale hazard displacement has not yet been established.	Hospital and regional reunification procedures are in place to reunite children with their families, though are not well-tested. Able to provide shelter for some (but not all) displaced children. State and nationwide plans for large-scale hazard displacement exist but are not well-established.	Hospital and regional reunification procedures are in place to reunite large amounts of children with their families, as well as potentially provide shelter for displaced children. State and nationwide coordination for large-scale hazard displacement is well-established.
		School and childcare closures have the potential to greatly impact staffing, with existing procedures unable to overcome shortage. Hospital and/or regional alternative childcare options do not exist.	Staffing impacted due to school and childcare closures, yet the effects are overall blunted due to flexible staffing procedures, enough staff, and/or alternative childcare options.	Staffing uninterrupted due to school and childcare closures as a result of flexible staffing procedures, enough staff, and/or alternative childcare options.
		Limited to no plans are in place for regional, state, and nationwide coordination that would be able to provide food and shelter, as well as address lingering environmental/CBRNE effects of a hazard.	Plans are in place, but are not stress-tested, for regional, state, and nationwide coordination that would be able to provide food and shelter, as well as address lingering environmental/CBRNE effects of a hazard.	Regional, state, and nationwide coordination exists and is proven among private and public agencies in order to provide food and shelter, as well as address lingering environmental/CBRNE effects of a hazard.
		No establishment of connections with private and/or public outside organizations.	Connections with private and/or public outside organizations have been established.	Connections with private and/or public outside organizations have been established and the hospital/region continuously uses these organizations for new insights.
		Hospital and/or region has not recognized or populations and does not equitably address issues of race, gender, education, and socioeconomic status in the setting of hazard outcomes.	Hospital and/or region has recognized the adverse effects the hazard has on disparate populations and considered issues of race, gender, education, and socioeconomic status. However, proven plans are not yet in place to address equity and barriers to treatment.	Hospital and/or region has considered and has plans to mitigate against the adverse effects the hazard has on disparate populations. Plans include providing food, shelter, and healthcare access to communities experiencing low socioeconomic conditions and other barriers to treatment. Equity in terms of race, gender, education, and other factors are considered.

Recommendations and Next Steps

- Submit the pediatric HVA template to a peer-reviewed journal.
- Recruit hospital and/or regional emergency managers to determine the usefulness and applicability of the pediatric HVA template.
- Update the pediatric HVA template based on how managers utilize the tool alongside their existing preparedness systems.
- Consider standardizing the impact and severity measures for various geographic regions around the United States.

Conclusion/Recommendation

Although children comprise a large proportion of the population and are one of the most vulnerable sub-groups, they are often overlooked within the field of disaster management. We surveyed regional coalitions, drafted helpful infographics, and created a novel HVA template in order to provide emergency managers with insights into how hazards impact their pediatric populations. Further work is needed to determine the overall effectiveness and usefulness of the pediatric HVA template.

- Create a standardized model for a pediatric annex within the Michigan and Ohio regions.
- Formalize an annual review process of pediatric annexes to be conducted by pediatric disaster experts.
- Maintain on-going relationships between EGL members and RDCs to promote pediatric preparedness efforts.
- Broaden current HVA templates to include pediatric-specific implications. ‘Human Impact’ as described within the Kaiser Permanente framework could be expanded to include relevant impact by age.
- Create pediatric-specific HVAs that highlights implication of all hazards on children.
- Hospital accreditation agencies should incorporate pediatric-specific hazard assessments during hospital surveys.
- Create a publicly available database that provides pediatric-specific implications for all hazards. This would include but not limited to data on: hospitalization, injury patterns, morbidity, and mortality.
- Highlight this pediatric-specific data within HVA templates for hospitals and regional planners.
- Expand the infographics to provide state-based data across the US.
- Recruit hospital and regional emergency management leaders to assess how best to incorporate these documents into their planning.

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Appendices

- **Appendix A. Pediatric HVA Template**
- **Appendix B. Impact/Severity Examples Using the Impact Score Key**
- **Appendix C. Workgroup Members & Sites**

Appendix A. Pediatric HVA Template

Provided as a separate PDF document

Appendix B. Impact/Severity Examples Using the Impact Score Key

Provided as a separate PDF document

Attachment C. Workgroup Members & Sites

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