Received: 14 July 2023 | Revised: 8 November 2023 | Accepted: 9 November 2023

DOI: 10.1002/emp2.13073

JACEP OPEN
JOURNAL OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS OPEN
A GLOBAL JOURNAL OF EMERGENCY MEDICINE
Open Access
WILEY

SPECIAL CONTRIBUTION

Pediatrics

Review of pediatric emergency care and the COVID-19 pandemic

Ashley A. Foster MD[1] | Theresa A. Walls MD, MPH[2] | Kiyetta H. Alade MD, MEd, RDMS[3] | Kathleen Brown MD[4] | Marianne Gausche-Hill MD[5,6,7,8] | Sophia D. Lin MD[9] | Emily A. Rose MD[10] | Timothy Ruttan MD[11] | Sam Shahid MBBS, MPH[12] | Annalise Sorrentino MD[13] | Michael J Stoner MD[14] | Muhammad Waseem MD, MS[15] | Mohsen Saidinejad MD, MBA[5,6,8] | On behalf of the ACEP Pediatric Emergency Medicine Committee

[1]Department of Emergency Medicine, University of California, San Francisco, San Francisco, California, USA

[2]Division of Emergency Medicine, Department of Pediatrics, The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA

[3]Division of Emergency Medicine, Department of Pediatrics, Texas Children's Hospital, Houston, Texas, USA

[4]Division of Emergency Medicine, Department of Pediatrics, Children's National Hospital, Washington, DC, USA

[5]Departments of Emergency Medicine and Pediatrics, David Geffen School of Medicine at University of California, Los Angeles, California, USA

[6]Department of Emergency Medicine, Harbor-University of California Los Angeles Medical Center, Los Angeles, California, USA

[7]Department of Pediatrics, Harbor-University of California Los Angeles Medical Center, Los Angeles, USA

[8]The Lundquist Institute for Biomedical Innovation at Harbor University of California, Los Angeles, California, USA

[9]Departments of Emergency Medicine and Pediatrics, Weill Cornell Medical College, New York, New York, USA

[10]Department of Emergency Medicine, Los Angeles County + University of Southern California Medical Center, Los Angeles, California, USA

[11]Department of Pediatrics, Dell Medical School, The University of Texas at Austin, US Acute Care Solutions, Canton, Ohio, USA

[12]Department of Clinical Affairs, American College of Emergency Physicians, Irving, Texas, USA

[13]Department of Pediatrics, Division of Emergency Medicine, University of Alabama at Birmingham, Birmingham, Alabama, USA

[14]Division of Emergency Medicine, Department of Pediatrics, Nationwide Children's Hospital, Columbus, Ohio, USA

[15]Division of Emergency Medicine, Lincoln Medical Center, Bronx, New York, USA

Correspondence
Ashley Foster, MD, Department of Emergency Medicine, University of California San Francisco, 550 16th Street, Box 0649, San Francisco, CA 94143.
Email: Ashley.Foster@ucsf.edu

Funding and support: By *JACEP Open* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines

Abstract

The coronavirus disease 2019 (COVID-19) pandemic posed new challenges in health care delivery for patients of all ages. These included inadequate personal protective equipment, workforce shortages, and unknowns related to a novel virus. Children have been uniquely impacted by COVID-19, both from the system of care and socially. In the initial surges of COVID-19, a decrease in pediatric emergency department (ED) volume and a concomitant increase in critically ill adult patients resulted in re-deployment of pediatric workforce to care for adult patients. Later in the pandemic, a surge in the number of critically ill children was attributed to multisystem inflammatory

Supervising Editor: Matthew Hansen, MD, MCR.

(see www.icmje.org). The authors have stated that no such relationships exist.

syndrome in children. This was an unexpected complication of COVID-19 and further challenged the health care system. This article reviews the impact of COVID-19 on the entire pediatric emergency care continuum, factors affecting ED care of children with COVID-19 infection, including availability of vaccines and therapeutics approved for children, and pediatric emergency medicine workforce innovations and/or strategies. Furthermore, it provides guidance to emergency preparedness for optimal delivery of care in future health-related crises.

KEYWORDS
COVID-19, pandemic emergency preparedness, pediatric emergency medicine, pediatrics

1 | INTRODUCTION

Infectious disease pandemics have continued to emerge throughout history, with human pathogens often transmitted from non-human reservoirs.[1] Pandemics such as the coronavirus disease 2019 (COVID-19) have had a devastating global toll on human lives. The overall threat from infectious disease outbreaks is greater than ever due to the ease of air travel, urbanization, and increasing population size. Each new pandemic creates unique challenges and educational opportunities for preparedness and response.

Since SARS CoV-2 was first recognized as the causative agent of COVID-19, most research has focused on disease impact and resource use for adult patients. This article reviews the impact of the COVID-19 pandemic on the pediatric emergency care continuum, encompassing prehospital transport and interfacility transfer, emergency department (ED) operations, clinical considerations, diagnostic testing and therapeutics, and workforce considerations with an aim to provide lessons from the pandemic that can help prepare emergency medical services (EMS) and ED systems to care for children in future health-related crises.

2 | EMS AND INTERFACILITY TRANSPORT CONSIDERATIONS

At the onset of the COVID-19 pandemic, very little was known about its epidemiology, infectious potential, and illness severity. However, it later became clear that adult patients with COVID-19 had higher illness burden than children, causing an increase in pre-hospital adult transport along with a decrease in pediatric transport. Meanwhile, COVID-19–specific infection control protocols and guidelines had not yet been established, and critical shortage of personal protective equipment (PPE) and challenges with prioritizing distribution of PPE stockpiles put EMS clinicians at a safety risk.[2] Although certain EMS dispatch screening protocols[3] were used early in the pandemic to identify patients at high risk for COVID-19, these were later discontinued because any patient transported may be infected.[4]

Decrease in pediatric transports in the early phase of the COVID-19 pandemic was likely secondary to school closures, stay-at-home orders, and social distancing, which decreased infectious disease transmission risk.[5] Children who were transported by EMS were more critically ill, some of whom died either before EMS arrival or during transport.[6] Additionally, pediatric trauma centers experienced an increase in transfers of ill and injured children from other acute care settings.[7] One plausible explanation for the increased transfers is decreased capacity of general EDs to care for pediatric patients due to significantly increased adult patient volumes.[7] Routing pediatric patients to more highly specialized regional pediatric medical centers versus the closest ED increased transport duration and took paramedic units out of service for longer periods of time.[7]

COVID-19 also impacted the assignment of EMS professionals to differing tasks. Paramedics, for example, were redistributed to public testing sites to perform specimen collection and to administer vaccinations to adults and later, children.[8] In addition to this, establishment of standing transfer protocols and acceleration of telehealth programs helped improve local and regional communication between hospitals and EDs.

3 | ED AND HEALTHCARE SYSTEM OPERATIONS

3.1 | ED physical space and equipment

The COVID-19 pandemic caused EDs to face space redesign needs in order to optimize infection control. Along with general EDs, pediatric emergency departments (PEDs) made changes to the ED layout, such as installation of plastic barriers to care areas without rooms or doors, expansion of ED care areas to the triage area, outdoor tents, or the waiting room, and separating infectious and non-infectious children into different care areas to promote safety of all patients in the ED.[9–11] In addition to these changes to the environment, many previously designated PED and pediatric units were converted to adult care areas. PEDs also incorporated telehealth for virtual urgent care, post-ED visit follow-up, and mental health consultations.[12,13]

From an equipment standpoint, to preserve limited available PPE[14] and to minimize infectious exposure by ED staff, some PEDs reduced the number of staff directly interacting with patients under investigation for COVID-19 to one non-trainee provider.[13,15] In academic

centers, this effort to preserve PPE impacted the training of medical students and residents.[16] Additionally, several PEDs began using a phone or tablet in order to obtain history and provide updates to patients and their families without physically being inside the examination room.[13] Protocols for airway management and resuscitations were amended to minimize ED staff exposure to aerosolizing procedures.[15,17–20] Staff adherence to PPE during resuscitations requiring aerosol-generating procedures in the start of the pandemic was inconsistent,[21] highlighting need for quality initiatives tailored to improving PPE adherence and minimizing infectious exposure of PED staff.

3.2 | ED staffing and scope of practice

Early in the pandemic, it became rapidly clear that COVID-19 was readily transmissible and was highly virulent, with a high rate of significant illness in adults.[22] The number of critically ill patients in many hospitals exceeded the number of critical care and ED beds, prompting the need for other inpatient areas to serve as intensive care units. At the same time, PED volumes declined sharply, leading to reduced pediatric emergency physician hours in many PEDs.[23] Additionally, at some institutions, pediatric-trained staff (physicians, nurses, respiratory therapists, etc) were given temporary change in delineation of privileges to expand scope of practice and were redeployed to care for adults as part of the disaster response, or were transitioned to providing telehealth services.[15,16,24] Non-emergency medicine trainees (medical students, residents, and fellows) who were originally assigned to work within the PED experienced restrictions on patient care provision and procedures, were reassigned to care for adults, or away from the ED altogether.[15] These measures initially helped to maximize hospital staffing in locations of increased infection risk and minimized exposure within the pediatric ED, with a tradeoff of impact on trainee learning about emergency pediatrics and overall decreased trainee exposure to more typical pediatric illness and injury.[16] Additionally, emergency medicine trainees may have been reassigned and/or had decreased exposure to pediatric illness and injury due to change in pediatric emergency volumes. The impact of this decrease in exposure to pediatric emergency medicine on trainee education and preparedness to care for children after residency is unknown.[25,26]

3.3 | Unique ED challenges

A significant proportion of pediatric patients (children under age 2 years, children with special needs or with complex care needs) could not tolerate face masks, thus putting this population at increased risk for disease transmission.[27,28] In addition, screening for COVID-19 symptoms was a challenge as mild or atypical COVID-19 symptoms were commonly seen in children, making infection control difficult.[12,13] Hospital visitor policies also needed to be changed to minimize infectious exposure to patients and staff with some hospitals allowing only one caregiver to accompany a pediatric patient.[15,29] This strategy had a profoundly negative consequence for ill and injured children, both for obtaining valuable medical history and for emotional support and comfort to the child.[30,31]

Although infections with other viruses such as respiratory syncytial virus (RSV) and influenza decreased significantly in the beginning of the COVID-19 pandemic, a rise was noted later in the summer months of 2021 with increased ED visits and hospitalizations. The RSV surge was likely in the setting of relaxed physical distancing measures,[32,33] and decreased population immunity after a period of decreased RSV exposure.[34,35] Children of all ages were impacted, but a disproportionate increase of infection was seen in children under 5 years of age.[36] Infants, those with history of prematurity, and children with chronic medical conditions were at increased risk of hospitalization.[37] Viral surges complicated existing staffing challenges and identified the need for increased flexibility of health care resources in the face of rapid influxes of children.

3.4 | Impact on pediatric outpatient care

The COVID-19 pandemic also impacted routine care for children. Well-child visits in the first 2 years of life are critical for a child and involve tracking a child's health and development, counseling on preventive care, and engaging caregivers in the health care of their child. Unfortunately, during the first years of COVID-19,[38,39] there was a significant reduction in the in-person well-child visits and pediatric vaccinations.[40,41] The effect of these missed in-person appointments for children may be far reaching, including delays in diagnoses that have significant impact on a child's life, as well as susceptibility to disease that may lead to downstream infections and future morbidity and mortality.[42] Additionally, since the start of the pandemic, routine immunization rates in the United States and globally have been down trending.[43,44] The full consequences for missed in-person, well-child visits and decreased routine vaccination rates and the potential future impact on pediatric emergency care are yet unknown.

4 | CLINICAL CONSIDERATIONS

Although early in the COVID-19 pandemic, the majority of children had mild illness and better outcomes than adults, some children were at risk for potentially severe disease.[45,46] As the pandemic progressed, specific COVID-19 variants (eg, Delta) contributed to an increase in hospitalizations for children.[45] Additionally, others developed multisystem inflammatory syndrome in children (MIS-C) within 2–6 weeks of their acute COVID-19 infection.[47,48] Children with MIS-C presented with symptoms of prolonged fever and signs of inflammation throughout the body, with a subgroup showing clinical similarities to Kawasaki disease.[49] Although all ages of children were affected by COVID-19 infection, MIS-C most frequently impacted children 6–12 years old and required multi-specialty supportive and immunomodulatory care.[50]

Although overall ED visits by children declined during early COVID-19, the proportion of ED visits for mental or behavioral health

symptoms increased during the same time period and have continued to increase as the pandemic has continued.[51–53] Anxiety about the pandemic, social isolation due to remote learning mandates, local quarantine regulations, travel restrictions, pediatric general and specialty clinic closures, and limited availability of community-based services against the backdrop of pre-pandemic rising ED utilization for mental health conditions and decreasing psychiatric inpatient beds, likely all contributed to this rise.[53,54] For children in the ED who need inpatient psychiatric care, the strained health care systems have led to substantial lengths of time awaiting disposition, called ED boarding. In 2021, many hospitals reported average wait time for an admission or transfer to a psychiatric bed of 48 hours.[55] ED boarding has profound impact on children, their families, ED staff, and the ED's ability to care for other patients.[56,57] Additionally, during the initial months of the pandemic, visits related to child abuse or maltreatment sharply decreased.[52,58] This was possibly due to less involvement of mandated reporters including schools and primary care offices in the wake of school closures and the transition to virtual learning.[59–64] A systematic review reveals that although there was a decline in allegations of child maltreatment, there was a reported rise in severity of maltreatment presentations with lockdown measures.[65] The consequences of lockdown measures, school closures, decreased reporting of child abuse, and a rise in pediatric ED utilization for mental health conditions are unclear on a population level and the full impact is yet to be determined.

5 | DIAGNOSTIC TESTING, VACCINES, AND THERAPEUTICS

5.1 | Testing

The COVID-19 pandemic has demonstrated that reliable, accurate, timely, and accessible testing was critical to the health care response. Moreover, reliable test results can be used to guide isolation practices and policies. In the absence of accurate testing, children whowere symptomatic, had to be assumed to carry the disease and be isolated and treated according to the best public health approaches. During the early phase of COVID-19 pandemic, diagnostic testing availability was limited, and guidelines for whom to test were unclear. The rapidly fluctuating recommendations on testing made it difficult for emergency physicians to test all children who potentially warranted diagnostics.

5.2 | Vaccine development

Development of vaccines for SARS and the Middle East Respiratory Syndrome helped provide the foundation for rapid development of an effective vaccine candidate for SARS-CoV-2. The United States (US) government led an operation that bridged public and private sector sharing of knowledge, expertise, and infrastructure, called Operation Warp Speed.[66] In less than 10 weeks from the release of its gene sequence, Moderna, Inc (Cambridge, MA) entered clinical trials for its mRNA-based SARS-CoV-2 vaccine, with Pfizer, Inc (New York, NY) only a few weeks behind. An integral component to expedited vaccination deployment was US government investment in commercial-scale manufacturing of candidate vaccinations early in the process, before data availability of harmonized phase 3 trials.[67]

Vaccine development in children and adolescents was not part of the initial development plan potentially because the original COVID-19 variant caused mild symptoms in most children. This perspective changed over time, likely due to increased virulence of new variants, a concern for the impact of MIS-C and "Long COVID" syndrome (persistent COVID-19 symptoms for a prolonged time after initial recovery from the disease[68]), and potential harms to children not related to health, such as school absenteeism.[69] In May of 2021, the Food and Drug Administration granted emergency use authorization (EUA) for Pfizer-BioNTech COVID-19 vaccine use in adolescents 12–15 years of age. Although there are now 4 vaccines approved in the United States for primary series and boosters in children as young as 6 months, the approval timeline was substantially longer than that of adults.[70] More recently, a new bivalent COVID-19 vaccine was developed, which is effective in preventing hospitalizations for children with either the original viral strain or the Omicron subvariants.[71,72]

5.3 | Therapeutics

To date, no published results from pediatric clinical trials evaluating the treatment of COVID-19 exist.[73] The available literature on pharmacologic therapies for children who have acute COVID-19 infection is limited to descriptive and observational studies. Therefore, guidance around use of therapies to treat children with COVID-19 is based primarily on extrapolating recommendations for adults through expert panel recommendations.[74–76] Data from adult studies is most applicable to older children and adolescents with lower respiratory tract infection, and caution is recommended when extrapolating adult data to children with COVID-19 infection who present with differing respiratory symptoms (eg, croup, asthma).

For non-hospitalized children with COVID-19 infection, expert panel recommendations include supportive care management.[77] Ritonavir-boosted nirmatrelvir is approved for children ≥12 years old and 40 kg who are deemed to be high risk of developing severe COVID-19 infection. For hospitalized children, recommendations are based on the risk of developing severe COVID-19 infection and supplemental oxygen requirements. Intravenous remdesivir is approved for children >28 days and 3 kg. Although a phase 2/3 open-label study on remdesivir was performed to evaluate the safety and pharmacokinetics in hospitalized children with COVID-19,[78] the efficacy of the drug in children has yet to be confirmed via clinical trial. Dexamethasone is also recommended for hospitalized children with COVID-19 who require oxygen through a high flow device, non-invasive ventilation, have escalating oxygen therapy needs, or require ventilation or extracorporeal membrane oxygenation.[73] For hospitalized children with concern for MIS-C, there are no existing clinical trials that compare treatments for MIS-C and all available data is based on descriptive studies. Expert panel recommendations include

TABLE 1 Recommendations for future pandemic/disaster pediatric ED preparedness for children

Issue/area	Successful measures	Areas for improvement
Emergency medical services/transfer	-Flexibility of prehospital staff to work in different settings based on patient need -Development of protocols aimed to keep transport teams and patients safe	-Pre-existing transfer agreements for children among hospitals when surges occur -Ensuring appropriate personal protective equipment is available for prehospital staff -Early national warning system to alert institutions about potential surges
Pediatric ED operations	-Adaptability of physical space for infection control -Expansion of telehealth -Limiting direct patient care to essential emergency staff	-ED and institutional maintenance of active disaster readiness program with consideration of care for children and families in disasters -Development of patient flow plans to facilitate movement of patients experiencing boarding from the ED -Pre-existing plan to care for adult patients -Investment in sustainable pediatric telehealth programs
Clinical considerations	-Recognition of differing clinical presentations of illness among children compared to adults	-Centralizing communication to prioritize information shared for creation of training resources, protocols, guideline development
Diagnostic testing/vaccines/therapeutics	-Development of vaccines specific to infants and children	-Early consideration of children in vaccine development -Inclusion of children in therapeutic studies
Workforce effects	-Shift of trainees to populations in most need during disasters -Pediatric emergency medicine physicians cross-training to care for adults -ED staff flexibility to provide care in other areas of the hospital/prehospital environment, when needed	-Reduce barriers of licensing of physicians in disaster/pandemic -Develop strategies keep trainees engaged and ensuring appropriate exposure and training in pediatric emergency medicine -Institutional investment in health and well-being of their employees

Abbreviation: ED, emergency department.

intravenous immunoglobulin plus concomitant glucocorticoid therapy and antithrombotic treatment.[79]

6 | HEALTHCARE SYSTEM AND WORKFORCE EFFECTS

6.1 | System of care

Over the years, pandemics have revealed the challenges of preparedness in the continuum of emergency care. In 2003, The SARS-CoV-1 pandemic exposed system inefficiencies,[80] which became more apparent as the pandemic continued. For the COVID-19 pandemic, initial attempts at containment resulted in the shutdown of more than one third of the world's economies and a global standstill ensued. Despite these efforts, the transmission rate, infectivity, severe illness, and mortality associated with SARS CoV-2 have been among the highest of any pandemic.[81]

6.2 | Financial impact

COVID-19 further highlighted the challenges inherent in the current system of medical care in the United States. Rapid loss of revenue from cancelled high-value elective procedures and other medical care early in the pandemic to prepare for anticipated surges had a significant financial impact on the system. Additionally, although some areas such as adult acute care areas required additional staffing, other areas such as pediatric wards, intensive care units, urgent cares, and primary care clinics were asked to cut back on staffing or to furlough staff.[82] The very same areas later became the most highly needed areas for staffing, with surges in pediatric respiratory illnesses. Understanding a balance between current and future needs to patients of all ages as well as the financial impact to health care systems will be needed in future pandemic planning.

6.3 | Health care workforce exhaustion and burnout

The COVID-19 pandemic has had a substantial impact on the wellness of pre-hospital and hospital-based health care professionals, with many reporting high levels of emotional exhaustion and burnout.[83–86] Despite initial lower ED volumes on shifts, pediatric emergency physicians experienced heightened stress and anxiety due to multiple contributing factors including availability of PPE, risk of infection to themselves and their families, guilt about colleagues in the adult ED (perceived to be experiencing more stress in the ED as a result of the

pandemic), and concern about job stability or salary decreases due to unknown pediatric volumes.[15]

7 | LESSONS LEARNED

To best prepare for the future, the medical community can look to challenges that have been faced during the COVID-19 pandemic pertaining to pediatric emergency care. Prior literature outlines emergency medicine recommendations to prepare for the next pandemic, such as centralize information, create early warning systems, ensure availability of appropriate equipment, streamline physician licensing, allocate appropriate financial support, ensure disaster plans include policies and recommendations for patients of all ages, facilitate bidirectional communication between institutional leadership and staff, institute robust infection control measures, establish relationships between local authorities and community resources, and invest in the health and well-being of medical staff.[87] Pediatric-specific recommendations can be added to ensure children are considered in pandemic planning (Table 1).

8 | CONCLUSIONS

Children have been impacted differently than adults by the COVID-19 pandemic. Although most children have had mild disease, some have experienced more severe COVID-19 symptoms and MIS-C. The EMS system has experienced shifts in pediatric staffing needs with decreases in pediatric transports and ED visits early in the pandemic leading to changes to pediatric emergency physician and nurse staffing redistribution. However, as the pandemic has evolved, surges in children seeking medical care have led to staffing challenges, strain on health care resources, and emotional exhaustion and burnout across a spectrum of health care professionals. Additionally, there are unexpected effects to pediatric care including decreased in-person well-child visits and scheduled vaccinations, an increase in proportion of ED mental health visits, and decrease in visits related to suspected child mistreatment. The full impact of the COVID-19 pandemic on the emergency care of children is yet to be fully elucidated and careful reflection on how this pandemic affected children will help with preparation for future global events.

AUTHOR CONTRIBUTIONS

Each author listed in this manuscript has provided sufficient input in terms of literature review, content writing, editing, and meeting attendance to be eligible to be listed as and author in this article.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ORCID

Ashley A. Foster MD https://orcid.org/0000-0002-3059-6218

REFERENCES

1. van Doorn HR. The epidemiology of emerging infectious diseases and pandemics. *Medicine*. 2021;49(10):659-662.
2. Cash RE, Rivard MK, Camargo CA, Powell JR, Panchal AR. Emergency medical services personnel awareness and training about personal protective equipment during the COVID-19 pandemic. *Prehosp Emerg Care*. 2021;25(6):777-784.
3. Los Angeles County EMS Agency Dispatch Screening tool. 2020. On July 31 2022. https://file.lacounty.gov/SDSInter/dhs/1068165_DispatchScreeningAdvisory2020-01-29.pdf
4. Albright A, Gross K, Hunter M, O'connor L. A dispatch screening tool to identify patients at high risk for COVID-19 in the prehospital setting. *West J Emerg Med*. 2021;22(6):1253-1256.
5. Satty T, Ramgopal S, Elmer J, Mosesso VN, Martin-Gill C. EMS responses and non-transports during the COVID-19 pandemic. *Am J Emerg Med*. 2021;42:1-8.
6. Oulasvirta J, Pirneskoski J, Harve-Rytsälä H, et al. Paediatric prehospital emergencies and restrictions during the COVID-19 pandemic: a population-based study. *BMJ Paediatr Open*. 2020;4(1):e000808.
7. Flynn-O'brien KT, Collings AT, Farazi M, et al. Midwest pediatric injury transfer patterns during the COVID-19 pandemic: an interrupted time series analysis. *J Surg Res*. 2023;281:130-142.
8. Emergency Medical Services Authority. Updated Emergency Medical Service Personnel Expanded Local Scope of Practice (LOSOP) Response & Authorizations to Treat Patients Impacted by the COVID-19 Pandemic and Influenza-Comprehensive Summary. 2022. Accessed on n July 31 2022. https://emsa.ca.gov/wp-content/uploads/sites/71/2022/03/EMSA-Memo_EMS-Personnel-COVID-and-Influenza-Current-Scope-22.03.02.pdf
9. Golberstein E, Wen H, Miller BF. Coronavirus Disease 2019 (COVID-19) and mental health for children and adolescents. *JAMA Pediatr*. 2020;174(9):819-820.
10. Jain PN, Finger L, Schieffelin JS, et al. Responses of three urban U.S. children's hospitals to COVID-19: Seattle, New York and New Orleans. *Paediatr Respir Rev*. 2020;35:15-19.
11. Conrardy M, Chodakowski JD, Kippenhan M, Loftus TM, Malik S. Rapid Emergency Department Physical Space Modifications for COVID-19: Keeping Patients and Health Care Workers Safe. *Disaster Med Public Health Prep*. 2021;4:1-4. https://doi.org/10.1017/dmp.2021.248. Epub ahead of print.
12. Mehta NS, Mytton OT, Mullins EWS, et al. SARS-CoV-2 (COVID-19): what do we know about children? A systematic review. *Clin Infect Dis*. 2020;71(9):2469-2479.
13. Yasuhara J, Kuno T, Takagi H, Sumitomo N. Clinical characteristics of COVID-19 in children: a systematic review. *Pediatr Pulmonol*. 2020;55(10):2565-2575.
14. Tabah A, Ramanan M, Laupland KB, et al. Personal protective equipment and intensive care unit healthcare worker safety in the COVID-19 era (PPE-SAFE): an international survey. *J Crit Care*. 2020;59:70-75.
15. Walker DM, Tolentino VR. COVID-19: the effects on the practice of pediatric emergency medicine. *Pediatr Emerg Med Pract*. 2020;17(6-3):1-15.
16. Bailey J, Nadeau N, Jordan K, Yerxa H, Lam S. The effect of COVID-19 on United States pediatric emergency departments and its impact on trainees. *West J Emerg Med*. 2022;23(6):893-896.
17. Bahl P, Doolan C, De Silva C, Chughtai AA, Bourouiba L. Airborne or droplet precautions for health workers treating Coronavirus Disease 2019? *J Infect Dis*. 2022;225(9):1561-1568.
18. Guo ZD, Wang ZYi, Zhang SF, et al. Aerosol and surface distribution of Severe Acute Respiratory Syndrome Coronavirus 2 in hospital wards, Wuhan, China, 2020. *Emerg Infect Dis*. 2020;26(7):1583-1591.
19. Leeb RT, Price S, Sliwa S, et al. COVID-19 trends among school-aged children—United States, March 1-September 19, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(39):1410-1415.

20. Van Doremalen N, Bushmaker T, Morris DH, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N Engl J Med*. 2020;382(16):1564-1567.
21. Alberto EC, Mccarthy KH, Hamilton CA, et al. Personal protective equipment adherence of pediatric resuscitation team members during the COVID-19 pandemic. *Ann Emerg Med*. 2021;78(5):619-627.
22. CDC COVID-19 Response Team. Coronavirus Disease 2019 in Children—United States, February 12-April 2, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(14):422-426.
23. Cheng CW, Huang YB, Chao HY, et al. Impact of the COVID-19 pandemic on pediatric emergency medicine: a systematic review. *Medicina*. 2022;58(8):1112.
24. Penwill NY, Roessler De Angulo N, Pathak PR, et al. Changes in pediatric hospital care during the COVID-19 pandemic: a national qualitative study. *BMC Health Serv Res*. 2021;21(1):953.
25. Lo HY, Lin SC, Chaou CH, Chang YC, Ng CJ, Chen SY. What is the impact of the COVID-19 pandemic on emergency medicine residency training: an observational study. *BMC Med Educ*. 2020;20(1):348.
26. Weygandt PL, Jordan J, Caretta-Weyer H, Osborne A, Grabow Moore K. Impact of the COVID-19 pandemic on emergency medicine education: insights from faculty and residents. *AEM Educ Train*. 2021;5(3):e10603.
27. Cheng Y, Ma N, Witt C, et al. Face masks effectively limit the probability of SARS-CoV-2 transmission. *Science*. 2021;372(6549):1439-1443.
28. Wang Y, Deng Z, Shi D. How effective is a mask in preventing COVID-19 infection? *Med Devices Sens*. 2021;4(1):e10163.
29. Fraymovich S, Levine DA, Platt SL. A blueprint for pediatric emergency resource reallocation during the COVID-19 pandemic: an NYC hospital experience. *Pediatr Emerg Care*. 2020;36(9):452-454.
30. Meert KL, Clark J, Eggly S. Family-centered care in the pediatric intensive care unit. *Pediatr Clin North Am*. 2013;60(3):761-772.
31. Virani AK, Puls HT, Mitsos R, Longstaff H, Goldman RD, Lantos JD. Benefits and risks of visitor restrictions for hospitalized children during the COVID pandemic. *Pediatrics*. 2020;146(2):e2020000786.
32. Lavoie PM, Reicherz F, Solimano A, Langley JM. Potential resurgence of respiratory syncytial virus in Canada. *CMAJ*. 2021;193(29):E1140-E1141.
33. Movva N, Suh M, Reichert H, et al. Respiratory syncytial virus during the COVID-19 pandemic compared to historic levels: a retrospective cohort study of a health system. *J Infect Dis*. 2022;226(2):S175-S183.
34. Billard MN, Bont LJ. Quantifying the RSV immunity debt following COVID-19: a public health matter. *Lancet Infect Dis*. 2023;23(1):3-5.
35. Munro AP, Jones CE. Immunity debt and unseasonal childhood respiratory viruses. *Br J Hosp Med*. 2022;83(9):1-3.
36. Falsey AR, Cameron A, Branche AR, Walsh EE. Perturbations in respiratory syncytial virus activity during the SARS-CoV-2 pandemic. *J Infect Dis*. 2022;227(1):83-86.
37. Alrayes T, Wait A, Spencer P, et al. Features of an atypical RSV surge during the COVID-19 pandemic. *Clin Pediatr*. 2022:99228221124677.
38. Overview of COVID-19 vaccines. 2022. On January 23 2023. https://www.cdc.gov/vaccines/schedules/index.html
39. Turner K. Well-child visits for infants and young children. *Am Fam Physician*. 2018;98(6):347-353.
40. Kujawski SA, Yao L, Wang HE, Carias C, Chen Ya-T. Impact of the COVID-19 pandemic on pediatric and adolescent vaccinations and well child visits in the United States: a database analysis. *Vaccine*. 2022;40(5):706-713.
41. Sexton K, Susi A, Lee E, et al. Trends in well-child visits and routine vaccination among children of U.S. military members: an evaluation of the COVID-19 pandemic effects. *J Clin Med*. 2022;11(22):6842.
42. Sabapathy T, Bansal R, Bojorquez L, et al. Missed opportunities and the impact of the pandemic. *J Dev Behav Pediatr*. 2022;43(3):176-179.
43. Seither R, Calhoun K, Yusuf OB, et al. Vaccination coverage with selected vaccines and exemption rates among children in kindergarten—United States, 2021–22 school year. *MMWR Morb Mortal Wkly Rep*. 2023;72(2):26-32.
44. Yunusa A, Cabral C, Anderson E. The impact of the Covid-19 pandemic on the uptake of routine maternal and infant vaccines globally: a systematic review. *PLOS Glob Public Health*. 2022;2(10):e0000628.
45. Quintero AM, Eisner M, Sayegh R, et al. Differences in SARS-CoV-2 clinical manifestations and disease severity in children and adolescents by infecting variant. *Emerg Infect Dis*. 2022;28(11):2278-2288.
46. Wang L, Berger NA, Kaelber DC, et al. Comparison of outcomes from COVID infection in pediatric and adult patients before and after the emergence of Omicron. *medRxiv* [Preprint]. 2022 Jan 2:2021.12.30.21268495.
47. Belay ED, Abrams J, Oster ME, et al. Trends in geographic and temporal distribution of US children with multisystem inflammatory syndrome during the COVID-19 pandemic. *JAMA Pediatr*. 2021;175(8):837-845.
48. Dufort EM, Koumans EH, Chow EJ, et al. Multisystem inflammatory syndrome in children in New York state. *N Engl J Med*. 2020;383(4):347-358.
49. Whittaker E, Bamford A, Kenny J, et al. Clinical characteristics of 58 children with a pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2. *JAMA*. 2020;324(3):259-269.
50. Blatz AM, Randolph AG. Severe COVID-19 and multisystem inflammatory syndrome in children in children and adolescents. *Crit Care Clin*. 2022;38(3):571-586.
51. Shankar LG, Habich M, Rosenman M, Arzu J, Lales G, Hoffmann JA. Mental health emergency department visits by children before and during the COVID-19 pandemic. *Acad Pediatr*. 2022;22(7):1127-1132.
52. Leeb RT, Bitsko RH, Radhakrishnan L, et al. Mental health-related emergency department visits among children aged <18 years during the COVID-19 pandemic—United States, January 1-October 17, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(45):1675-1680.
53. Santillanes G, Axeen S, Lam CN, Menchine M. National trends in mental health-related emergency department visits by children and adults, 2009–2015. *Am J Emerg Med*. 2020;38(12):2536-2544.
54. Nicks BA, Manthey DM. The impact of psychiatric patient boarding in emergency departments. *Emerg Med Int*. 2012;2012:360308. Epub 2012 Jul 22. https://doi.org/10.1155/2012/360308
55. Leyenaar JK, Freyleue SD, Bordogna A, Wong C, Penwill N, Bode R. Frequency and duration of boarding for pediatric mental health conditions at acute care hospitals in the US. *JAMA*. 2021;326(22):2326-2328.
56. Ibeziako P, Kaufman K, Scheer KN, Sideridis G. Pediatric mental health presentations and boarding: first year of the COVID-19 pandemic. *Hosp Pediatr*. 2022;12(9):751-760.
57. Wolff JC, Maron M, Chou T, et al. Experiences of child and adolescent psychiatric patients boarding in the emergency department from staff perspectives: patient journey mapping. *Adm Policy Ment Health*. 2023;50(3):417-426.
58. Schreyer KE, Del Portal DA, King LJL, et al. Emergency department management of the Covid-19 pandemic. *J Emerg Med*. 2020;59(6):946-951.
59. Kuehn BM. Surge in child abuse, harm during COVID-19 pandemic reported. *JAMA*. 2020;324(7):621.
60. Rapoport E, Reisert H, Schoeman E, et al. Reporting of child maltreatment during the SARS-CoV-2 pandemic in New York City from March to May 2020. *Child Abuse Negl*. 2021;116(Pt 2):104719. https://doi.org/10.1016/j.chiabu.2020.104719
61. Rodriguez CM, Lee SJ, Ward KP, Pu DF. The perfect storm: hidden risk of child maltreatment during the Covid-19 pandemic. *Child Maltreat*. 2021;26(2):139-151.
62. Sharma S, Wong D, Schomberg J, et al. COVID-19: differences in sentinel injury and child abuse reporting during a pandemic. *Child Abuse Negl*. 2021;116(Pt 2):104990.

63. Sidpra J, Abomeli D, Hameed B, Baker J, Mankad K. Rise in the incidence of abusive head trauma during the COVID-19 pandemic. *Arch Dis Child*. 2021;106(3):e14.
64. Xue J, Chen J, Chen C, Hu R, Zhu T. The hidden pandemic of family violence during COVID-19: unsupervised learning of tweets. *J Med Internet Res*. 2020;22(11):e24361.
65. Huang N, Yang F, Liu X, Bai Y, Guo J, Riem MME. The prevalences, changes, and related factors of child maltreatment during the COVID-19 pandemic: a systematic review. *Child Abuse Negl*. 2023;135:105992.
66. Corey L, Miner MD. Accelerating clinical trial development in vaccinology: COVID-19 and beyond. *Curr Opin Immunol*. 2022;76:102206.
67. Bok K, Sitar S, Graham BS, Mascola JR. Accelerated COVID-19 vaccine development: milestones, lessons, and prospects. *Immunity*. 2021;54(8):1636-1651.
68. Raveendran AV, Jayadevan R, Sashidharan S. Long COVID: an overview. *Diabetes Metab Syndr*. 2021;15(3):869-875.
69. Rudan I, Adeloye D, Katikireddi V, et al. The COVID-19 pandemic in children and young people during 2020–2021: a complex discussion on vaccination. *J Glob Health*. 2021;11:01011.
70. U.S. Department of Health and Human Services. COVID-19 Vaccines. Accessed September 15, 2023. https://www.hhs.gov/coronavirus/covid-19-vaccines/index.html
71. Chalkias S, Harper C, Vrbicky K, et al. A bivalent omicron-containing booster vaccine against Covid-19. *N Engl J Med*. 2022;387(14):1279-1291.
72. Piechotta V, Siemens W, Thielemann I, et al. Safety and effectiveness of vaccines against COVID-19 in children aged 5–11 years: a systematic review and meta-analysis. *Lancet Child Adolesc Health*. 2023;7(6):379-391.
73. National Institutes of Health. Therapeutic management of hospitalized children with COVID-19. *Coronavirus Disease 2019 (COVID-19) Treatment Guidelines*. National Institutes of Health. Last updated July 21, 2023. https://www.covid19treatmentguidelines.nih.gov/management/clinical-management-of-children/hospitalized-children-therapeutic-management/
74. Chiotos K, Hayes M, Kimberlin DW, et al. Multicenter initial guidance on use of antivirals for children with Coronavirus Disease 2019/Severe Acute Respiratory Syndrome Coronavirus 2. *J Pediatric Infect Dis Soc*. 2020;9(6):701-715.
75. Dulek DE, Fuhlbrigge RC, Tribble AC, et al. Multidisciplinary guidance regarding the use of immunomodulatory therapies for acute Coronavirus Disease 2019 in pediatric patients. *J Pediatric Infect Dis Soc*. 2020;9(6):716-737.
76. Wolf J, Abzug MJ, Anosike BI, et al. Updated guidance on use and prioritization of monoclonal antibody therapy for treatment of COVID-19 in adolescents. *J Pediatric Infect Dis Soc*. 2022;11(5):177-185.
77. National Institute of Health.. Therapeutic management of nonhospitalized children with COVID-19. *Coronavirus Disease 2019 (COVID-19) Treatment Guidelines*. National Institutes of Health. Last updated December 28, 2022. https://www.covid19treatmentguidelines.nih.gov/management/clinical-management-of-children/nonhospitalized-children-therapeutic-management/
78. Ahmed A, Rojo P, Agwu A, et al. Remdesivir treatment for COVID-19 in hospitalized children: CARAVAN interim results. Poster presented at:Conference on Retroviruses and Opportunistic Infections; February 12-16, 2022; virtual.
79. National Institute of Health. Therapeutic management of hospitalized pediatric patients with MIS-C. *Coronavirus Disease 2019 (COVID-19) Treatment Guidelines*. National Institutes of Health; Last updated July 21, 2023. https://www.covid19treatmentguidelines.nih.gov/management/clinical-management-of-children/hospitalized-children-therapeutic-management-of-mis-c/
80. Derraik JGB, Anderson WA, Connelly EA, et al. Rapid review of SARS-CoV-1 and SARS-CoV-2 viability, susceptibility to treatment, and the disinfection and reuse of PPE, particularly filtering facepiece respirators. *Int J Environ Res Public Health*. 2020;17(17): 6117.
81. Meyerowitz-Katz G, Merone L. A systematic review and meta-analysis of published research data on COVID-19 infection fatality rates. *Int J Infect Dis*. 2020;101:138-148.
82. Wolfson BJ. *The Pandemic is Hurting Pediatric Hospitals, Too*. KFF Health News; May 19,2020.
83. Alanazi TNM, McKenna L, Buck M, et al. Reported effects of the COVID-19 pandemic on the psychological status of emergency healthcare workers: a scoping review. *Australas Emerg Care*. 2022;25(3):197-212.
84. Amro TM, Arcos González P, Montero Viñuales E, et al. Impact of COVID-19 pandemic on stress and burnout levels amongst emergency medical technicians: a cross-sectional study in Spain. *Ann Med*. 2022;54(1):3007-3016.
85. Rodriguez RM, Montoy JCC, Hoth KF, et al. Symptoms of anxiety, burnout, and PTSD and the mitigation effect of serologic testing in emergency department personnel during the COVID-19 pandemic. *Ann Emerg Med*. 2021;78(1):35-43.e2.
86. Shopen N, Schneider A, Aviv Mordechai R, et al. Emergency medicine physician burnout before and during the COVID-19 pandemic. *Isr J Health Policy Res*. 2022;11(1):30.
87. Jaquis WP, Schneider SM; Panelists from Preparing for the Next Pandemic Summits. Preparing for the next pandemic. *Ann Emerg Med*. 2021;78(2):212-219.

How to cite this article: Foster AA, Walls TA, Alade KH, et al. Review of pediatric emergency care and the COVID-19 pandemic. *JACEP Open*. 2023;4:e13073. https://doi.org/10.1002/emp2.13073