



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Characterizing pediatric emergency department visits during the COVID-19 pandemic

Jesse M. Pines^{a,b,*}, Mark S. Zocchi^c, Bernard S. Black^d, Justin N. Carlson^{a,e}, Pablo Celedon^a, Ali Moghtaderi^f, Arvind Venkat^{a,b}, For the US Acute Care Solutions Research Group

^a US Acute Care Solutions, Canton, OH, United States of America

^b Department of Emergency Medicine, Allegheny Health Network, Pittsburgh, PA, United States of America

^c The Heller School for Social Policy and Management, Brandeis University, Waltham, MA, United States of America

^d Northwestern University, Pritzker School of Law and Kellogg School of Management, Evanston, IL, United States of America

^e Department of Emergency Medicine, Allegheny Health Network, Erie, PA, United States of America

^f Milken Institute School of Public Health, George Washington University, Washington, DC, United States of America

ARTICLE INFO

Article history:

Received 9 October 2020

Received in revised form 16 November 2020

Accepted 17 November 2020

ABSTRACT

Objective: We determine how pediatric emergency department (ED) visits changed during the COVID-19 pandemic in a large sample of U.S. EDs.

Methods: Using retrospective data from January–June 2020, compared to a similar 2019 period, we calculated weekly 2020–2019 ratios of Non-COVID-19 ED visits for adults and children (age 18 years or less) by age range. Outcomes were pediatric ED visit rates before and after the onset of pandemic, by age, disposition, and diagnosis.

Results: We included data from 2,213,828 visits to 144 EDs and 4 urgent care centers in 18 U.S. states, including 7 EDs in children's hospitals. During the pandemic period, adult non-COVID-19 visits declined to 60% of 2019 volumes and then partially recovered but remained below 2019 levels through June 2020. Pediatric visits declined even more sharply, with peak declines through the week of April 15 of 74% for children age < 10 years and 67% for 14–17 year. Visits recovered by June to 72% for children age 14–17, but to only 50% of 2019 levels for children < age 10 years. Declines were seen across all ED types and locations, and across all diagnoses, with an especially sharp decline in non-COVID-19 communicable diseases. During the pandemic period, there was 22% decline in common serious pediatric conditions, including appendicitis.

Conclusion: Pediatric ED visits fell more sharply than adult ED visits during the COVID-19 pandemic, and remained depressed through June 2020, especially for younger children. Declines were also seen for serious conditions, suggesting that parents may have avoided necessary care for their children.

© 2020 Elsevier Inc. All rights reserved.

1. Introduction

On March 13, 2020, the federal government declared a national emergency in response to escalating cases of coronavirus disease (COVID-19) which have since become a global pandemic. Early U.S. pandemic responses included closing schools and many businesses and restricting large gatherings, as well as promoting handwashing, social distancing and later, mask wearing to reduce viral spread. In mid-March, visits to U.S. emergency departments (ED) declined sharply, nadiring nationally at approximately 58% of 2019 volume in the second week of April [1]. Potential contributors to this steep fall included lower incidence of communicable disease and fewer injuries due to social

distancing as well as reduced travel and activity, patients avoiding EDs due to fear of themselves contracting COVID-19 in the ED, and moves to telehealth as a substitute for face-to-face healthcare [2]. Since April, there has been a partial recovery in non-COVID ED visits but visit levels have remained substantially below 2019 levels.

ED visits for children in the U.S. and other countries also declined dramatically during the COVID-19 pandemic [1,3]. Studying pediatric ED visits in isolation is important because they occur for different reasons than adults, largely being driven by injury and communicable illness rather than underlying medical conditions [4]. Some children also have serious, time-sensitive emergencies such as appendicitis and sepsis that require immediate care that can only be delivered in hospitals. The detailed nature of the ED visit declines for children in the U.S. and potential health implications have not been previously been analyzed.

In this study, we analyze trends in pediatric visits of over the early months of the COVID-19 pandemic in a large sample of U.S. EDs. We

* Corresponding author at: National Director of Clinical Innovation, US Acute Care Solutions, 2424 N. Potomac St., Arlington, VA 202-577-5084, United States of America.
E-mail address: pinesj@usacs.com (J.M. Pines).

study variation in those trends based on child age, diagnosis, discharge status, and facility type.

2. Materials and methods

2.1. Study design, setting, and selection of participants

We conducted a retrospective observational study of pediatric ED visits during January–June 2020, relative to the same time period in 2019, using data from a national emergency medicine group. We included data from 144 EDs and 4 urgent care centers in 18 states. This dataset has been described in detail elsewhere [5]. Data elements are automatically extracted directly from electronic health records at each site. Analyses included data from general EDs ($n = 110$), pediatric EDs ($n = 7$), freestanding EDs ($n = 26$) and urgent care centers ($n = 4$) which were continuously staffed by the emergency medicine group between January 1, 2019 and June 30, 2020. This study was approved by the Institutional Review Board of Allegheny Health Network.

2.2. Methods of measurement and data analyses

Using data from January–June 2019 and January–June 2020, we calculated for each facility the ratio of 2020 visit counts to visits during the same period in 2019, stratified by patient age, facility type and location, principal diagnosis, discharge category, and the state where the ED was located. We used the comparable period in 2019 as the denominator for the ratio to control for seasonality. For the numerator (2020 visits) we used a three-week rolling average ($t-2, t-1, t$). For the denominator (2019 visits), we used a 5-week rolling average ($t-3, t-2, t-1, t, t + 1$). We computed ratios for each facility and averaged across facilities with weights based on the number of 2019 visits. We used age groups <10 years, 11–13 years, and 14–17 years, and all adults (ages 18+). The child age bands were chosen based on observing similar patterns for children < age 10 using finer bands. For each weekly period, we calculated 95% confidence intervals using standard errors clustered at the facility-level. We also prepared graphs showing ratios for selected conditions.

We also measured changes in visit volumes for the full pandemic period (March 13–June 30, 2020) relative to the same period in 2019, stratified by age, gender, disposition, principal diagnosis, and facility characteristics. We studied the five most common serious pediatric

diagnoses [6], and the most common diagnoses using ICD-10 codes. For each category, we calculated a 95% confidence interval on the proportional difference between of 2020 visits that occurred during the pandemic period (March 13, 2020 to June 30, 2020) to the same proportion in 2019. Stata version 15.1 was used for all statistical analyses (College Station, TX).

3. Results

In early 2020, the 2020/2019 ratio of non-COVID ED visits was somewhat above 1 in January but declined after that. (Fig. 1A) The ratio fell starting the week of March 11 and accelerated over the next several weeks, finally nadiring in April and then beginning to gradually rise. The overall drop through mid-April was to 42% of 2019 volume for adults, but substantially higher to 67% for ages 14–17 years, and 74% for children <10 years. There was a gradual visit rebound across all age groups that started in late-April, yet pediatric visit ratios remained below adult ratios, especially for children <10 years. By the final week in June, visits had returned to 84% of 2019 levels for adults, 74% for 14–17 years, 67% for 10–13 years, and 50% for <10 years.

Visit rates for the three most common diagnoses and serious conditions followed different patterns. (Fig. 1B) “Other upper respiratory tract infection visits” fell precipitously throughout March and April nadiring at 7% of 2019 volume and by June had recovered only to 30%. By comparison, “Abdominal pain” and “Superficial injuries” visits followed similar patterns nadiring at 23% of 2019 volume and recovering to 61% by June. Visits for the five serious conditions included fell in April to 60% of 2019 volume, then increased to about 80% in May and June and returning to 100%, before falling again in late June. From March 13 to June 30, 2020, there were declines of 22% for the five common, serious conditions: appendicitis (–19%), septicemia (–49%), and intussusception (–42%), with no significant change for diabetic ketoacidosis and testicular torsion, compared to 2019 data from the same period. (Table 1)

For the most common diagnoses from March to June, especially large declines were seen in diagnoses for potentially communicable diseases: for example, for influenza (–84%), and other upper respiratory tract infections (–73%). Declines were smaller for arm fractures (–43%) and open head wounds (–31%), and for conditions commonly requiring antibiotics, including soft-tissue infections (–51%) and urinary tract infections (–47%). Declines were slightly smaller for small EDs (–52%) and

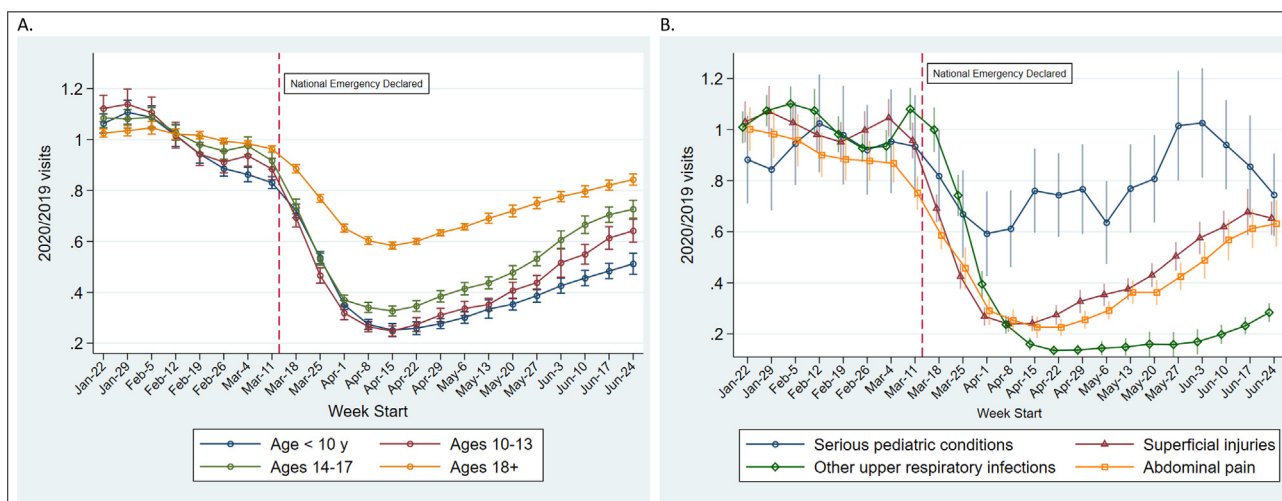


Fig. 1. Weekly Facility Ratios of ED Visits 2020/2019 in 147 Facilities by Age (A) and Selected Pediatric Conditions (B) During the COVID-19 Pandemic Note: Dotted vertical line separates pre-pandemic from pandemic period. Small vertical bars around each data point indicate 95% confidence interval, calculated using robust standard errors clustered at the facility-level. Trends in ages <3 were found to be nearly identical to trends in age 3–9 and were combined (<10 y). Serious pediatric conditions include appendicitis, sepsis, diabetic ketoacidosis, intussusception, and testicular torsion.

Table 1
Change in emergency department (ED) visits: 2020 (during pandemic; March 13–June 30) vs. same period in 2019.

	2019 volume	2020 volume	% change	95% CI
<i>All visits^a</i>				
Adults ≥18 years	1,236,447	882,240	−29%	(−31%, −26%) ^f
Pediatrics <18 years	271,269	111,764	−59%	(−62%, −56%) ^f
<i>Pediatric visit volume, by visit characteristics</i>				
<i>Ages</i>				
<10 y	174,788	68,263	−61%	(−64%, −57%) ^f
10–13 y	44,185	17,570	−60%	(−64%, −56%) ^f
14–17 y	52,296	25,931	−50%	(−54%, −47%) ^f
<i>Gender</i>				
Male	140,527	57,129	−59%	(−63%, −56%) ^f
<i>Payer source</i>				
Commercial	60,413	26,398	−56%	(−59%, −53%) ^f
Medicaid	172,599	64,251	−63%	(−66%, −59%) ^f
Self-pay	28,986	17,226	−41%	(−45%, −36%) ^f
Other	9252	3880	−58%	(−62%, −54%) ^f
<i>Disposition</i>				
Admitted	13,708	7795	−43%	(−46%, −40%) ^f
Transfer	4633	3019	−35%	(−40%, −30%) ^f
Discharge	243,935	98,004	−60%	(−63%, −57%) ^f
LWT/AMA ^b	7363	1584	−78%	(−87%, −70%) ^f
ED Death/DOA	99	55	−44%	(−70%, −19%) ^f
Other	1528	1306	−15%	(−24%, −5%) ^f
<i>COVID-19</i>				
Confirmed diagnosis	N/A	606	–	
<i>Serious conditions</i>				
Appendicitis	1144	921	−19%	(−27%, −12%) ^f
Septicemia	257	131	−49%	(−65%, −33%) ^f
Diabetic ketoacidosis	229	214	−7%	(−25%, 12%)
Intussusception	69	40	−42%	(−72%, −12%) ^f
Testicular torsion	89	96	8%	(−24%, 39%)
All urgent conditions combined	1788	1402	−22%	(−28%, −16%) ^f
<i>Most common visit diagnoses</i>				
<i>Injuries</i>				
Superficial injury; contusion	13,373	5892	−56%	(−60%, −52%) ^f
Other unspecified injury	9842	3891	−60%	(−64%, −57%) ^f
Sprains and strains	8138	2546	−69%	(−73%, −64%) ^f
Open wounds of head and neck	7858	5449	−31%	(−35%, −27%) ^f
Fracture of the upper limb	7382	4281	−42%	(−47%, −37%) ^f
Open wounds to limbs	5610	4522	−19%	(−26%, −13%) ^f
<i>Conditions commonly caused by communicable diseases</i>				
Other specified upper respiratory infections ^{c,d}	28,546	7829	−73%	(−80%, −65%) ^f
Fever	10,468	4512	−57%	(−61%, −53%) ^f
Respiratory signs and symptoms	6800	2894	−57%	(−64%, −51%) ^f
Viral infection	6713	2523	−62%	(−69%, −56%) ^f
Otitis media	10,781	2504	−77%	(−82%, −71%) ^f
Nausea and vomiting	10,208	2336	−77%	(−82%, −73%) ^f
Asthma	5512	1329	−76%	(−83%, −68%) ^f
Influenza	5501	900	−84%	(−109%, −58%) ^f
Acute bronchitis	4112	884	−79%	(−88%, −69%) ^f
<i>Symptoms & other body system diseases</i>				
Abdominal pain	11,951	4495	−62%	(−66%, −58%) ^f
Musculoskeletal pain, not low back pain	4960	1839	−63%	(−68%, −58%) ^f
Skin and subcutaneous tissue infections	4602	2270	−51%	(−56%, −46%) ^f
Urinary tract infections	4105	2186	−47%	(−51%, −42%) ^f
<i>Facility characteristics</i>				
<i>Facility types</i>				
General ED (N = 110)	166,016	65,294	−61%	(−64%, −58%) ^f
Pediatric ED (N = 7)	84,254	37,467	−56%	(−59%, −52%) ^f
Freestanding ED (N = 30)	20,999	9003	−57%	(−61%, −53%) ^f
<i>ED size^e</i>				
Small (<30,000 visits) (N = 70)	26,132	12,611	−52%	(−55%, −48%) ^f
Medium (30,000–59,999 visits) (N = 58)	97,941	37,474	−62%	(−65%, −59%) ^f
Large (>60,000 visits) (N = 19)	41,943	15,209	−64%	(−67%, −60%) ^f
<i>Location</i>				
Large central metro (N = 41)	37,159	13,667	−63%	(−67%, −60%) ^f
Large fringe metro (N = 51)	50,122	19,259	−62%	(−65%, −58%) ^f
Medium metro (N = 24)	42,074	16,062	−62%	(−65%, −59%) ^f
Small metro and non-metro (N = 31)	36,661	16,306	−56%	(−59%, −52%) ^f

^a Visits to 147 EDs (110 general hospital EDs, 7 pediatric EDs, and 30 free standing EDs (includes 4 urgent care clinics). Facilities are located in Texas (30), Colorado (28), Ohio (19), Maryland (13), North Carolina (12), Pennsylvania (12), Florida (11), Oklahoma (5), plus 1–3 facilities in each of California, Connecticut, Hawaii, Illinois, Kansas, Kentucky, Michigan, New Hampshire, Nevada, New York, and Virginia.

^b AMA/LWT = left against medical advice or left without treatment.

^c Other specified upper respiratory infections most commonly include acute upper respiratory infections, acute pharyngitis; streptococcal pharyngitis, acute obstructive laryngitis (croup), and acute nasopharyngitis (common cold).

^d The majority of visits in this category are for patients that LWT/AMA and includes ICD-10-cm code Z53.9 “procedure and treatment not carried out, unspecified reason.”

^e ED size based on 2019 annual visit volumes. Location determined using the National Center for Health Statistics 2013 Urban-Rural Classification Scheme for Counties.

^f 95% confidence interval does not cross zero. Confidence intervals are not corrected for multiple comparisons.

EDs in rural (−56%) areas. There were 606 specific COVID-19 diagnoses. The number of children who were dead on arrival or died in the ED fell (−44%).

4. Discussion

The COVID-19 pandemic led to sharply reduced pediatric ED visits, with especially large declines for younger children below the age of 10 years. Compared to adults, pediatric ED visits fell further and remain further below pre-pandemic levels. Certain visit types were more impacted. In particular, visits caused by communicable conditions, including influenza, other specified upper respiratory tract infections, otitis media, and symptoms of nausea and vomiting, had sharper and more persistent declines. There were also substantial reductions for injury, and for urgent infectious conditions requiring antibiotics. Approximately 1 in 2000 visits (relative to 2019 levels) involved a COVID-19 diagnosis, likely previously diagnosed because rapid testing was not yet available for definitive results in the ED.

Pediatric ED visits could be differentially affected relative to adult visits for a number of reasons. Social distancing, especially school closures, could have had a large impact on the causes of pediatric visits. Specifically, fewer face-to-face interactions likely reduced contagion and reduced school play reduced activity-related and motor vehicle crash injuries. Other studies have documented increased use of telemedicine but less office-based care during the pandemic [7]. Whether the lower pediatric ED visits observed in our study were a result of actual lower incidence of illness and injury, or whether care shifted to other settings or was avoided entirely is unknown [8]. However, an argument for a real reduction in incidence of disease and injury as the major contributor to our findings is supported by the very large percentage declines for infectious disease, as well as observed declines for fractures and open wounds, for which ED care would be hard to avoid.

Importantly, the visit rate for influenza in 2020 was less than one fifth of 2019 levels. These trends may portend a dramatically muted influenza season this fall and winter, mirroring the impact that has occurred in Australia [9]. The muted effect may be more prominent in regions which provide primarily distance-learning in the fall, and supports cautious optimism that COVID-19 pandemic may not be compounded by a typical yearly influenza epidemic to produce higher ED volumes.

As compared to adult visits, pediatric ED visits through June 2020 have remained dramatically depressed. Perhaps social distancing has had a larger effect on contagious disease for children than for adults, especially given that June is also summer break for children. Fear of ED-based contagion may also be more prominent when parents are considering bringing children for ED care. It is also possible that alternatives to ED care such as telemedicine by pediatric offices may also have been more readily available for children than for adults.

Perhaps the most concerning findings of our study are substantial drops in appendicitis, septicemia, and intussusception visits. These conditions are true emergencies that require immediate treatment and are rarely treated outside of hospital settings. This raises the strong possibility that care may have been deferred or never occurred, with more serious outcomes (i.e., bowel perforations from untreated appendicitis or intussusception) or even death (i.e., untreated sepsis). However, it is also possible that because sepsis and intussusception can be preceded by viral illness, lower ED visits may reflect actual lower incidence of disease. To the extent that severe sepsis leads to delay in ED visits, rather than death at home, it is encouraging that visits with the child dead on arrival or died in the ED were rare and even fell during the pandemic period. This lower incidence of ED visits for severe conditions in children mirrors similar effects in adult patients with fewer visits for adults with acute myocardial infarction that occurred early in the pandemic [10].

Close examination of trends in pediatric ED visits during the COVID-19 pandemic, including study of outcomes after hospitalization should be a priority for both physicians and public health officials.

Interventions may be required to ensure that children receive access to timely emergency care when necessary. The sharp decline in ED visits also severely affect the economics of sustaining an ED and, if sustained, may require subsidies for lower-volume EDs to avoid closure.

There are several study limitations. Our study EDs are geographically diverse (18 states) but represent only about 3% of U.S. EDs and may not generalize to other sites. In particular, our EDs were not in New York City or Seattle, which were early COVID-19 hotspots. However, our data include a variety of settings such as general EDs, children's hospitals, freestanding EDs, and urgent care centers in multiple states.

Second, we solely examined ED and urgent care visit data and did not observe the outcomes of avoided or deferred care. We also cannot determine how often care was delivered in other settings, such as in pediatric offices or by telemedicine. Declines for specific conditions could reflect reduced incidence of disease (e.g. for limb fractures), or alternatively ED avoidance, or a combination of both. Further study will be required to assess the extent to which avoided or deferred care impacted children's health and well-being. Finally, presumptive COVID-19 diagnoses based on exposure and symptoms would not have been coded as COVID-19 diagnoses. Therefore, we likely underestimated the actual COVID-19 prevalence in this study.

5. Conclusion

We found that pediatric ED visits fell more sharply than adult ED visits during the COVID-19 pandemic, and remained depressed through June 2020, especially for younger children. Declines were seen for serious conditions, suggesting in some case that parents may potentially have avoided necessary care for their children.

Funding/Support

No funding was secured for this study.

Disclosures

JMP has been an advisor to CSL Behring, Medtronic, and Abbott Point-of-Care for unrelated work. No other authors have conflicts to disclose.

References

- [1] Hartnett KP, Kite-Powell A, DeVies J, et al. Impact of the COVID-19 pandemic on emergency department visits - United States, January 1, 2019–May 30, 2020. *MMWR Morb Mortal Wkly Rep.* 2020;69:699–704.
- [2] Pines JM. COVID-19, Medicare for All, and the Uncertain Future of Emergency Medicine [published online ahead of print, 2020 Jun 24]. *Ann Emerg Med.* 2020. <https://doi.org/10.1016/j.annemergmed.2020.06.034> S0196-0644(20)30496-0.
- [3] Lazzerini M, Barbi E, Apicella A, Marchetti F, Cardinale F, Trobia G. Delayed access or provision of care in Italy resulting from fear of COVID-19. *Lancet Child Adolesc Health.* 2020 May;4(5):e10–1. [https://doi.org/10.1016/S2352-4642\(20\)30108-5](https://doi.org/10.1016/S2352-4642(20)30108-5) Epub 2020 Apr 9. PMID: 32278365; PMCID: PMC7146704.
- [4] Rasooly IR, Mullins PM, Alpern ER, Pines JM. US emergency department use by children, 2001–2010. *Pediatr Emerg Care.* 2014;30:602–7.
- [5] Carlson JN, Foster KM, Pines JM, et al. Provider and practice factors associated with emergency physicians' being named in a malpractice claim. *Ann Emerg Med.* 2018;71:157–64 e4.
- [6] Michelson KA, Bachur RG, Mahajan P, Finkelstein JA. Complications of serious pediatric conditions in the emergency department: Definitions, prevalence, and resource utilization. *J Pediatr.* 2019;214:103–12 e3.
- [7] Ziedan E, Simon KI, Wing C. Effects of state COVID-19 closure policy on NON-COVID-19 health care utilization. NBER Working Paper No 27621; July 2020 Available from <https://www.nber.org/papers/w27621>. accessed October 20, 2020.
- [8] Lazzerini M, Barbi E, Apicella A, Marchetti F, Cardinale F, Trobia G. Delayed access or provision of care in Italy resulting from fear of COVID-19. *Lancet Child Adolesc Health.* 2020;4:e10–1.
- [9] Australian Influenza Surveillance Report. No 05 - week ending 14. Available from <https://www1.health.gov.au/internet/main/publishing.nsf/Content/ozflu-surveil-no05-20.htm>; June 2020. accessed October 20, 2020.
- [10] Solomon MD, McNulty EJ, Rana JS, et al. The covid-19 pandemic and the incidence of acute myocardial infarction. *N Engl J Med.* 2020;383:691–3.