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# Emergency department utilization among children with Long COVID symptoms: a COVID-19 research consortium study

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## Abstract

**Background and objectives** Long COVID, characterized by persistent symptoms beyond the acute infection phase, remains poorly characterized in children. Our study aim is to determine if children who exhibit any symptoms/conditions associated with Long COVID after acute COVID-19 infection have higher Emergency Department (ED) utilization compared to those who do not exhibit these symptoms.

**Methods** Data from the HealthJump ambulatory database from the COVID-19 Research Database Consortium was utilized to identify pediatric COVID-19 cases from March 2020 to May 2023. Long COVID cases were defined based on symptoms/conditions occurring 30–180 days after initial COVID diagnosis. Descriptive statistics and multi-variable logistic regression models were used to model the relationship between Long COVID and child ED utilization.

**Results** Out of 130,010 children diagnosed with COVID-19, 43,645 (33.6%) exhibited at least one Long COVID symptom/condition. Children with Long COVID symptoms/conditions had 152% higher odds (OR: 2.52, CI: 2.32–2.73) of ED visits, while those with specific symptoms including “chest pain” had 255% higher odds (AOR: 3.55, CI: 2.73–4.54) and “fluid and electrolyte disturbances” had 229% higher odds (AOR: 3.29, CI: 2.23–4.73) compared to those without those symptoms/conditions.

**Conclusion** This study reveals that children with Long COVID symptoms had notably higher odds of ED visits, with chest pain, fluid imbalances, and generalized pain being most closely linked to such visits. This study highlights the burden of Long COVID on ED providers and underscores the importance of improved guidance for managing Long COVID symptoms in children.

**Keywords** Long COVID, Symptoms, Emergency use, COVID-19 Research Database

## Introduction

COVID-19, a disease caused by infection from the virus SARS-CoV-2, affected children, albeit less severely compared to adults [1, 2]. Studies have also reported that children, like adults, can suffer from “Long COVID” or “post-acute sequelae of COVID-19 (PASC),” symptoms that occur after the acute phase of the infection [3].

The World Health Organization (WHO) has defined Long COVID symptoms and the timing of the condition using a Delphi method that applies primarily to adults, and specifically stated that there could be a separate definition for children [4]. An updated definition,

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also using a Delphi method, suggests that Long COVID can occur in children and young adults with one or more physical symptoms that affect daily functioning for at least 12 weeks after acute COVID-19 infection [5, 6]. There are several studies describing aspects of the disease such as immunological profile or exercise intolerance [7–9]. Others have estimated the prevalence [3, 7, 10, 11], which ranges from 6 to 25% in the first 90 days after acute infection [11] using a meta-analysis [7]. However, there is no consensus on how to delineate the set of symptoms and there have been calls for better definitions [12].

One study, Rao et al., conducted as part of the RECOVER project, identified a set of symptom and condition clusters likely associated with Long COVID in children using data from PEDSNet, a compilation of electronic medical records from several medical centers in the country [13]. The study selected symptoms and conditions that were significantly more prevalent when comparing children with and without COVID infection. This set of symptoms and conditions provides a starting point for describing Long COVID in children [13].

Moreover, few studies offer any insight into the health-care utilization patterns of children with Long COVID. One Norwegian study found a 13% increase in primary care or Emergency Department (ED) use among children aged 1–5 years in the 6 months following a positive test for COVID-19 [14]. A Swedish study found that in a group of 5 children, 1 was hospitalized for peri-myocarditis within the 2 months following their COVID diagnosis [15]. As the ED usually forms the first line of clinical care for many children, it is important to understand the burden that Long COVID, a complex, multi-symptom condition with no clear clinical guidelines [16], can place on ED use.

The primary aim of this study is to determine if children who exhibit any symptoms or conditions after acute COVID illness have higher ED utilization compared to those who do not exhibit these symptoms. Secondly, we aim to profile ED utilization by the different symptom and condition clusters among those with at least one symptom.

For this study we use the HealthJump database, a data integrator that houses electronic medical record (EMR) data of privately insured patients across outpatient and ambulatory settings. HealthJump provides data on over 90 million patients, including over 9 million children, to the COVID-19 Research Database consortium, which in turn provides free access to researchers with COVID-related research questions [17, 18]. This technology is at an early stage and the ability to use such services is still being tested.

## Methods

### Data source

We utilized the HealthJump stand-alone ambulatory database that compiles electronic health record (EHR) data including diagnoses, procedures, labs, vitals, medications, and histories sourced from participating members. This data is currently free and accessible with permissions from the COVID-19 Research Database consortium [19, 20]. This consortium, led by Datavant, brings together numerous private and public partners from various sectors to enable data access and promote knowledge sharing. The COVID-19 Research Database was established with approval from the Western Institutional Review Board and has an exemption from patient consent due to the use of deidentified data certified under HIPAA (Health Insurance Portability and Accountability Act of 1996), including both HIPAA limited data and non-HIPAA-covered data, and this exemption applies to all research conducted within the COVID-19 Research Database. In partnership with the COVID-19 Research Database, HealthJump enables authorized access to its database of records from various EMR platforms, and while all regions in the United States are represented, there are some limitations to this representation, particularly from New England and the West North Central states.

The process of obtaining access required the submission of a research protocol for review and approval by the consortium. After several procedural steps, we were granted access to the Amazon Web Services (AWS) cloud and the appropriate databases. Database software (Snowflake), statistical software (R, SAS, etc.) were made available within the AWS environment. The HealthJump data used for this study was last updated as of May 18th, 2023.

### Study sample

The study included children from birth to 17 years old who had at least one confirmed diagnosis of COVID-19 (ICD-10 Code 'U07.1x') between March 2020 and May 2023 and with a date associated with that diagnosis code (Supplementary Figure 1).

### Long COVID symptom and condition clusters

The main exposure was symptom and condition clusters defined by Rao et al. as being clinically and statistically significantly associated with Long COVID [13]. The symptoms that were identified were changes in smell or taste, hair loss, generalized pain, chest pain, abnormal liver enzymes, skin rashes, allergies, fatigue and malaise, fever and chills, cardio-respiratory symptoms, genitourinary symptoms, nausea and vomiting, and diarrhea. The conditions identified were myocarditis, acute respiratory distress syndrome, myositis, mental health conditions,

disorders of the teeth and gingiva, ill-defined heart disease, fluid/electrolyte disturbances, thrombophlebitis and thromboembolism, acute kidney injury, tonsillitis, bronchiolitis, pneumonia, inflammatory skin conditions, obesity, motor disorders and gastroenteritis. Conditions and symptoms were classified using at least one ICD-10 diagnosis codes in the database between 30 and 180 days after initial COVID diagnosis. All other observed children were classified as not having Long COVID (Supplementary Fig. 1). We will refer to children having these symptoms or conditions as having “Long COVID” in the rest of the manuscript.

### Other variables

We evaluated age, gender, race, region, and medical complexity as potential confounders. Medical complexity was defined using the complex chronic conditions (CCC) classification system developed by Feudtner et al. [21]. They defined CCC as “Any medical condition that can be reasonably expected to last at least 12 months (unless death intervenes) and to involve either several different organ systems or 1 organ system severely enough to require specialty pediatric care and probably some period of hospitalization in a tertiary care center,” and identified the ICD-10 diagnosis codes that were indicative of such complexity [21]. Analysis for pediatric CCC was completed in R using the pccc package as developed and described by Feinstein et al. [22].

### Emergency department utilization visits or attendance

The outcome is ED use between 30 and 365 days after initial COVID diagnosis. ED visits were defined using the following CPT codes: 99,281, 99,282, 99,283, 99,284, 99,285.

### Statistical analysis

Descriptive statistics were first employed to characterize the final study sample. We utilized t-tests, chi-squared tests, and Wilcoxon rank sum tests to compare ED visits among children indicating Long COVID to those without, based on variables such as gender, race, region, and medical complexity. We also evaluated the relative proportions of ED visits by computing percentages across population sizes by each Long COVID symptom.

To further explore the association between indication of Long COVID and ED use, we used a series of multivariable logistic regression models. Logistic regression is well-suited for modeling binary outcomes, making it especially useful for modeling ED utilization. Interpretability of such models is facilitated by the computation of odds ratios, allowing for a straightforward understanding of the impact of Long COVID symptoms on the likelihood of an ED visit. Models were built sequentially,

starting with a crude model (Model 1), then adjusting for race and gender (Model 2), medical complexity (Model 3), year of COVID diagnosis (Model 4), and finally an interaction term with Long COVID and year of diagnosis (Model 5).

Among those with at least one symptom/condition, we assessed the association of specific symptoms and conditions with ED visits after adjusting for medical complexity. For model robustness, symptoms and conditions with low ED utilization were filtered out; we included symptoms and conditions affecting at least 30 patients and where the number of ED visits was at least 10. Adjusted odds ratios, 95% confidence intervals (95% CI), and p-values were calculated for each estimate. P-values < 0.05 were considered statistically significant. All analyses were conducted with SQL within the AWS environment and R/RStudio.

### Results

In the HealthJump database, there were over 9 million children under 17 years of age, with 130,010 having at least one COVID-19 diagnosis code with an associated date. Of them, 43,645 (33.6%) had Long COVID according to the work completed by Rao et al. (Rao et al., 2022) (Supplementary Fig. 1).

Children with Long COVID reported a higher level of such symptoms in 2022 (58.6% vs. 32% in 2021) and had more medical complexity (5.8% vs. 2.9%) compared to children without. Overall, 3.2% of children with symptoms/conditions visited the Emergency Department (ED) compared to 1.3% of children without symptoms/conditions (Table 1).

Among children with Long COVID, approximately 13% with “Fluid and electrolyte disturbances” and 9.5% with “chest pain” visited the ED (Table 2).

In multivariable analysis, the crude model (Model 1) showed that children with Long COVID had 152% higher odds (OR: 2.52, CI: 2.32–2.73) of visiting the ED compared to those without. After adjustment for race, gender, medical complexity, and year of COVID-19 diagnosis (Model 4), the results remained relatively unchanged (AOR: 2.70, CI: 2.49–2.93). In the multivariable model with an interaction term (Model 5), children with Long COVID in 2021 (compared to 2022) had 292% higher odds (AOR: 3.92, CI: 2.62–5.87) of an ED visit (Table 3).

In terms of specific symptoms among children with Long COVID, multivariable analysis showed that children with “chest pain” had 255% higher odds of an ED visit (AOR: 3.55, CI: 2.73–4.54), those with “fluid and electrolyte disturbances” had a 229% (AOR: 3.29, CI: 2.23–4.73) higher odds of an ED visit, and those with “generalized pain” had 160% (AOR: 2.60, CI: 1.77–3.69)

**Table 1** Profile of Children from HealthJump with a COVID-19 Diagnosis from January 2020 to May 2023, by existence of Long COVID symptoms or conditions<sup>a</sup>

Profile Variable	Value set	Children with no symptoms or conditions: n, (%)	Children with any symptom or condition: n, (%)	p-values
Total n		86,365	43,645	
Year of COVID Diagnosis	2020	8,710 (10.1)	3,192 (7.3)	< 0.001
	2021	30,474 (35.3)	13,958 (32.0)	
	2022	41,243 (47.8)	25,588 (58.6)	
	2023	5,938 (6.9)	907 (2.1)	
Sex	Female	42,435 (49.1)	21,153 (48.5)	0.005
	Male	43,905 (50.8)	22,488 (51.5)	
	Unknown	25 (0.0)	4 (0.0)	
Race Categories	White	43,496 (50.4)	23,281 (53.3)	< 0.001
	American Indian	1,244 (1.4)	979 (2.2)	
	Asian	1,478 (1.7)	742 (1.7)	
	African American	11,513 (13.3)	5,155 (11.8)	
	Hawaiian/Pacific Islander	233 (0.3)	119 (0.3)	
	N/A	28,401 (32.9)	13,369 (30.6)	
Region	South	39,720 (46.0)	21,058 (48.2)	< 0.001
	Midwest	18,191 (21.1)	8,615 (19.7)	
	Northeast	5,741 (6.6)	1,565 (3.6)	
	West	18,414 (21.3)	9,730 (22.3)	
	N/A	4,299 (5.0)	2,677 (6.1)	
Medical Complexity <sup>c</sup>	No complexity	63,696 (73.8)	37,105 (85.0)	< 0.001
	Medical complexity	2,544 (2.9)	2,529 (5.8)	
	N/A	20,125 (23.3)	4,011 (9.2)	
Any Emergency Department (ED) Visit <sup>b</sup>	No	85,251 (98.7)	42,256 (96.8)	< 0.001
	Yes	1,114 (1.3)	1,389 (3.2)	

<sup>a</sup> Defined based on symptoms and condition codes shown in Supplemental Table 1 between 30–180 days from the date of initial COVID-19 diagnosis

<sup>b</sup> Defined based on CPT (Current Procedural Terminology) codes documenting an emergency room visit

<sup>c</sup> Any complex chronic conditions (CCC)

higher odds of an ED visit compared to those without these symptoms (Fig. 1).

## Discussion

This study utilized a publicly available database to explore ED utilization among children with possible Long COVID symptoms compared to those without and found that children with symptoms had 170% higher odds of presenting to the ED. We hypothesize that a heightened concern amongst parents of children previously diagnosed with COVID-19 as well as the potential severity of symptoms were possible contributors to the greater number of ED visits in the group with Long COVID symptoms. Further, the study found that the symptoms or conditions most associated with ED visits were chest pain, fluid and electrolyte imbalances, and generalized pain.

These three symptoms were also among the PASC symptoms reported by Rao et al. [13] as being highly associated with COVID-19 infection in children,

providing additional support for the likelihood of these symptoms being clinical features of Long COVID in children. These findings also align with results from another paper which found that chest pain was reported by 35% of children as a lingering symptom more than 12 weeks after initial COVID infection [16].

Our study did not find an association between persistent fatigue/malaise, a highly reported symptoms of Long COVID in children [16], and increased ED visits, implying that these symptoms alone may be insufficient to warrant an ED visit.

Our paper also showed that children with anxiety and other mental health problems had 85–96% higher odds of an ED visit, however, it is unclear whether this is a consequence of Long COVID or other hardships associated with the pandemic, including social isolation, school closures or disruption to routines [23].

Finally, our study highlights the high rates of ED visits among children with Long COVID symptoms. For example, 9.5% of those with chest pain, 13.5% of those

**Table 2** Symptom and condition categories and ED visits among children with Long COVID

Conditions associated with Long COVID	N with condition/symptom	N visiting ED	Percent visiting ED
Any condition	19,972	615	3.07
acute kidney injury	6	1	16.67
fluid and electrolyte disturbance	275	37	13.45
SARS pneumonia	16	2	12.50
pneumonia	656	37	5.64
communication and motor disorders	2,021	99	4.90
bronchiolitis	1,187	56	4.72
mental health treatment	2,333	107	4.59
gastroenteritis	2,788	100	3.59
tonsillitis	1,475	44	2.98
other and ill-defined heart disease	35	1	2.86
other specified inflammatory condition of skin	1,827	50	2.74
disorders of teeth and gingiva	3,164	74	2.34
obesity	7,508	167	2.22
myocarditis	22	0	0
thrombophlebitis and thromboembolism	6	0	0
myositis	4	0	0
acute respiratory distress syndrome	3	0	0
<b>Symptoms associated with Long COVID</b>			
Any Symptom	33,999	1,208	3.55
respiratory failure	30	8	26.67
chest pain	801	76	9.49
generalized pain	415	34	8.19
nausea and vomiting	4,569	285	6.24
<sup>a</sup> post covid code	132	8	6.06
other changes in smell or taste	34	2	5.88
anxiety symptoms	399	23	5.76
skins signs and symptoms	681	39	5.73
hair loss	142	8	5.63
abnormal liver enzymes	127	7	5.51
diarrhea	2,071	99	4.78
skin rashes	1,846	85	4.60
fever and chills	9,506	406	4.27
general signs and symptoms	5,239	221	4.22
cardiorespiratory signs and symptoms	6,410	263	4.10
genitourinary signs and symptoms	2,057	65	3.16
fatigue and malaise	1,455	44	3.02
allergies	13,078	370	2.83
loss of smell	78	0	0
Either Condition or Symptom	43,645	1,389	3.20

<sup>a</sup> Code U09.9 for post covid code indicates the presence of an unspecified post COVID-19 condition

with fluid and electrolyte disturbances, and 8.2% of those with generalized pain had at least one ED visit. There is some evidence that Long COVID symptoms in children are a consequence of inflammation and changes in the immune system [24–27] however, given the lack of

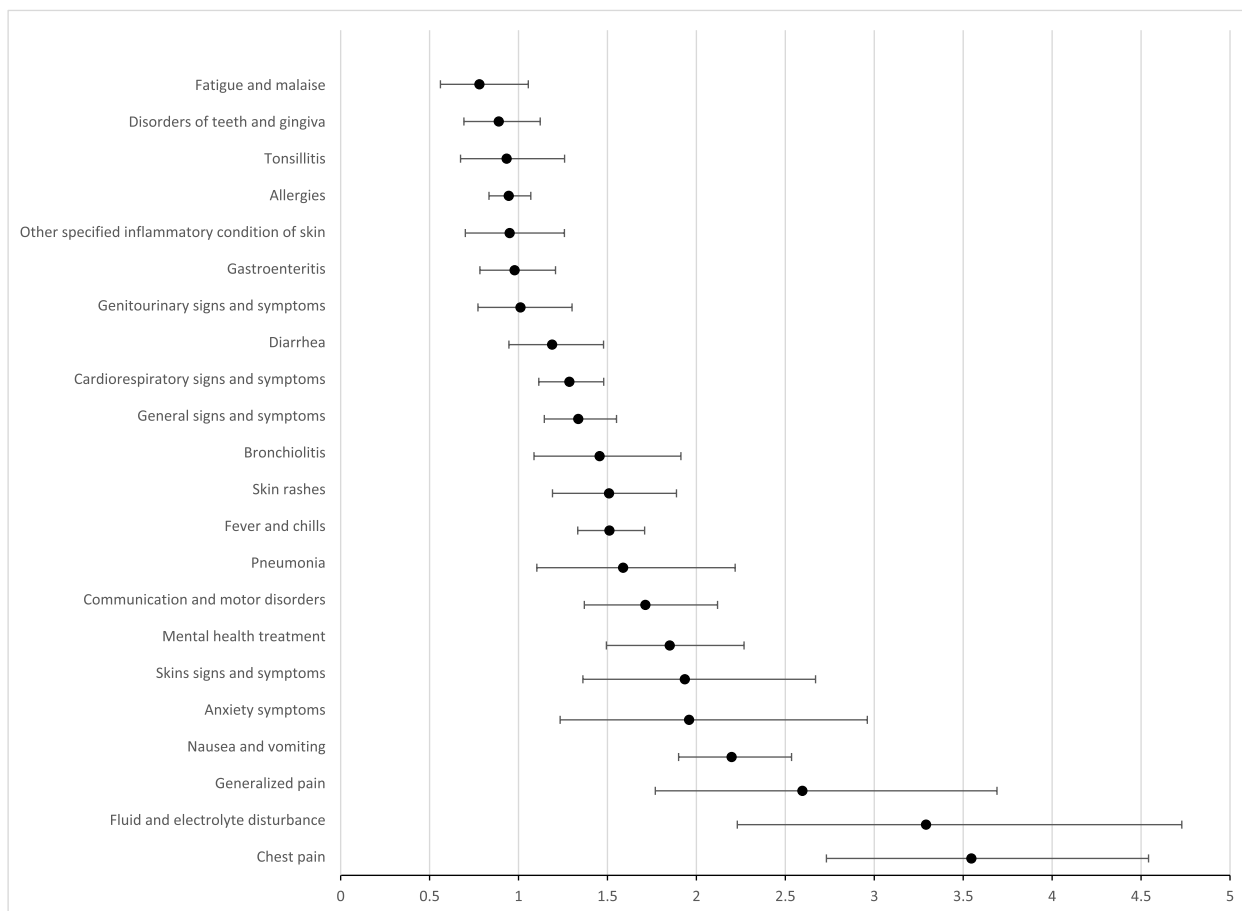
standardized guidelines to diagnose, care for, or manage Long COVID in children [16, 28], the burden of care for these children often falls on ED providers.

Finally, this study tested the feasibility of using a large EHR-integrated database such as the COVID-19

**Table 3** Multivariable association between Long COVID and ED Utilization<sup>a</sup>

Exposure:	Model details	Odds Ratio, (95% CI) Any Long COVID (Ref: No Long COVID)
Model 1	Crude Model	2.52 (2.32–2.73)
Model 2	Model 1 adding Race Category and Gender	2.58 (2.38–2.79)
Model 3	Model 2 adding Medical Complexity	2.68 (2.47–2.91)
Model 4	Model 3 adding Year of COVID Diagnosis	2.70 (2.49–2.93)
Model 5	Model 4 adding interaction between Year of COVID Diagnosis and Any symptoms/conditions	
	For Year 2020 (compared to 2022)	1.82 (0.87–3.73)
	For Year 2021 (compared to 2022)	3.92 (2.62–5.87)

<sup>a</sup> Included symptoms and conditions affecting least 30 patients and accounting for at least 10 ED visits



**Fig. 1** Association of some specific symptoms/conditions with ED visits among those with any symptom or condition

Research Database Consortium for analysis of utilization outcomes. The initial process was encumbered by changes to the databases and challenges receiving access, resulting in a 6-to-9-month delay in the analysis. Additionally, limitations within the data, such as binning of

children’s ages (birth to 17 years) restricted the ability to use exact ages in the analysis. Despite these limitations, integrated data providers such as these are important, as they provide access to large swaths of EHR data that would otherwise be inaccessible. Further, they provided a



free data source to study COVID-19 and its implications on adults and children.

This study has several limitations. One, since we used only ICD-10 code to determine the existence of symptoms and conditions in children, there is a chance of misclassification. Two, we were unable to use age as an adjuster in the models due to restrictions imposed by the data consortium.

## Conclusion

Our findings highlight the potential impact of particular clinical features such as chest pain, generalized pain, and fluid and electrolyte disturbances on increased ED visits. Moreover, the study underscores the importance of improved guidance for managing Long COVID symptoms in children, to alleviate the burden on ED providers. This research sets the stage for more studies in this direction, fostering a better understanding of the implications of Long COVID on healthcare utilization in children.

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12887-024-04817-9>.

Supplementary Material 1.

## Authors' contributions

M.R. and A.S. conceived of the research idea and wrote the research proposal to the COVID-19 Research Database Consortium. P.B. did the data management and statistical analysis and M.R. and P.B. wrote the manuscript. A.S. provided critical comments to the final manuscript.

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None.

## Availability of data and materials

The data that support the findings of this study are available from COVID-19 Research Database partners, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of COVID-19 Research Database partners, who are acknowledged at <https://covid19researchdatabase.org/>. Please contact the corresponding author, Mangala Rajan, at [mar2834@med.cornell.edu](mailto:mar2834@med.cornell.edu) for more information regarding data availability.

## Declarations

### Ethics approval and consent to participate

The COVID-19 Research Database was established with approval from the Western Institutional Review Board and has an exemption from patient consent due to the use of deidentified data certified under HIPAA (Health Insurance Portability and Accountability Act of 1996), including both HIPAA limited data and non-HIPAA-covered data and this exemption applies to all research conducted within the COVID-19 Research Database. As such, we did not require approval from the Weill Cornell Institutional Review Board.

### Consent for publication

All authors have provided consent for publication.

### Competing interests

The authors declare no competing interests.

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