Original article

Evaluation of reported medical services provided to pediatric viral bronchiolitis diagnoses during the COVID-19 pandemic

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STRUCTURED ABSTRACT

Background: Mitigation strategies were implemented during the coronavirus disease 2019 (COVID-19) pandemic that slowed the spread of this virus and other respiratory viruses. The objective of this study is to assess the impact of COVID-19 mitigation strategies on the medical services that children less than 1 year of age with acute bronchiolitis required (emergency department services, hospitalization, critical care services, and mechanical ventilation).
Methods: This was a retrospective observational cohort study utilizing TriNetX ® electronic health record (EHR) data. We included subjects less than 1 year of age with a diagnosis of acute bronchiolitis. After the query, the study population was divided into two groups [pre-COVID-19 (March 1st, 2019 until February 29th, 2020) and COVID-19 (March 1st, 2020 until February 1th, 2021)]. We analyzed the following data: age, sex, race, diagnostic codes, common terminology procedures (CPT), and antimicrobials administered.
Results: A total of 5063 subjects (n,%) were included [4378 (86.5%) pre-COVID-19 and 685 (13.5%) during the COVID-19 pandemic]. More subjects were diagnosed with acute bronchiolitis in the pre-COVID time frame (4378, 1.8% of all hospitalizations) when compared to the COVID-19 pandemic time frame (685, 0.5%). When diagnosed with acute bronchiolitis, the frequency of emergency department services, critical care services, hospitalization, and mechanical ventilationwere similar between the two cohorts.
Conclusions: During the COVID-19 pandemic, less infants were diagnosed with acute bronchiolitis but the frequency of emergency department services, hospitalization, and mechanical ventilation, reportedly required was similar. Longer-term studies are needed to evaluate the benefits of COVID-19 mitigation strategies on common viruses that require critical care.

Introduction

Acute bronchiolitis is one of the most common diseases that afflict pediatric patients each year [1]. It results from multiple viruses that may result in a wide spectrum of symptoms [2]. While a majority of children may have mild symptoms when infected [3], there are certain subgroups of patients that appear to be at particular risk of hospitalization and death, including children aged less than 1 year of age [4]. Due to their unique physiological and anatomical features as well as immunologic immaturity, they are at particular risk of developing severe symptoms [4,5], which can include airway obstruction of small caliber airway passages as well as inflammation of the lower airways [4]. This impacts the patient's ability to maintain adequate oxygenation and ventilation [4]. Annually, up to 100,000 children are admitted to United States hospitals with viral bronchiolitis [6].

Despite intensive intervention, approximately 100 children succumb to this illness in the United States each year (often with co-morbidities such as prematurity and/or a cardiovascular condition), with a greater proportion (who may have no comorbidities) occurring in resource-limited countries [4,7,8].

In 2020, the world was impacted by the coronavirus-2019 (COVID-19) pandemic [9]. To curb its spread and conserve medical supplies, various mitigation strategies were implemented including masks and social distancing [10]. Shortly after these restrictions were instituted, regional centers reported a fall in respiratory viral infection diagnoses [2,10]. While a decrease in hospital resource utilization occurred, it is unknown if the severity of illness was impacted, specifically in infants, the group at highest risk [11]. An examination and an understanding of the outcomes of this patient population may help inform future public health practices within the United States as well as resource-limited settings.

The objective of this present study is to determine if widespread COVID-19 mitigation strategies decreased the frequency of acute

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bronchiolitis diagnoses, hospitalizations, and critical care services in children less than 1 year of age. We hypothesized that the frequency of acute bronchiolitis diagnoses and hospitalizations in children less than 1 year of age would be reduced during the time period when mitigation strategies were implemented.

Materials and methods

Study design

This is a retrospective observational cohort study utilizing the Tri-NetX ® electronic health record (EHR) data of pediatric subjects aged less than 1 year of age who were diagnosed with the International Classification of Diseases, 10th edition diagnostic code acute bronchiolitis (J26). TriNetX is global federated research network that provides EHR data elements (i.e. diagnoses, procedures, laboratory values) of approximately 68 million patients in 56 large health care organizations (HCOs) predominately in the United States. The data is aggregated within a real-time user-friendly browser-based software in a de-identified fashion, thus no protected health information is received. Because of this, we received a waiver from the Penn State Health Institutional Review Board (IRB) to perform this study.

Data collection

TriNetX provided a de-identified dataset of electronic medical records of 5063 subjects patients from 30 HCOs in the United States. Using the diagnoses, procedures, medications, and laboratory values entered by any clinician (outpatient or inpatient medical providers as well as consultants during a given encounter), this data is mapped to a standard and controlled set of clinical terminologies and transferred into a proprietary database schema. The data is de-identified based on standard defined in Section §164.514(a) of the HIPAA Privacy Rule. The process by which datasets are de-identified is attested to through a formal determination by a qualified expert as defined in Section §164.514(b)(1) of the HIPAA Privacy Rule. On February 9th, 2021, we focused and analyzed the following EHR data: age, sex, race, ethnicity, International Classification of Diseases, 10th edition diagnostic, encounter, medication, and procedural codes (specifically examining critical care services, application of invasive mechanical ventilation as well as continuous positive airway pressure). The medical setting

of the EHR data included ambulatory, inpatient, and emergency encounters. Laboratory data identifying specific viruses were not available due to database limitations. Medications were evaluated for antimicrobial usage. While acute bronchiolitis is commonly caused by viruses, secondary bacterial infections may occur and may signal the patient's illness severity. [Please see Table Supplementary 1 for diagnostic, medication, and procedural code definitions].

The study population was divided into two cohorts [pre-COVID-19 (March 1st, 2019 until February 29th, 2020) and during COVID-19 pandemic (March 1st, 2020 until February 1st, 2021) and analyzed. These dates were chosen based on when mitigation strategies were approximately initiated. Due to database privacy, we were unable to determine the exact location of the HCO where subjects were diagnosed with acute bronchiolitis.

Statistical analysis

Summary counts and percentages were computed for categorical variables of interest and the results were displayed in contingency tables. Fisher's exact test was used to assess the statistical significance of associations between categorical variables of interest and pre/post-COVID status, except for Race and Ethnicity, where a Monte Carlo version of Fisher's exact test was applied (100,000 replicates, random seed used for reproducibility). All analyses were summarized in reports generated with R Markdown while running R 4.0.2 [12,13].

Results

Demographic characteristics

A total of 5063 subjects were included in this study. During the pre-COVID time frame, emergency or inpatient encounters made up 249,314 subjects less than 1 year of age in the TriNetx database, while in the COVID-19 pandemic time frame, it made up of 130,409 subjects. More subjects were diagnosed with acute bronchiolitis in the pre-COVID time frame (4378, 1.8% of all hospitalizations) when compared to the COVID-19 pandemic time frame (685, 0.5%). Patient characteristics of sex, race, ethnicity, and frequency of death was similar across both groups. Subject characteristics are summarized in Table 1.

Table 1
Demographics of pediatric subjects aged 0 to 1 years diagnosed with acute bronchiolitis.

	pre-COVID-19 pandemic (n = 4378; 86.5%)	During COVID-19 pandemic (n = 685; 13.5%)	p value
Sex			0.645
Male	2521 (57.6%)	395 (57.7%)	
Female	1856 (42.4%)	279 (40.7%)	
Race[a]			0.4474
American Indian or Alaska Native	33 (0.8%)	7 (1.0%)	
Asian	97 (2.2%)	15 (2.2%)	
Black or African American	676 (15.4%)	111 (16.2%)	
Native Hawaiian or Other Pacific Islander	24 (0.5%)	2 (0.3%)	
White	2684 (61.3%)	372 (54.3%)	
Ethnicity			0.175
Hispanic or Latino	785 (17.9%)	103 (15.0%)	
Not Hispanic or Latino	1889 (43.1%)	308 (45.0%)	
Unknown	1704 (38.9%)	274 (40.0%)	
Deaths	2 (0.05%)	2 (0.3%)	0.091

[a] Number of subjects in each cohort had race listed as unknown [864 (19.7%) in pre-COVID-19 pandemic and 178 (26.0%) in during COVID-19 pandemic. These subjects were not included in the analysis.

Table 2
Viruses diagnosed per subject pre-COVID-19 pandemic and during COVID-19 pandemic.

	Pre-COVID-19 Pandemic(n = 4378)	During COVID-19 Pandemic(n = 685)
Frequency of Co-Infection		
1 Virus	2364 (54.0%)	217 (31.7%)
More than 2 viruses	145 (3.3%)	19 (2.8%)
*Specific Viruses**a**		
Adenovirus	29 (0.7%)	10 (1.5%)
Coronavirus	29 (0.7%)	2 (0.3%)
Coronavirus-2019	0 (0.0%)	10 (1.5%)
Coxsackie Virus	0 (0.0%)	1 (0.1%)
Enterovirus	71 (1.6%)	30 (4.4%)
Human metapneumovirus	58 (1.3%)	16 (2.3%)
Influenza	98 (2.2%)	6 (0.9%)
Parainfluenza	3 (0.1%)	0 (0.0%)
Pertussis	6 (0.1%)	0 (0.0%)
Rhinovirus	23 (0.5%)	12 (1.8%)
Respiratory Syncytial Virus	2345 (53.6%)	168 (24.5%)
Viral and Chlamydial	3 (0.1%)	2 (0.3%)

Viruses diagnosed by clinicians

In the pre-COVID-19 pandemic cohort, 2364 (54.0%) had only one virus diagnosed and 145 (3.3%) had more than one virus diagnosed compared to 217 (31.7%) and 19 (2.8%) during the COVID-19 pandemic. In subjects diagnosed with viral bronchiolitis and COVID-19 [10 (1.5%)], no co-infections were identified. Respiratory syncytial virus was the most common virus diagnosed in both cohorts. The frequency of respiratory syncytial diagnosis was 14 times higher pre-COVID (2345, 53.6%) when compared to during the COVID-19 pandemic (168, 24.5%) Table 2.

Seasonality of respiratory syncytial virus diagnosed by clinicians and frequency of critical services required

Similar rates of respiratory syncytial virus were reported during the March to May months. During the COVID-19 period, the reported frequency of respiratory syncytial virus decreased while during the pre-COVID-19 period, the frequency seasonally decreased and increased during the September to November and December to February months. Frequency of critical care services had the highest proportion during March to May [12 (7.7%)] months but then decreased during the June to August [11 (5.4%)], September to November [48 (4.4%)], and December to February [140 (4.8%)] months pre-COVID-19 pandemic. During the COVID-19 period, the similar proportions of critical care services were noted in all months with the exception of the September to November months [9 (6.8%) Fig. 1 and Table 3.

Procedural services and encounter types

The frequency of critical care services [211 (4.8%) versus 30 (4.4%), p = 0.699], mechanical ventilation [38 (0.9%) versus 4 (0.6%), p = 0.649], and non-invasive respiratory support [66 (1.5%) versus 7 (1.0%), p = 0.391] were similar in both cohorts (Table 3). Both groups also had similar frequencies of emergency [3006 (68.7%) versus 489 (71.4%), p = 0.1553] inpatient encounters [(1515 (34.6%) versus 217 (31.7%), p = 0.1409], and ambulatory encounters [(578 (13.2%) versus 92 (13.4%)]. Of the subjects diagnosed with viral bronchiolitis and COVID-19, 9 were reported to have (90%) required emergency services, 1 (10%) was hospitalized, and none required critical care services, mechanical ventilation, or non-invasive respiratory support Table 4.

Antibacterial use

The frequency of antibacterial administration were similar in both groups [611 (14.0%) versus 110 (16.1%), p = 0.142].

Discussion

We hypothesized that mitigation strategies implemented throughout the United States in order to reduce the spread and impact of COVID-19 have resulted in a decrease in acute bronchiolitis diagnoses, emergency department services, hospitalizations, critical care services, and mechanical ventilation. Utilizing the TriNetX EHR database of more than 30 healthcare organizations nationally, we found that while there was a six-fold decrease in diagnoses and hospitalizations overall, there was still a significant proportion of children that required hospitalization upon those infected. This implies that, while the total number of children infected was markedly decreased, the severity of illness of those impacted was similar. These
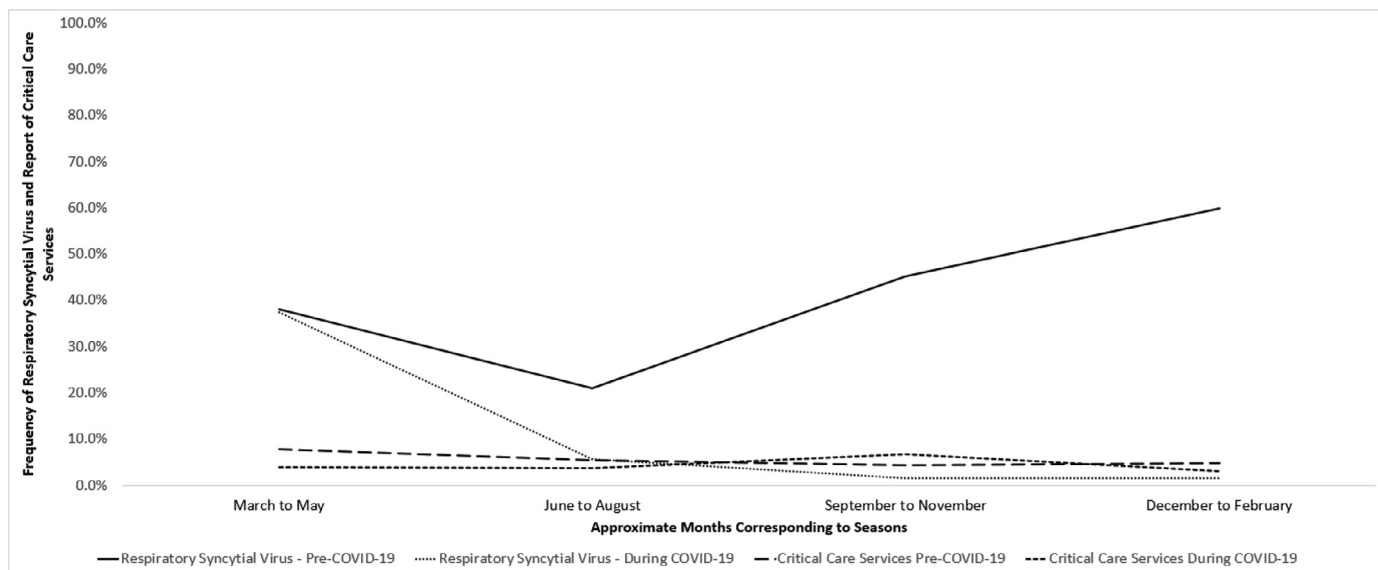

Fig. 1. Seasonality of respiratory syncytial virus and report of critical care services.

Table 3
Seasonal virus rates, critical care services, mechanical ventilation, and non-invasive respiratory support reported.

	March to May		June to August		September to November		December to February	
	Pre-COVID	During COVID	Pre-COVID	During COVID	Pre-COVID	During COVID	Pre-COVID	During COVID
Viruses								
Adenovirus	2 (1.3%)	3 (0.7%)	2 (1.0%)	4 (7.5%)	8 (0.7%)	2 (1.5%)	17 (0.6%)	1 (1.5%)
Coronavirus	1 (0.6%)	2 (0.5%)	0 (0.0%)	0 (0.0%)	3 (0.3%)	0 (0.0%)	25 (0.9%)	0 (0.0%)
Coronavirus-2019	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (5.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	7 (10.4%)
Coxsackie Virus	0 (0.0%)	1 (0.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Enterovirus	11 (7.1%)	11 (2.5%)	3 (1.5%)	4 (7.5%)	26 (2.4%)	11 (8.3%)	31 (1.1%)	4 (6.0%)
Human metapneumovirus	5 (3.2%)	16 (3.7%)	3 (1.5%)	0 (0.0%)	5 (0.5%)	0 (0.0%)	45 (1.5%)	0 (0.0%)
Influenza	2 (1.3%)	6 (1.4%)	0 (0.0%)	0 (0.0%)	10 (0.9%)	0 (0.0%)	86 (2.9%)	0 (0.0%)
Parainfluenza	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.1%)	0 (0.0%)	2 (0.1%)	0 (0.0%)
Pertussis	0 (0.0%)	0 (0.0%)	1 (0.5%)	0 (0.0%)	2 (0.2%)	0 (0.0%)	3 (0.1%)	0 (0.0%)
Rhinovirus	6 (3.9%)	4 (0.9%)	1 (0.5%)	2 (3.8%)	5 (0.5%)	3 (2.3%)	11 (0.4%)	3 (4.5%)
Respiratory Syncytial Virus	59 (38.1%)	162 (37.5%)	43 (21.0%)	3 (5.7%)	495 (45.2%)	2 (1.5%)	1748 (59.8%)	1 (1.5%)
Viral and Chlamydial	1 (0.6%)	1 (0.2%)	1 (0.5%)	1 (1.9%)	1 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Medical Services								
Critical Care Services	12 (7.7%)	17 (3.9%)	11 (5.4%)	2 (3.8%)	48 (4.4%)	9 (6.8%)	140 (4.8%)	2 (3.0%)
Mechanical Ventilation	6 (3.9%)	4 (0.9%)	0 (0.0%)	0 (0.0%)	4 (0.4%)	0 (0.0%)	28 (1.0%)	0 (0.0%)
Non-Invasive Respiratory Support [CPAP]	8 (5.2%)	7 (1.6%)	6 (2.9%)	0 (0.0%)	10 (0.9%)	0 (0.0%)	42 (1.4%)	0 (0.0%)

Table 4
Summary of common procedural services and encounter types.

	pre-COVID-19 pandemic	During COVID-19 pandemic	p value
Common Procedural Services (n,%)			
Critical Care Services	211 (4.8%)	30 (4.4%)	0.699
Mechanical Ventilation	38 (0.9%)	4 (0.6%)	0.649
Non-Invasive Respiratory Support [CPAP]	66 (1.5%)	7 (1.0%)	0.391
Encounters (n,%) [a]			
Emergency	3006 (68.7%)	489 (71.4%)	0.155
Inpatient	1515 (34.6%)	217 (31.7%)	0.141
Ambulatory	578 (13.2%)	92 (13.4%)	0.856

[a] The encounter sum is greater than the total number within the cohort due to some subjects that were reported to have more than one encounter type on the same visit date (698 Pre-COVID, 108 During-COVID).

findings, nevertheless, may have important implications in how we address other respiratory viruses in children in the future.

Severe acute bronchiolitis is associated with various co-morbidities. Infants who are infected may require invasive mechanical ventilation which places the patient at risk of barotrauma and ventilator-associated infections [14,15]. To avoid accidental extubation while ventilated and to assist with the patient's comfort, sedatives are often initiated which may result in withdrawal upon discontinuation [16]. Finally, related to acute bronchiolitis itself, there is a possibility it may be associated with long-term impact on pulmonary function and prolonged bronchial activity [17,18].

In this present study, we found that during the time period where various mitigation strategies (including public masking and social distancing) were implemented, the frequency of acute bronchiolitis diagnoses was reduced. This is in line with regional data currently reported [10]. But, in addition to a reduction in diagnosed acute bronchiolitis, there were less reported hospitalizations and likely a reduction of hospital resource use. These findings confirm that mitigation strategies assist in reducing the burden on hospital systems from not only COVID-19 but other respiratory viral illnesses as well.

We also found, however, that despite the reduction in cases, subjects who were diagnosed with acute bronchiolitis appeared to still have symptoms severe enough to require hospitalization, mechanical ventilation, and critical care services. This implies that the mitigation strategies employed may only serve to conserve hospital resources and may not limit the severity of illness of common respiratory viral illnesses. Future studies are needed to evaluate the clinical factors and risk of mortality to truly understand the effects of mitigation strategies employed during the COVID-19 pandemic.

A small proportion of subjects in our cohort were concomitantly diagnosed with COVID-19 and viral bronchiolitis (with no reported co-infection) and in these cases, they were not reported to require critical care. There are several possible reasons for these findings. While viral bronchiolitis may be associated with COVID-19, the frequency may be rare [19,20]. Children may be less likely to develop critical illness or concerning symptoms (i.e. viral wheeze) from COVID-19 prompting a medical evaluation [21−23]. Finally, the presence of a non-COVID respiratory viral infection may interfere or block infection from other viruses (including COVID-19) [24].

Limitations

There are several limitations to this study. Due to database limitations, the accuracy of the diagnoses could not be confirmed with radiological or virology data. It is also unknown if there were other diagnoses and/or procedures present that were not coded. Subjects may have received care at one institution which was continued in another institution not part of the TriNetX research network. To ensure patient privacy, the location of the healthcare organizations was not reported by TriNetX. Therefore, we were unable to confirm the type of mitigation strategies employed as well as the timing. Admission dates and discharge dates were not provided, thus the length of hospitalization was unable to be evaluated. Limitations of this database prevented us from performing a closer examination of this patient population. It is unknown if the severity of illness was truly elevated or reduced based on the clinical data that was available. For instance, due to limitations in procedural coding, we were unable to determine the type of respiratory support applied in order to gage severity.

Conclusions

During the COVID-19 pandemic, less infants were diagnosed with acute bronchiolitis but the frequency of emergency department services, hospitalization, and mechanical ventilation were similar. Longer-term studies are needed to evaluate the benefits of COVID-19 mitigation strategies.

Declaration of Competing Interest

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.resmer.2022.100909.

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