

The Changing Virology and Trends in Resource Utilization for Bronchiolitis since COVID-19

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Abstract

Background: Bronchiolitis is a viral respiratory illness most commonly caused by respiratory syncytial virus (RSV). COVID-19 disrupted typical patterns of viral transmission. Our study aimed to compare low value care for bronchiolitis in a tertiary emergency department (ED) in the United States over the previous five years. **Methods:** This was a descriptive cohort study through a retrospective chart review from 2017-2022 analyzing ED visits for bronchiolitis including disposition, disease severity, chest radiographs, albuterol, and high flow nasal cannula. A year was a 12 month period from March to February. **Results:** In the three years prior to the pandemic, there were over 2000 ED visits for bronchiolitis per year (3.1% of all ED visits), which decreased to 450 visits for bronchiolitis (1% of all visits) in 2020. Human rhino/enterovirus was the most common virus detected (92%). Admission rates, albuterol use, high flow nasal cannula use, and chest radiographs were all higher during the first year of the pandemic. The summer of 2021 had the highest visits across the 5 study years (2743, 4.0% of all visits) with a return to previous rates of resource utilization. **Conclusions:** During the early pandemic, measures to halt the spread of COVID-19 also altered the transmission of RSV and emergency visits for bronchiolitis. There was an increase in lower value care while the volume was low and rhinovirus was the dominant virus detected. As restrictions lifted in 2021, there was a large resurgence of RSV in the atypical summer months with a return of previous rates of resource utilization.

Introduction

Bronchiolitis is a common disease affecting children from infancy to 24 months with inflammation and mucous production in the distal bronchioles that can progress to significant respiratory distress [1-3]. It is most commonly due to respiratory syncytial virus (RSV) but can be caused by numerous other viruses including human rhinovirus, metapneumovirus, influenza, adenovirus, coronavirus, and parainfluenza virus [3-5]. Bronchiolitis is the most common cause of hospitalizations for infants less than 12 months of age and incurs a large financial burden on the United States health system at over \$400 million dollars per year [3, 6]. According to the Centers for Disease Control, traditionally RSV peaks in December through March in North America with some regional variations. The treatment is largely supportive, and guidelines recommend against routine use of chest radiographs, albuterol, steroids, and corticosteroids [1]. More recently, evidence does not support early use of high flow nasal cannula in mild to moderate bronchiolitis [Franklin 7, Keprotos 8]. Despite these guidelines, use is widespread and recently was the target of a national quality improvement project [Byrd 9].

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2 or COVID-19) developed in late 2019 and quickly spread globally in the spring of 2020, causing a worldwide pandemic [10]. Many measures and practices were put in place to try to slow the spread including social distancing, increased hand hygiene, face coverings in public places, “Stay at Home Orders”, and mandatory closures of many businesses and schools. Early on in the pandemic, emergency departments saw a significant decline in patient encounters, including a decline in pediatric visits for respiratory complaints [11]. A sharp decline in bronchiolitis was noted in the Southern Hemisphere while COVID-19 cases were rising [12]. A decrease in RSV cases continued worldwide

during the first year of the pandemic in 2020 to early 2021 [4, 12-15]. Previous studies have focused on all emergency department (ED) visits or just inpatient visits during the pandemic, but there is a lack of information about changing patterns of bronchiolitis ED visits after more recent rebounds, as well as how the changing volumes affect typical emphasis of decreasing low value interventions.

This descriptive study aimed to compare bronchiolitis visits at a large tertiary care pediatric ED in the southeast United States after the onset of COVID-19 compared to the three years prior. Secondary aims included comparing markers of visit acuity, virology, resource utilization and general demographics of the study population to determine if bronchiolitis ED visits consumed more resources after the onset of the pandemic.

Materials and Methods

This study was a retrospective cohort study performed at a tertiary children’s hospital in the Southeastern US with annual ED visits of 74,000 before the pandemic. All emergency department visits for patients under 24 months of age from March 2017 through February 2022 with an ICD-10 diagnosis code for bronchiolitis (J.21) coded at any time during their hospital stay. There were no exclusion criteria. Demographic information including age, gender, race and ethnicity were collected from the medical record. Visit information including acuity (based on triage Emergency Severity Index level), disposition (admitted, discharged, expired), admission unit, use of high flow nasal cannula, albuterol, and chest radiographs during ED visit or after admission, along with viral respiratory testing results were extracted. Viral respiratory testing from nasopharyngeal swabs included three possible panels that could be ordered at the prescriber’s discretion including a viral respiratory panel (VRP) polymerase chain reaction that tested for 15 common viruses as well as Sars-CoV-2, RSV, and influenza antigen detection, and a rapid BioFire® FilmArray® respiratory panel. Human rhinovirus is not distinguished from other enteroviruses on these tests and is reported as “rhino/enterovirus.” Data from the three years prior to the pandemic (2017, 2018, 2019) were compared with “pandemic years” 2020 and 2021. A year was a 12 month period from March to February to help align with the emergence of COVID within the United States in March of 2020.

Basic database management and analysis of descriptive statistics were performed using Excel and SSPS statistical software. Comparisons of differences among and within the 5 year study samples were accomplished using the One Way ANOVA with post hoc pairwise multiple year comparisons using Tukey’s HSD at $\alpha = 0.05$. For nonparametric group analyses, Kruskal-Wallis ANOVA with the post hoc multiple group Bonferroni correction with an α of 0.005 was used. Year to year comparisons of the proportions of use of therapies, medications, orders or unit specific admissions was performed using a 95% confidence interval estimation of the differences of proportions (no continuity correction). Intervals of the difference in proportions not inclusive of 0 were considered statistically significant at $p < 0.05$. This study was approved by the University of Alabama at Birmingham Institutional Review Board under exempt category four, protocol number IRB-300006644-004. The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

Results

In the three years prior to the pandemic, there were over 2000 ED visits for bronchiolitis per year, averaging 3.1% of all visits seen (Table 1). In 2020, there were 450 visits for bronchiolitis, representing 1% of all ED visits, a statistically significant decrease in mean bronchiolitis visits over the 5 years of study, ($F = 4.5$, $p = 0.003$). All years had higher mean bronchiolitis visits compared to 2020, Tukey’s HSD for year to year comparisons, ($\alpha = 0.05$), |2017 vs 2020|=146.4167 ($p = 0.0358$); |2018 vs 2020|=149.75 ($p = 0.03$); |2019 vs 2020|=157.6667 ($p = 0.0196$); |2020 vs 2021|=191.0833 ($p = 0.0027$). In the second year of the pandemic (2021), bronchiolitis visits had the highest proportion of ED visits for the 5 study years at 4% in addition to having the highest number of visits (2743 visits). Race/ethnicity, gender and age were similar between study years. There was an increase in rates of patients with bronchiolitis admitted to the hospital in the first year of the pandemic at 44% but returned to previous rate of 38% the following year. Viral testing was performed on 11% of patients on average, which increased to 35% during the pandemic but again decreased the year after.

In the pre-pandemic period (2017-2019), RSV was positive in 43% of samples versus 29% in the pandemic period (2020-2021) ($z=4.9$, $p<0.0001$). In 2020 alone only 4% of viral testing was positive for RSV, followed by a sharp rebound to 63% in 2021-2022 (Table 1 and Figure 2). Rhino/enterovirus was detected in 92% of viral samples in 2020 (Table 1 and Figure 1). While there were no patients diagnosed with bronchiolitis with COVID-19 through the first year of the pandemic, 31% tested positive in the second year (Table 1 and Figure 1).

Multiple measures were analyzed to assess acuity of visits including estimated severity index (ESI), admission unit and use of high flow. There was no difference in ESI scores pre-pandemic compared to pandemic; median ESI's were 3 for all study years except for 2018 with median ESI of 4 (Table 1). During 2020, 22% of patients with bronchiolitis were admitted to the ICU, which represented a significant increase ($p<0.05$) compared to all other study years (Table 2). In the second year of the pandemic, only 9% of patients were admitted to the ICU. There was a statistically significant increase ($p<0.05$) in high flow usage in 2020 with 23% of patients being placed on high flow. Chest radiographs increased in the first year of the pandemic compared to the other study years with 37% compared to 24%-31% in other years. Albuterol use in 2020 was 29%, compared to 15% in 2021 and 20% and 24% in the 2 years prior to the pandemic.

In addition to changes in overall yearly visit numbers, there was a shift in the seasonality of visits (Figure 2). Higher numbers of bronchiolitis visits were seen in late fall and winter in the pre-pandemic years. During the first year of the pandemic, there was a uniform decrease in visits for bronchiolitis, with the exception of March 2020. In 2021, there is a spike in bronchiolitis in the summer months of June and July with almost 500 visits each month and lower numbers during the winter months.

Discussion

COVID-19 nearly erased bronchiolitis and RSV infections within our emergency department during the first year of the pandemic, with over 80% reduction in bronchiolitis visits from the year prior. While all ED visits fell, the proportion of visits due to bronchiolitis also decreased. The marked decline in respiratory illness is likely multi-factorial and is hypothesized to be largely driven by social distancing, hand hygiene, masking, and Stay at Home Orders [11]. This trend was also noted in other parts of the world including Belgium, New Zealand, Brazil, France, and the US [12-15]. While other studies have focused on ICU patients or all cause ED visits, this study adds detailed information with a large cohort of bronchiolitis ED visits in the Southeastern US with measures of resource utilization and changes in virology as cases of bronchiolitis fell dramatically and then rose sharply.

The 2014 AAP Guidelines for the management of bronchiolitis recommends against routine chest radiographs and albuterol use [1]. Despite this, over use still occurs in many hospitals. The pandemic brought about many changes in how respiratory illnesses were acutely managed due to the novelty of COVID-19 and fears that it would be more severe in young children. However, none of the patients in 2020-2021 actually tested positive for COVID. Increased use of high flow, albuterol, chest radiographs and ICU admissions for bronchiolitis were seen during the lower volume period when rhinovirus was the dominant pathogen detected. Other studies have shown that providers are more likely to utilize diagnostic tests and medications once high flow is initiated, and increased use of low value care for bronchiolitis during lower census periods has been described [18, 19]. Prior studies have not shown an increase in bronchiolitis severity during this time [20]. In 2021-2022, 31% of patients tested had COVID, a substantial increase likely reflecting increased lower respiratory symptoms with changing variants, but albuterol and decreased. The resurgence of bronchiolitis after such a dramatic decrease means this disease is likely never going to completely disappear. Ironically, concentrating quality improvement efforts into periods of low census for a disease may have more impact.

This hospital saw a stark change in the virology of patients seen in the ED with bronchiolitis over the course of the study period. There was an initial disappearance of RSV in the first year of the pandemic with only four RSV cases identified in 2020 among our study population. An atypical summer spike in RSV in 2021 followed, which is likely the primary driver in the increased bronchiolitis visits. The summer ED visits were almost as high as the winter of the last typical season in 2019. During the low volume year of 2020,

rhino/enterovirus was the predominant virus detected by percentage, though the raw number detected was relatively similar to previous years. It is possible that more rhinovirus was detected due to higher testing rates, which increased by 23% from the year prior. Rhinovirus is often found to be a co-infection with a large number of asymptomatic carriers but is also known to cause bronchiolitis, especially associated with wheezing, and may be an early predictor of asthma [21-24]. It is possible that more albuterol was used during this time due to more rhino/enterovirus induced wheezing heard on exam.

The dominance of rhino/enterovirus during the emergence of the pandemic and the disappearance of RSV raises important questions about how the transmission of this virus was affected by efforts to slow the spread of COVID. RSV is an enveloped, single-stranded, negative-sense RNA virus of the Pneumoviridae family and is transmitted via droplet [24]. Because of its enveloped structure, RSV is more affected by hand washing than the non-enveloped structure of rhinovirus, which has a moderate resistance to hand sanitizer [24, 25]. RSV's main reservoir is in chronic obstructive pulmonary disease and immunocompromised hosts, whereas rhinovirus is often carried and spread by asymptomatic healthy children [1, 25]. Hand washing was heavily stressed as a non-pharmaceutical intervention during the pandemic and could have decreased RSV transmission but would not have the same impact on rhinovirus. The relative resilience of rhinovirus during the pandemic likens it to the cockroach of viruses- one that never completely disappears and survives most extinguishing efforts.

Immunity to RSV is complex. For infants, the transfer of maternal antibodies can help protect them in the first couple months of life [27]. Adults also need continued antigenic exposure, as it has been shown there is a loss of RSV-specific IgA memory B-cells, usually in the summer months when RSV is dormant [27]. It is reasonable to hypothesize there was decreased maternal antibody transfer to infants by mothers who were pregnant during the early COVID pandemic and were not being exposed to RSV antigens. Therefore it is not surprising there was a large, atypical RSV spike in the summer of 2021 (Figure 2) when there was likely a large population of infants and toddlers who were immunologically naive to RSV being exposed for the first time. As COVID precautions relaxed in the spring of 2021, RSV was able to have a strong resurgence. The rise in bronchiolitis visits in the summer of 2021 also followed the end of the state mask mandate in this state, which expired in April of 2021. In the future, we will see if this shift in RSV seasonality persists with bronchiolitis becoming a relatively steady year-round illness, or return to previous seasonal norms. This could influence the timing of Synagis given to eligible infants, as it is currently only available during the winter months. It also remains to be seen if other Sars-CoV-2 variants will cause more respiratory illness in this population, as is suggested by the upwards trend in 2021-2022.

This study is limited by being a single-institution, retrospective study. The diagnosis of bronchiolitis was based on ICD-10 coding only and testing from other sources prior to admission were not included. The increased ICU admission rate for bronchiolitis is difficult to interpret as ICU admission criteria changed such that all patients on high flow nasal cannula were admitted to the ICU instead of the step-down unit until their COVID test resulted until November 2020, though the numbers were very small. During 2021 this hospital participated in a Value in Inpatient Pediatrics high flow initiation reduction quality improvement project (HIFLO), which may account for some of the decreased high flow rate from 2020 to 2021. Internal quality improvement projects targeted albuterol use which likely accounts for the sharp decrease from 2017 to 2018.

In summary, COVID-19 had a significant impact on bronchiolitis emergency department visits in overall number, admission rates, an increase in low value care, and virology, while not being the predominant driver of respiratory disease in young children.

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