

Unexpected decline in pediatric asthma morbidity during the coronavirus pandemic

Lisa Ulrich MD^{1,2}  | Charlie Macias MHA³ | Ashish George DO¹  |
Shasha Bai PhD^{4,5} | Elizabeth Allen MD^{1,2}

¹Section of Pulmonary Medicine, Nationwide Children's Hospital, Columbus, Ohio, USA

²Department of Pediatrics, The Ohio State University College of Medicine, Columbus, Ohio, USA

³Quality Improvement Services, Nationwide Children's Hospital, Columbus, Ohio, USA

⁴Biostatistics Resource at Nationwide Children's Hospital, Columbus, Ohio, USA

⁵Department of Biomedical Informatics, College of Medicine, The Ohio State University, Ohio, USA

Correspondence

Lisa Ulrich, MD, Section of Pulmonary Medicine, Nationwide Children's Hospital, Columbus, 700 Children's Dr, Columbus, Ohio, USA.

Email: lisa.ulrich@nationwidechildrens.org

Abstract

The Coronavirus disease 2019 (COVID-19) pandemic profoundly impacted health care utilization. We evaluated asthma-related emergency department (ED) and inpatient health care utilization by a county-specific Medicaid population, ages 2–18, during the COVID-19 pandemic and compared it to utilization from a 3-year average including 2017–2019. All-cause ED utilization and asthma medication fill rates were evaluated during the same timeframes. Relative to the 2017–2019 3-year average, cumulative asthma-related ED visits from January through June decreased by 45.8% ($p = .03$) and inpatient admission rates decreased by 50.5% ($p = .03$). The decline in asthma-related ED utilization was greater than the reduction of overall ED use during the same time period, suggesting that the decline involved factors specific to asthma and was not due solely to avoidance of health care facilities. Fill rates for asthma controller medications decreased during this time ($p = .03$) and quick relief medication fill rates had no significant change ($p = .31$). Multiple factors may have contributed to the decrease in acute asthma health care visits. Locally, decreased air pollution and viral exposures coincided with the “Stay-at-home” order in Ohio, and increased utilization of telehealth for assessment during exacerbations may have impacted outcomes. Identification of the cause of the decline in visit rates could spur new interventions to limit the need for ED and inpatient visits for asthma patients, leading to both economic and health-associated benefits.

KEYWORDS

asthma, coronavirus, health care utilization, pandemic

1 | INTRODUCTION

Cases of novel coronavirus were first reported in Wuhan, Hubei province, China, in December 2019.¹ The Coronavirus disease (COVID-19) was declared a worldwide pandemic on March 11, 2020 by the World Health Organization.² While adult hospitals worked to increase patient capacity to accommodate COVID-19 patients during this time, pediatric hospitals saw patient volumes decrease.³ Initial reports from London,⁴ Boston,⁵ and Philadelphia^{6,7} suggest that acute asthma visits declined as well. This significant decline in pediatric asthma health care utilization has not been confirmed elsewhere in the United States.

At Nationwide Children's Hospital in Columbus, Ohio, asthma contributes to a significant portion of emergency department (ED) and inpatient (inpatient) visits. As part of a larger quality improvement project the hospital routinely monitors ED and inpatient admission rates for children with asthma in a pediatric accountable care organization Partners for Kids (PFK).⁸ In response to the spread of viral infection to the United States, the state of Ohio closed schools on March 14, 2020 and enacted a “Stay at Home” order limiting all nonessential travel from the home March 22, 2020–May 29, 2020.⁹ We hypothesized that the rates of ED and inpatient visits for asthma would decrease during the COVID-19 pandemic.

We aimed to compare baseline ED and admission rates for asthma in PFK patients at our institution to rates during the COVID-19 pandemic. We also investigated pharmacy fill rates of asthma-related controller and reliever medications (short acting β -agonists), looking for possible association with health care utilization rates.

2 | MATERIAL AND METHODS

The Nationwide Children's Hospital (NCH) is a large, 527-bed free-standing tertiary referral center in an urban setting in Franklin County, Ohio with over 18,000 patients discharged annually. Franklin County has an estimated population of 1,326,756 in 2019 with 23.2% under the age of 18.¹⁰ NCH participates in the care of more than 325,000 Medicaid managed care patients in PFK, one of the largest nonprofit accountable care organizations in the United States.¹¹ Nearly 50% of these patients live in Franklin County. All PFK patients located in Franklin County, Ohio between the ages of 2–18 years old were included in the study.

The electronic medical record (EMR) was used to identify patients in this population with ED and inpatient visits for asthma, International Classification of Diseases, Tenth Revision code J45.nn, as listed on the visit's diagnostic discharge information. Data was collected monthly and was displayed in year-long cumulative line graphs. In these graphs each time point is inclusive of January through the labeled month. (E.g., the data point for April reflects total resource use from January through April.) This graph type was utilized to reduce effect of the month to month fluctuations caused by seasonal variation in asthma. ED visit rates were displayed as ED visits per 1000 members. Inpatient visits were displayed as cumulative year to date inpatient visits per 1000 members. Both ED and inpatient data was based on annualized member-months, a product of total monthly enrollment of patients 2–18 years old in Franklin County covered by the Medicaid managed care plan and the number of months in the plan.¹² Baseline data was established from a 3-year average of ED and inpatient rates from 2017 to 2019 to avoid effects of single year variation. These were compared to 2020 rates January through June, including after the COVID-19 restrictions were put into place in Franklin County, Ohio from March to June 2020.

The rate of ED visits with any discharge diagnosis (not limited to asthma) at NCH for all PFK patients between the ages of 2 and 18 years old in Franklin County was also evaluated during the same timeframes. Data was collected monthly from the EMR and was displayed in similar cumulative line graphs.

Pharmacy billing information regarding asthma controller and reliever (short-acting β -agonist) medications filled for covered patients aged 2–18 living in Franklin County was obtained from PFK. Data was displayed in similar cumulative line graphs. Prescription counts were based on the number of days supply for the script, so that a script with days supply of less than 60 counts as one fill, and a script with days supply between 60 and 89 counts as two fills, and so on. Medication lists were updated to reflect new Healthcare Effectiveness Data and Information Set (HEDIS) recognized asthma therapies that became available during the years studied.

This study did not meet the definition of human subject's research and IRB approval was waived.

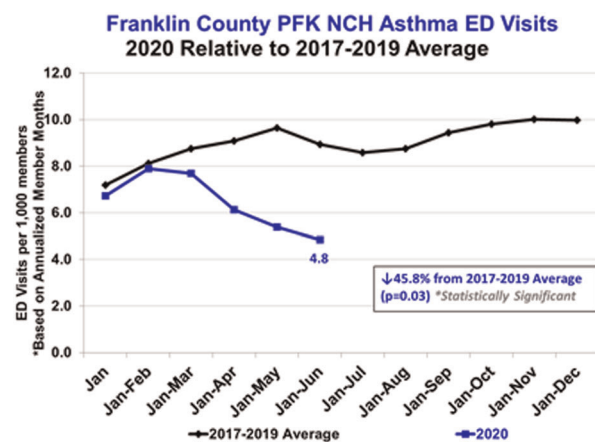
2.1 | Statistical analysis

Statistical comparisons were conducted for ED visit rates for all diagnoses, asthma ED visit rates, cumulative year to date asthma inpatient visit rates, and medication fill rates for asthma controller and quick relief medications between 2020 and the 3-year average 2017–2019. The *p*-values were derived from a nonparametric Wilcoxon Signed-rank test for the single center at Nationwide Children's Hospital. This statistical procedure is commonly used for pre- versus post-test. A *p* < 0.05 indicated statistical significance. Statistical computing was implemented using R version 4.0.3.¹³

3 | RESULTS

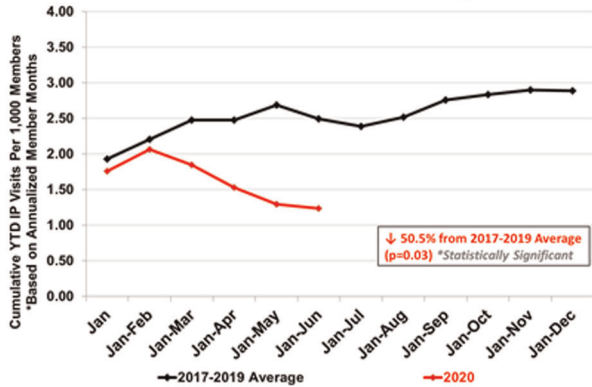
The size of the PFK Franklin County population ages 2–18 was stable between 2017 and 2020, ranging from 121,000 to 125,000 members. From January to June there was a total of 636 ED visits for asthma in 2017, 614 in 2018, and 590 in 2019. There were 166 inpatient admissions for asthma in 2017, 182 in 2018, and 177 in 2019 from January to June. Inpatient and ED visits with a primary diagnosis of asthma by PFK patients in Franklin County in January–February 2020 were similar to those seen in 2017–2019. ED and inpatient visits started to decline after school closures and the initiation of the “Stay at Home” Order in Ohio. By June 2020, the ED visit rate for this population decreased by 45.8% when compared to the 2017–2019 3-year average (*p* = .03) (Graph 1). Inpatient admission rates decreased by 50.5% compared to the 3-year average (*p* = .03) (Graph 2).

The rate of ED visits for PFK patients with any diagnosis (not limited to asthma) seen at NCH also declined but less so than was



GRAPH 1 Franklin County PFK NCH asthma ED visits. ED, emergency department; NCH, Nationwide Children's Hospital; PFK, partners for kids [Color figure can be viewed at wileyonlinelibrary.com]

**Franklin County PFK NCH Asthma Inpatient Visits
2020 Relative to 2017-2019 Average**



GRAPH 2 Franklin County PFK NCH asthma inpatient visits. ED, emergency department; NCH, Nationwide Children's Hospital; PFK, partners for kids [Color figure can be viewed at wileyonlinelibrary.com]

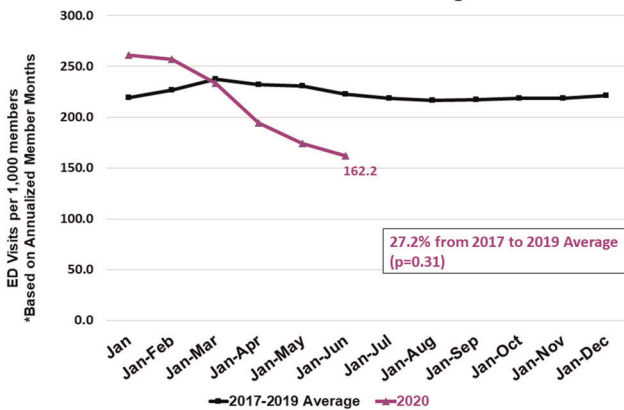
seen with the asthma discharge diagnosis code. A 27.2% decline was noted in ED visits 2020 compared to the 2017–2019 average of ED visits (Graph 3). This decline was not statistically significant ($p = .31$).

Reliever medication fill rates for Franklin County PFK patients aged 2–18 declined by 16.8% in 2020 compared to the 2017–2019 average, but this decline was not statistically significant ($p = .31$) (Graph 4). Controller medication fill rates did decline significantly by 17.4% ($p = .03$) (Graph 5).

4 | DISCUSSION

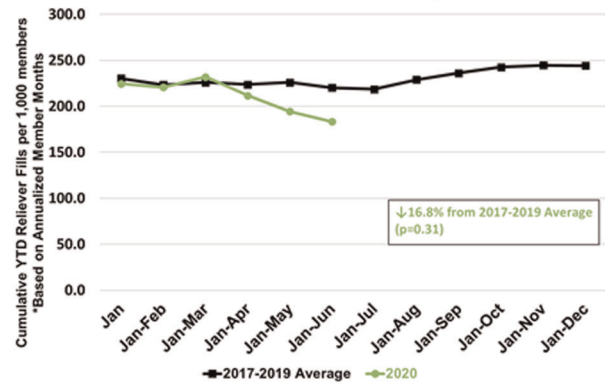
Asthma contributes significantly to health care utilization in the United States. It is estimated that asthma costs the US economy about \$80 million annually in medical expenses, missed work/school days, and deaths.¹⁴ Pediatric ED and inpatient rates for asthma

**Franklin County PFK All Cause NCH ED Visits
2020 Relative to 2017-2019 Average**



GRAPH 3 Franklin County PFK NCH all cause ED visits. ED, emergency department; NCH, Nationwide Children's Hospital; PFK, partners for kids [Color figure can be viewed at wileyonlinelibrary.com]

**Franklin County PFK NCH Asthma Reliever Fills
2020 Relative to 2017-2019 Average**

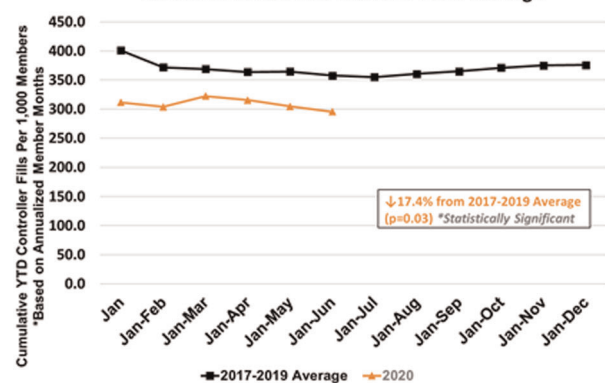


GRAPH 4 Franklin County PFK NCH asthma reliever fills. NCH, Nationwide Children's Hospital; PFK, partners for kids [Color figure can be viewed at wileyonlinelibrary.com]

dropped drastically for Franklin County PFK patients at NCH after the start of the COVID-19 pandemic, coinciding with school closures and implementation of the Ohio “Stay at Home” order. Statistically significant decreases of 45.8% and 50.5% in ED and inpatient visit rates, respectively, were noted when compared to the 2017–2019 average in this population. ED visit rates for PFK patients with all diagnoses also declined but not to the degree seen with asthma exacerbation visits. This decline did not reach the level of statistical significance. Medication fill rates for controller medications declined and acute reliever therapies had no significant change during the same time period.

Our study adds to the available literature on decreased asthma health care utilization during the pandemic by evaluating January–June 2020 ED and inpatient rates compared to a 2017–2019 average within a defined, measurable patient population. It also includes evidence of medication fill rates in the same population to address concerns with medication adherence. By providing

**Franklin County PFK NCH Asthma Controller Fills
2020 Relative to 2019 and 2017-2019 Average**



GRAPH 5 Franklin County PFK NCH asthma controller fills. NCH, Nationwide Children's Hospital; PFK, partners for kids [Color figure can be viewed at wileyonlinelibrary.com]

historic health care utilization data illustrating the seasonality of acute asthma visits, as well as variability from year to year, our approach more graphically illustrates the degree to which 2020 has departed from normal illness patterns. These results are likely generalizable to other similar Medicaid populations, and potentially non-Medicaid populations, as they are similar to previous results including both populations.⁶ Further evaluation is required at our institution to confirm generalizability to the non-Medicaid population.

While COVID-19 data was not available as part of our PFK-centered asthma quality improvement database, previous pediatric studies have shown that children accounted for less than 5% of total COVID-19 infections and they tended to have less severe manifestations of COVID-19.^{15,16} When studied, asthma was not associated with an increased rate of hospitalization with COVID-19.¹⁷ This could explain the lack of increase in patient volume in our pediatric institution during this period.

There are several potential reasons for the decline in visit rates. Air pollution and poor air quality can contribute to increase in asthma symptoms and potentially trigger exacerbations.¹⁸ Pollution related to road traffic has been linked to asthma exacerbations, along with other pollutants.¹⁹ During the COVID-19 pandemic, air quality was improved in many major urban cities with "Stay At Home" orders limiting nonessential travel.²⁰ Franklin County, a mostly urban county with 800 miles of roads,²¹ also saw an improvement in the Air Quality Index (AQI), in March–May 2020 when compared to March–May 2019 but further studies are needed to determine the definitive etiology of this improvement.^{22–24} The AQI, established by the United States Environmental Protection Agency, is used to evaluate five major pollutants including ground-level ozone, particle pollution, carbon monoxide, sulfur dioxide, and nitrogen dioxide.²⁵

Viruses are another common cause of asthma exacerbation in children.²⁶ Asthma exacerbation prevalence tends to increase as schools reopen in September and children are exposed to more viral illnesses.²⁷ School closures and the Ohio "Stay at Home" order, prohibiting all large gatherings, likely resulting in decreased viral exposure for children. Children's Hospital of Philadelphia reported a decline in rhinovirus, a common viral pathogen trigger for asthma exacerbations, during the pandemic.⁶ Nationwide Children's Hospital also saw a decline in non-COVID-19 respiratory viral pathogen testing and positivity during this time.²⁸ The decline in viral exposure likely contributed to decrease in asthma exacerbations and need for acute care.

Despite relatively low pediatric infection rates, COVID-19 has caused uncertainty for many parents of children with chronic respiratory conditions. Increased anxiety levels related to COVID-19 were found in the mothers of both healthy patients and patients with cystic fibrosis.²⁹ Caregivers of patients with asthma may also have higher asthma-related anxiety levels due to COVID-19. Previous studies have shown that increased asthma-related anxiety in urban adolescents and their caregivers was associated with an increase in asthma preventative care.³⁰ A 15.3% improvement in adherence to controller (preventative) medication was reported in adult patients with asthma and chronic obstructive pulmonary disease in

conjunction with the pandemic.³¹ Asthma providers estimated, per survey, that their pediatric asthma patients had a 20% improvement in asthma medication adherence during the pandemic.³² Controller medications are effective in preventing asthma exacerbations when taken properly, but adherence rates are typically low.³³ An increase in adherence due to asthma-related anxiety caused by COVID-19 could contribute to the decrease in asthma exacerbations seen. However, in our largely urban, Medicaid patient population between the ages of 2–18 improvements in asthma medication adherence (estimated by pharmacy fill rates) was not seen for controller medications. For our population, improved medication utilization did not appear to contribute to reduced asthma morbidity during the pandemic.

Anxiety related to the pandemic and the potential for COVID-19 exposures in the ED may have caused parents to delay seeking care for their child's asthma exacerbation. A survey by the Kaiser Family Foundation, released May 2020, reported that 48% of Americans had a family member who delayed their medical care during the COVID-19 pandemic.³⁴ While the overall decline in Franklin County PFK population ED utilization suggests this was possibly a factor in Columbus, the greater decline in asthma-specific ED utilization suggests a change in underlying asthma morbidity as well. This is further supported by a lack of increase in acute asthma medication fill rates, which may have otherwise enabled families to avoid ED visits.

Telemedicine became a more widely accepted health care option during the pandemic. Providers conducted medical visits by phone or video visits to allow for the recommended social distancing and limited travel necessary during the pandemic. In 2014, in Houston, TX, telemedicine was shown to reduce unnecessary ambulance transports to the ED when it was performed at the time of an acute medical event.³⁵ Telemedicine visits increased drastically at NCH during the pandemic. It is possible that these visits were used during acute asthma exacerbations to provide a rapid assessment and prevent the need to go to the ED.

Limitations of this study include reliance on EMR discharge diagnosis codes for ED and inpatient for data collection and the possibility of incomplete data if these codes were not entered correctly. We were not able to identify visits to other medical centers for acute asthma care during this study. We were not able to evaluate the demographics of the PFK population more closely to determine if health care utilization differed based on age, asthma severity, or race. This will be an important focus of follow up studies in this population. A small portion of the asthma medication fills included in this report were utilized by patients with a diagnosis other than asthma (e.g., by those with cystic fibrosis). It is unlikely that this nonasthma patient population substantially impacted the trends seen in our data. At the time of this report, information regarding telemedicine visit use for this population was not accessible; we plan to evaluate this factor when this data become available.

The drastic decline in ED and inpatient visit rates for asthma exacerbation was in excess of the decline seen in ED utilization for all diagnoses. We suspect a reduction in respiratory viral illnesses and

potential improved air quality caused by the Stay at Home order during the pandemic contributed to this decline. We did not see evidence of improved asthma medication adherence, based on pharmacy fill rates, that could explain the reduced health care utilization. Identification of factors, such as efforts to reduce respiratory viral contagion, that contribute to the reduction in asthma morbidity may suggest new interventions to improve patient quality of life and reduce the financial health care burden of this common pediatric condition.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

AUTHOR CONTRIBUTIONS

Lisa Ulrich: conceptualization (lead); data curation (equal); supervision (lead); writing original draft (lead); writing review and editing (lead). **Charlie Macias:** conceptualization (equal); data curation (lead); formal analysis (equal); methodology (equal); writing original draft (supporting); writing review and editing (equal). **Ashish George:** conceptualization (supporting); data curation (supporting); investigation (supporting); resources (equal); writing original draft (supporting); writing review and editing (equal). **Shasha Bai:** conceptualization (supporting); formal analysis (lead); methodology (equal); writing review and editing (equal). **Elizabeth Allen:** conceptualization (equal); data curation (equal); formal analysis (supporting); methodology (equal); supervision (equal); writing original draft (equal); writing review and editing (equal).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Lisa Ulrich  <http://orcid.org/0000-0002-7232-2442>

Ashish George  <http://orcid.org/0000-0002-2952-1884>

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