

## Table of Contents

<i>Title Page</i> -----	1
<i>Thesis Summary</i> -----	4
<i>Abstract</i> -----	6
<i>Introduction</i> -----	8
<i>Main Body</i> -----	9
<i>Methods</i> -----	9
<i>Results</i> -----	11
<i>Discussion</i> -----	21
<i>Conclusion</i> -----	24
<i>Reflection</i> -----	26
<i>References</i> -----	28
<i>Appendix</i> -----	38

## Thesis Summary

The COVID-19 pandemic began in January 2019 when the World Health Organization [WHO] announced the presence of an unknown pneumonia-like disease in Wuhan, China. Caused by SARS-CoV-2, the disease began to spread worldwide, being declared as a pandemic by the WHO in March 2019. Prior to the COVID-19 pandemic, asthma was the most common cause of pediatric emergency department visits. Due to the respiratory effects of COVID-19, including coughing and shortness of breath, researchers initially hypothesized that the pandemic would worsen this pattern. However, this was not the case, likely as the impact of mandated social distancing and other COVID-19 prevention strategies were not initially considered.

To explore this multifactorial phenomenon, a scoping review was performed to characterize research focused on pediatric asthma ED visits after the onset of the COVID-19 pandemic. Articles were searched on 3 databases (Embase, CINAHL, and PubMed) using key words (*asthma, emergency/emergency department/emergency room, COVID/coronavirus/pandemic, and pediatric*) that were established after consultation with a university librarian. Ultimately, the 43 articles that were included in the review were categorized into 3 thematic groups (Government Mandated Lockdowns, School Closures, and Environmental Changes).

All but one article showed significant decreases in rates of pediatric ED asthma visits. Reductions were attributed to reduced exposure to asthma triggers (e.g., pollen, air pollution, exercise, upper respiratory infections). Parental anxiety and fear related to the potential for exposure to SARS-CoV-2 may have also contributed to the observed reductions in ED rates. Finally, improvements in asthma outcomes suggest pervasive and intersecting effects of social and structural determinants of health (e.g., biophysical/mental stress related to exposure to

microaggressions/overt racism), as those interactions were likely reduced during stay-at-home mandates. Thus, research regarding COVID-19's impact on pediatric ED visits for asthma exacerbation should continue to be studied.

## **Abstract**

*Background & Objective:* Prior to the onset of the COVID-19 pandemic, the most common reasons for ED visits among children ages 0-18 were acute upper respiratory infections and asthma, a chronic disease that causes narrowing and swelling in the airways of the lungs. Asthma has various triggers, one of the most common being respiratory tract infections that further impair the airways (Busse et al., 2010). Caused by SARS-CoV-2, COVID-19 infection is associated with respiratory symptoms including shortness of breath, congestion, coughing, and sore throat. While there was a sharp decline in the number of total pediatric ED after the pandemic onset, there was also a significant reduction in those related to childhood asthma, an unexpected and seemingly paradoxical outcome. The purpose of this scoping review was to evaluate and characterize research focused on pediatric asthma ED visits after the onset of the COVID-19 pandemic.

*Methods:* A scoping review following the PRISMA-ScR guidelines was completed. After consultation with a university librarian, 3 databases (Embase, CINAHL, and PubMed) were searched using key terms of *asthma*, *emergency/emergency department/emergency room*, *COVID/coronavirus/pandemic*, and *pediatric*. Both authors conducted searches, then met to review articles to determine eligibility for inclusion and extract relevant information. Articles were included if they were data-based research studies examining ED trends between 2019 and 2022 related to asthma exacerbation in children.

*Results:* Of the 187 articles identified, 43 met inclusion criteria. All but one were retrospective studies; one was a prospective cohort study. All but one study demonstrated a significant decline in pediatric ED asthma visits during the pandemic compared to years prior. Many reductions aligned with periods of lockdown and school closures implemented during 2019 and 2020, with

authors concluding that stay-at-home mitigation strategies likely resulted in avoidance of pollen exposures and a resultant decrease in asthma symptomatology. Four studies associated declines in asthma-related pediatric ED visits with improvements in air quality. One study noted children experienced fewer upper respiratory tract infections and febrile episodes that were associated with decreased incidence of asthma exacerbation.

*Conclusion:* Despite the respiratory symptoms associated with COVID-19, global pediatric asthma ED visits were significantly reduced during the pandemic.

## Introduction

In 2019, the COVID-19 pandemic began in Wuhan, China when an outbreak of an abnormal pneumonia-like disease was reported among citizens (Fung Tsang et. al, 2020). Initially designated the “2019 novel coronavirus” by the World Health Organization, SARS-CoV-2, a strain of the species *severe acute respiratory syndrome–related coronavirus*, was identified as the causative agent. COVID-19 infection is associated with a variety of symptoms (e.g., fever, fatigue), including respiratory symptoms of dry cough, shortness of breath, and difficulty breathing (Fung Tsang et. al, 2020). As of March 2023, its rapid contagion has resulted in approximately 759,408,703 deaths worldwide, according to the World Health Organization (World Health Organization [WHO], 2023). Because of the high virulence and easy transmission of the virus via mucosal exposure to respiratory droplets and aerosols, various prevention methods were implemented across the globe, including social distancing, personal protective equipment (PPE) requirements, as well as community lockdowns and stay-at-home orders (Fung Tsang et al., 2020).

Due to many of these isolation protocols, the composition of hospital and doctor visits changed during the pandemic. Since 2019, when the COVID-19 pandemic began, pediatric emergency department visits for all diagnoses fell sharply by 67-74% (Pines et al., 2021). However, prior to the pandemic, the most common reason for emergency department visits among children was acute upper respiratory infection and asthma (Weiss & Jiang, 2018). Asthma is a chronic disease among children in the United States that significantly affects children’s quality of life. Pediatric asthma can result in episodes of wheezing, chest tightness, shortness of breath, and coughing that can take up to a full week to completely resolve (Haktanir & Phipatanakul, 2019). Despite these detrimental health impacts, asthma exacerbations in children

are both treatable and preventable. Common triggers among children that induce respiratory symptoms include exercise, environmental allergens, infection, pollutants, and stress (de Benedictis & Attanasi, 2016). Thus, reducing exposure to these triggers may result in fewer pediatric asthma complications.

Although it is known that the quantity of pediatric asthma visits was reduced during the COVID-19 pandemic, no clear description of the research regarding this phenomenon has been synthesized. Several medical professionals believe that reduced face-to-face interaction due to school closures may have resulted in reduced contagion among children, as well as play/activity-related injuries (DeLaroche et al., 2021). Others have noted that quicker and easier access to medical care and guidance through telemedicine appointments may have prevented the need for trips to the emergency department (Pines et al., 2021). Therefore, the purpose of this scoping review was to identify and characterize research focused on pediatric asthma ED visits after the onset of the COVID-19 pandemic.

## Methods

*Study Design:* A scoping review was completed following the PRISMA-ScR guidelines to examine the impact of the COVID-19 pandemic on pediatric emergency department visits for asthma exacerbation.

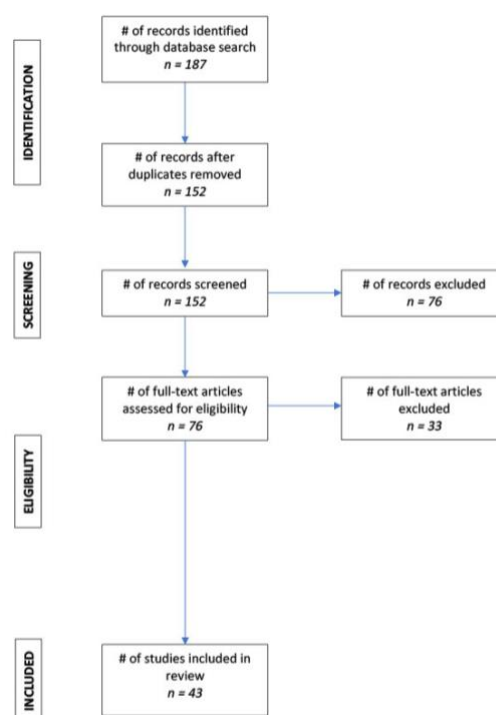
*Study Setting and Population:* A University of South Carolina librarian was consulted to select relevant databases and key terms. Ultimately, three databases (Embase, CINAHL, and PubMed) were utilized to complete an initial literature search using key terms of *asthma*, *emergency/emergency department/emergency room*, *COVID/coronavirus/pandemic*, and *pediatric*. The population resulting from this search consisted of children aged 0-18 in studies based in the United States and 9 international countries (United Kingdom, Italy, Turkey, Israel,

Spain, Japan, Jordan, Ecuador, and Taiwan). These countries were the only locations in which studies related to pediatric ED visits for asthma were found in the literature search.

*Search Protocol:* The first and second authors first conducted independent identification searches. During the initial search, articles were selected for inclusion if they were data-based research studies (e.g., retrospective and prospective observational studies) published between September 2020 and October 2022. The abstracts of included articles were analyzed for relevance to asthma exacerbation in children and inclusion of the key words listed above. Initially, 187 articles were identified in the database search (**Figure 1**).

After the removal of duplicates, 157 articles remained for abstract screening. Based on abstract review, 76 articles were excluded due to their failure to meet inclusion criteria (e.g., study occurred prior to pandemic onset, did not focus specifically on childhood asthma). The 76 remaining articles then underwent independent full text review for eligibility by both authors, after which they met to discuss inclusion criteria and extract relevant information. After the second screening, another 33 articles were excluded due to the absence of data relating to pediatric emergency department visits for asthma exacerbation. Article reference lists were assessed to ensure that the search captured all relevant sources; this resulted in the

inclusion of 1 additional article. The 43 articles selected for inclusion in this review were then



**Figure 1. PRISMA Flow Diagram**



thematically sorted into categories based on the researchers' experimental objectives in relation to the COVID-19 pandemic.

*Article Categorization:* Selected articles were categorized into 3 groups based on their relation to the pandemic. Articles referencing the “lockdown period” collected measures that included weekly and monthly averages of pediatric ED visits for AE, as well as yearly numbers of pediatric ED visits for AE. Several articles also observed daily visit rates for AE in the ED from years before (2010-2019) and during (2019-2020) the pandemic. Next, articles referencing “school closures” collected measures that included asthma ED visit numbers and daily averages in accordance with school closures and the shift to online learning in March before (2018 and 2019) and during (2020) the pandemic. Finally, articles referencing “environmental changes” collected measures that included not only monthly and yearly asthma ED visit rates and averages from years before and during the pandemic, but also measures of PM<sub>2.5</sub>, PM<sub>10</sub>, nitrogen dioxide, sulfur dioxide, and carbon monoxide concentrations, traffic related air pollution levels (TRAP), total virus levels, pollen levels, and temperature.

## **Results**

Of the 43 articles included in this study, all but one were retrospective studies; one was a prospective cohort study. In addition, all but one study demonstrated a consistent and significant decline in pediatric ED visits for asthma during the pandemic compared to years prior. Articles were sorted into 3 thematic categories: government mandated lockdowns (28 articles); school closures (5 articles); and environmental changes as predictors for pediatric asthma ED visits (10 articles).

*Theme 1 – Government Mandated Lockdowns:* Of the 43 included articles, 28 focused on government mandated lockdowns. In this group of articles, authors collected data surrounding

the weekly, monthly, and yearly numbers and/or rates of pediatric ED visits for asthma exacerbation during government mandated lockdowns, social-distancing, and stay-at-home orders were implemented and compared the findings to pre-pandemic data. Pediatric asthma visits to the ED showed significant reductions in 2020 after federal mitigation policies were enforced in the United States, Jordan, Italy, Spain, Israel, and Ecuador compared to 2017-2019 in 27 of the studies included in this group. Only 1 study conducted in Taiwan failed to show a statistically significant difference in ED visits in 2020 compared to 2017-2019 (Lin et al., 2020). The specific findings of each study included in this category can be found in **Table 1**.

*Theme 2 – School Closures:* Five articles explicitly focused on school closures. In this group of articles, authors collected data surrounding the weekly and monthly numbers and/or rates of pediatric ED visits for asthma exacerbation during periods when school closures were implemented and compared the findings to pre-pandemic data. All five studies in this group showed a significant reduction in pediatric asthma visits to the ED in 2020 after local home-based schooling was enforced in the United States and Turkey compared to the same periods in 2016-2019 in 27. The specific findings of each study included in this category can be found in **Table 2**.

*Theme 3 – Changes in the Environment Related to Lockdowns:* Ten articles focused on environmental changes. In this group of articles, authors collected data surrounding the weekly, monthly, and yearly numbers and/or rates of pediatric ED visits for asthma exacerbation in relation to various environmental factors and compared the findings to pre-pandemic data. The environmental factors investigated in this group included PM<sub>2.5</sub>, PM<sub>10</sub>, sulfur dioxide, nitrogen dioxide, carbon monoxide levels, TRAP levels, pollen levels, and virus levels. Pediatric asthma visits to the ED showed significant reductions in 2020 in accordance with declines in particulate

matter, pollen, and airborne viruses in the United States, Taiwan, Italy, China, and Japan compared to previous years in all 10 of the studies included in this group. The specific findings of each study included in this category can be found in **Table 3**.

**Table 1. Summary of articles citing government mandated lockdowns (n=28)**

Authors/Year	Study Setting	Study Aims	Study Design	Key Findings
Al-Hazaymeh, A., et al.; 2021	USA	To examine whether measures of asthma exacerbation, including ED visits, outpatient steroid prescriptions, and documented RV infections, decreased among children and adults at the University of Virginia from March to December 2020.	Retrospective study	The mean number of asthma-related ED visits in April 2020 was 15% of that forecasted based on trends before the pandemic
Al-Iede, M., et al.; 2021	Jordan	To evaluate the impact of a 10-week lockdown on children with asthma aged 4-17 years in terms of presentations to the ED, frequency of admissions, compliance with medications and changes in pulmonary function testing results.	Retrospective cross-sectional study	There was a reduction in ED presentations from 137 visits in 2019 to 80 visits in 2020
Attanasi, M., et al.; 2021	Italy	To compare the number of the PED visits for young allergic patients with respiratory or cutaneous symptoms during the first wave of the COVID-19 pandemic in 2020 with the same period in 2019, evaluating the percentage of positive cases to COVID.	Retrospective study	All PED visits for cutaneous or respiratory symptoms were decreased of 24.1% in 2020 to 14.8% in 2019
Be'er, M., et al.; 2022	Israel	To investigate whether the three nationwide COVID-19 lockdowns imposed in Israel during the full first pandemic year altered the traditional seasonality of pediatric respiratory healthcare utilization.	Retrospective study	The rate of respiratory ED visits for asthma out of total monthly visits peaked in June 2020
Bover-Bauza, C., et al.; 2021	Spain	To analyze the impact of the COVID-19 pandemic and lockdown measures on the ED in the pediatric asthmatic patient.	Retrospective observational study	Visit rates for wheezing decreased from 84.4 in 2019 to 15.6 in 2020
Chavassea, R., et al.; 2020	England	To review the numbers of acute hospital presentations with wheeze/asthma in children aged 1–17 years of age over the four weeks prior to the UK national lockdown in March 2020 and the 8 weeks afterwards.	Retrospective study	In 2020, prior to the lockdown, an average of 17 children presented to the ED each week for asthma, but decreased to 2 presentations per week in the eight weeks after the national lockdown
Fischell, S. Z., et al.; 2022	USA	To evaluate the impact of the COVID-19 pandemic on ED visits and hospitalizations in an inner-city pediatric population with specific comparisons of exacerbation severity.	Retrospective study	There was a 79.3% reduction in ED visits for asthma during the pandemic

Golan-Tripto, I., et al.; 2021	Israel	To examine the patterns of ED visits for asthma exacerbations during COVID-19 outbreak, in comparison to the previous year.	Retrospective study	273 children in 2019 and 239 children in 2020 visited the ED for asthma related symptoms
Haklai, Z., et al.; 2022	Israel	To examine the effect of the COVID-19 pandemic on respiratory ED visits and admissions broken down by age group and respiratory diagnostic category.	Retrospective study	Compared to 2017-2019 there was a 35% decrease in non-COVID ED visits for COPD and asthma
Hazan, G., et al.; 2022	USA	To examine how the COVID-19 lockdown impacted the seasonality of pediatric asthma exacerbations.	Retrospective study	The rate of asthma-related ED visits declined by 35% during the COVID lockdown period
Hurst, J., et al.; 2021	USA	To evaluate changes in healthcare utilization and outcomes in children with asthma during the COVID-19 pandemic.	Retrospective cohort study	Asthma exacerbation decreased in from 12.7% to 3.2% from Year 1 to Year 2
Iozzi, L., et al.; 2020	Italy	To analyze patient records for the PED of San Matteo Hospital, University of Pavia, Southern Lombardy, during the lockdown period of 10 March to 3 May and compared the findings with the same period in 2019.	Retrospective study	11 (1.7%) patients visited the PED for asthma in 2020
Koinis-Mitchell, D., et al.; 2022	USA	To examine current trends in ED utilization and hospitalizations for youth and young adults with asthma in RI during the early COVID-19 era compared with pre-COVID-19.	Retrospective study	The average number of asthma-related ED visits was 5.15 in 2018, 4.25 in 2019, and 2.09 during the same period in 2020
Levene, R., et al.; 2021	USA	To compare PED health-seeking behaviors and clinical characteristics during the 2020 pandemic and subsequent initial New York State (NYS) phased re-opening to the same period in 2019.	Retrospective study	The proportion of asthma visits declined from asthma 7% in 2019 to 2% in 2020
Liang, T., et al.; 2022	USA	To evaluate the characteristics of pediatric ED visits to NYC public hospitals during the pandemic lockdown and reopening periods of 2020 compared to the prior year.	Retrospective cross-sectional study	-76% and -77% differences in asthma ED visits during early and late pandemic periods
Lin, C., et al.; 2020	Taiwan	To analyze the effect of public health interventions on respiratory tract infection-related visits to pediatric emergency departments during the COVID-19 pandemic in Taiwan.	Retrospective study	The proportion of ED visits for selected diagnoses, including asthma, showed no statistical differences between 2020 and 2017– 2019 in January and February

Markham, J., et al.; 2021	USA	To describe the impact of the COVID-19 pandemic on inpatient use within children's hospitals.	Retrospective study	42% decline in ED visits in March 2020  81.3% decline in asthma hospitalizations
Ochoa-Avilés, et al.; 2021	Ecuador	To evaluate the impact of the COVID-19 lockdown on asthma exacerbation, medical facility visits, and use of asthma medications in children.	Prospective cohort study	Compared to before lockdown the number of asthma exacerbations remained constant, outpatient visits declined by 74%, and ER visits declined by 89%
Oreskovic, N., et al.; 2020	USA	To review changes in transportation & travel patterns, school attendance, physical activity, and time spent indoors, along with changes in health care delivery all play a role in asthma control in children during the pandemic.	Retrospective study	6.5% difference in asthma ED visits in January 2019, -8.0% difference in February 2019, -38.8% in March 2019, and -84.8% difference in April 2019
Papadopoulos, N., et al.; 2021	USA	To evaluate the impact of COVID-19 pandemic on childhood asthma outcomes.	Retrospective cohort study	Acute asthma events declined from 40.7% in 2019 to 9.6% during the pandemic
Ramgopal, S., et al.; 2021	USA	To identify trends in pediatric emergency department (ED) utilization following the COVID-19 pandemic.	Retrospective study	Asthma ED diagnoses declined from 1,036,001 in 2010-2019 to 40,504 in 2020
Rethi, S., et al.; 2020	USA	To determine the extent of decrease in ED visits for several common pediatric conditions for which parents normally would have sought emergency care.	Retrospective cohort study	Asthma-related ED visits decreased in March and April 2020 by 40% and 91% compared to the same months in 2019
Reyhan Onay, Z., et al.; 2022	Turkey	To quantitatively investigate the changes in the frequency of respiratory infections and asthma in the pediatric population during the COVID-19 pandemic.	Retrospective study	There was a decrease in asthma ED admission from 38.15% pre-COVID to 19.39% during COVID
Shah, M., et al.; 2022	USA	To determine how changes during COVID-19 pandemic affected asthma metrics in a majority African American pediatric population at a pediatric pulmonology clinic in a community hospital in New York.	Retrospective cross-sectional study	There was a 76% decrease in mean value ED visits for acute asthma exacerbation from 2019 to 2020
Sheehan, W., et al.; 2021	USA	To determine, among children with asthma residing in the District of Columbia, whether there was a decrease in asthma-related ED visits and hospitalizations and an increase in the acuity of asthma exacerbations seasons.	Retrospective study	There was a noted a reduction in asthma ED visits during the spring, summer, and fall of 2020 after the start of the pandemic

Solanke, F., et al.; 2021	United Kingdom	To assess the impact of the pandemic on emergency department (ED) presentations and admissions.	Retrospective study	ED presentations for infection and asthma/wheeze reduced by around 60%
Ulrich, L., et al.; 2021	USA	To compare baseline ED and admission rates for asthma in PFK patients at our institution to rates during the COVID-19 pandemic.	Retrospective study	By June 2020 asthma ED visits decreased by 45.8% compared to 2017-2019 averages
Votto, M., et al.; 2021	Italy	To assess the admission and hospitalization rates for respiratory diseases in the pediatric ED during the lockdown period.	Retrospective study	There was no difference in the ED admission rate for asthma found from March to May 2020 compared to 2019

**Table 2. Summary of articles citing school closures (n=5)**

Authors/Year	Study Setting	Study Aims	Study Design	Key Findings
Akelma, Z., et al.; 2022	Turkey	To investigate how asthmatic children are affected by pandemic conditions based on real-life data.	Retrospective cross-sectional study	The number of asthma ED department visits was significantly lower in 2020 in accordance with declines in school attendance when compared to 2019
Arsenault, S., et al.; 2021	USA	To determine if this trend of decreased ED visits for pediatric asthma was sustained throughout the first COVID-19 pandemic year.	Retrospective study	Asthma ED visits declined from 1304 visits in spring of 2019 to 260 in spring of 2020 after school closures
Kenyon, C., et al.; 2020	USA	To describe the trends in ED utilization in the first four months of 2020 in comparison to prior years, allowing us to account for year-to-year differences in seasonal utilization.	Retrospective study	Once home-based schooling was initiated, daily asthma ED visits fell 3 standard deviations below the daily mean from 2016-2019
Pepper, M., et al.; 2021	USA	To report PED utilization during the COVID-19 pandemic in an urban pediatric referral center located close to the epicenter in the northeastern US.	Retrospective study	School closures began March 17, 2020  By March 26 <sup>th</sup> PED visits declined by 70% when compared to 2018-2019 averages
Simoneau, T., et al.; 2021	USA	To determine the impact of these measures on frequency of asthma-related pediatric ED visits.	Retrospective cohort study	The week following school closures on March 21 AE visits decreased 80% and 82% when compared to 2018 and 2019



**Table 3. Summary of articles citing environmental changes (n=10)**

Authors/Year	Study Setting	Study Aims	Study Design	Key Findings
Cheng, C., et al.; 2022	Taiwan	To evaluate the effects of short-term exposure to PM <sub>2.5</sub> and other air pollutants on pediatric respiratory disease ED visits before and during the COVID-19 pandemic.	Retrospective observational study	An increase IQR for PM <sub>2.5</sub> , PM <sub>10</sub> , and NO <sub>2</sub> levels was associated with 72.5%, 98.0%, and 54.7% increased risks of pediatric respiratory disease-related ED visits during the pandemic
Diwadkar, A., et al.; 2021	USA	To identify changes in pediatric asthma-related healthcare utilization and levels of air pollution and gaseous chemicals during the COVID-19 pandemic in Philadelphia.	Retrospective study	In the early stages of the pandemic, outpatient asthma encounters decreased by 84% and average PM <sub>2.5</sub> , PM <sub>10</sub> , and NO <sub>2</sub> levels decreased by 29%
Dondi, A., et al.; 2022	Italy	To provide an evaluation on how restrictive measures during the pandemic impacted PED referrals for asthma exacerbations, and their potentially associated environmental triggers in Bologna, Northern Italy.	Retrospective study	Total PED visits for asthma declined from 2.5% of total visits in 2014-2019 to 2.4% in 2020 in accordance with reductions in TRAP levels between 40%-60%
Fan, H-F., et al.; 2021	China	To investigate the association between the frequency of asthma exacerbation and air pollutants before and during the pandemic.	Retrospective cross-sectional study	The frequency of severe asthma exacerbations per month decreased during the pandemic along with PM <sub>2.5</sub> , PM <sub>10</sub> , sulfur dioxide, nitrogen dioxide, and carbon monoxide concentrations
Guijon, O., et al.; 2021	USA	To confirm improved asthma outcomes during COVID-19 and evaluate potential contributing factors.	Retrospective study	In April-June 2020 asthma ED visits per 1000 patients per month decreased 90% and the number of days that PM <sub>2.5</sub> exceeded 10.0 ug/m <sup>3</sup> decreased 37% in comparison to January-March
Pecoraro, L., et al.; 2021	Italy	To evaluate if pollen avoidance prevents asthma exacerbations in children affected by pollen allergy in an ED setting.	Retrospective observational study	Children with a known diagnosis of pollen-allergy who accessed the ED decreased from 20 children in 2018 and 12 children in 2019 to 4 children in 2020
Stout, S., et al.; 2022	USA	To evaluate the effect of COVID-19 on unscheduled asthma visits by comparing monthly 2020 visits with those from the previous 10 years.	Retrospective study	The number of asthma ED visits was lower during most of the first COVID-19 year, but was higher in June when compared with previous years
Stout, S., et al.; 2022	USA	To determine what factors could explain the reduction in asthma emergency department and inpatient visits during the COVID-19 pandemic.	Retrospective study	There was a reduction in asthma ED visits from April-December, excluding October, during COVID-19, as well as a significant reduction in total virus
Taquechel, K., et al.; 2020	USA	To identify changes in pediatric asthma-related health care utilization, respiratory viral testing, and air	Retrospective study	Emergency and inpatient asthma decreased by 84% after March 17, 2020, in association with reduced rhinovirus infections, but air pollution levels did not change

		pollution during the COVID-19 pandemic.		
Yamaguchi, H., et al.; 2021	Japan	To compare the numbers of pediatric patients with AE in 2020, the year of the COVID-19 pandemic, with those in previous years.	Retrospective observational study	The daily number of visits for AE declined from 1.8 to 0.9 and there was a significant positive relationship between AE patients per day and average temperature

## Discussion

Logically, reduced exposure to asthma triggers should result in a reduced need for asthma treatment. The current data relating to pediatric asthma during COVID-19 implies that the reduction in pediatric asthma emergency department visits was consistently maintained in hospitals during the height of the pandemic (Arsenault et al., 2021). School closures, social distancing measures, and reduced exposure to upper respiratory infections lead to reduced exposure of children to asthma triggers, leading to a reduced occurrence of asthma flares and the need for emergency services (Arsenault et al., 2021). Of the 43 articles included in this scoping review, 42 showed a significant reduction in pediatric ED visits for asthma exacerbation during the COVID-19 pandemic, whether it was in accordance with government-mandated lockdowns, school closures, or environmental changes.

The first group of articles, ED visits after the implementation of lockdowns, noted substantial declines in monthly and yearly visits during 2020 compared to 2017, 2018, and 2019. Specifically, asthma ED visits during March and April 2020 showed the largest reductions, as the pandemic reached its height and mitigation strategies, like stay-at-home orders and social distancing measures were initiated. Due to these mandates, children likely experienced decreased exposure to asthma triggers, due to reductions in time spent out of the house and in contact with other individuals, as well as increased hygiene measures, leading to fewer URIs, as well as fewer exercise or allergy induced asthma symptoms (Reyhan Onay et al., 2022). Additionally, anxiety may have contributed to the observed reductions, as many parents were likely hesitant to enter hospitals out of fear of COVID-19 contraction (Rethi et al., 2020). Consequently, parents may have preferred to utilize the telehealth and virtual resources that were made more readily available by healthcare providers during the pandemic period, ultimately reducing ED visits.

The second group of articles, ED visits after the implementation of school closures, also demonstrated significant declines in monthly, weekly, and daily visits subsequently following the transition to remote learning. After school closures were initiated in late March, it is possible that many factors contributed to the consequent decline in ED visits among children, some of which include decreased participation in sports and exercise, decreased viral exposure, and greater adherence to medication (Pepper et al., 2021). It is also possible that remote learning rather than crowded classrooms resulted in fewer seasonal respiratory infections, and thus fewer asthma exacerbations (Aklema et al., 2022). Ultimately, this group of studies demonstrated a significant association between pediatric asthma ED visits and limited social interaction following school closures.

The third group of articles, ED visits in relation to environmental changes, also demonstrated significant declines in monthly and weekly visits in accordance with reduced levels of airborne gases, pollen, particulate matter, and viruses. Because of governmental, work, and school closures, travel decreased, likely resulting in less pollution and fossil fuel combustion that is commonly associated with vehicular transportation (Dondi et al., 2022). Air pollution can cause severe bronchoconstriction and sensitivity to inhaled allergens (Fan et al., 2021). Thus, improved air quality during the pandemic possibly contributed to children experiencing fewer asthma symptoms, and lead to a reduced need for asthma exacerbation treatment. Pollen avoidance among children also contributed to the observed decline in ED visits, along with reduced viral levels caused by increased hygiene and decreased public socialization (Taquichel et al., 2020). Overall, all studies included in this category observed a substantial decline in pediatric ED visits for asthma that coincided with environmental changes that resulted from COVID-19 mitigation strategies.

Despite the findings of this scoping review, there are various limitations associated with this project. The searches conducted for this review were broad and required analyzation of a large number of articles. As a result, it is possible that relevant articles discussing pediatric ED visits for asthma exacerbation may have been overlooked or missed during the data collection process. Additionally, this review only highlights changes observed during the initial pandemic period, when strict lockdowns and public health initiatives were implemented. However, COVID-19 is still prevalent worldwide, and may continue to evoke changes in ED trends. Furthermore, the limitations of our understanding of the disease, its transmission, and effects must also be taken into account as a hindrance to the accuracy of this review. Asthmatic individuals are less susceptible to severe COVID-19, making it difficult to determine whether the pandemic mitigation strategies investigated in this study are applicable to individuals with asthma (UNC School of Medicine, 2022). Therefore, a greater understanding of the biomechanics associated with COVID-19 infection and asthma is needed to determine definitive causes of ED reductions.

Finally, this review does not address the paradoxical phenomenon associated with significant indoor asthma triggers, such as dust mites and cockroaches. Many inner-city children experience allergies associated with mold, dust mites and cockroaches, leading to adverse asthma outcomes (Sheehan & Phipatanakul, 2016). During the pandemic, children were isolated to their homes for more extended periods, which would likely increase exposure to indoor allergens, resulting in increased asthma exacerbation. However, despite more time spent inside the home, asthma exacerbation incidence declined, meaning additional factors contributed to this pattern. The connection between exposure to social determinants of health, like socioeconomic status and racism, during the pandemic needs to be explored, as abuse, housing and financial instability,

and racial discrimination have previously been associated with asthma in children (Jones et al., 2019). Therefore, other mitigating factors during the pandemic, like exposure to stressors outside of the home, were also likely reduced leading to the observations of this review and should be further investigated.

### **Conclusion**

Overall, the purpose of this review was to investigate and organize information relating to the impact of the COVID-19 pandemic on pediatric ED visits for asthma exacerbation. As a primarily respiratory disease, initial assumptions regarding COVID-19 and asthmatic children anticipated a large increase in asthma symptoms and impairment among children during the pandemic period. However, the conduction of this scoping review revealed 43 articles that compared pediatric asthma ED data before and during the pandemic.

Results were categorized into 3 groups: Government Mandated Lockdowns, School Closures, and Environmental Changes. All but one article showed sharp reductions in the number and proportion of ED visits regarding asthma, leading to the conclusion that COVID-19 mitigation strategies implemented by national and international governments resulted in the avoidance of various asthma triggers. More specifically, social distancing measures and PPE likely facilitated reduced pollen and URI exposure among children, as well as reduced physical activity. Additionally, stay-at-home orders reduced school and work travel, leading to reductions in particulate matter and TRAP levels, which also likely reduced children's exposure to environmental asthma triggers. Therefore, based on the findings of this scoping review, it can be concluded that pediatric ED visits for asthma were significantly reduced during the COVID-19 pandemic in accordance with the implementation of disease prevention strategies.

Due to the ongoing nature of this disease and the pandemic itself, data collection relating to pediatric asthma ED visits should continue to take place. As more strains develop and preventative methods become increasingly commonplace, exposure to many of the frequently experienced asthma triggers may change among children, impacting the conclusions made by this review. Furthermore, it may be beneficial for future researchers to investigate the changes in ED data explicitly related to the varying mitigation measures enforced during the initial pandemic period and the current pandemic period.

### **Reflection**

As a student at the University of South Carolina Honors College, I have gained a variety of tools and experiences that will benefit me as I move on to my future career. One of the most valuable takeaways I obtained during my time as an honors student is to get outside of my comfort zone. As a primarily science-driven student, I tend to cling to STEM classes that I understand and have a basic foundation in. However, the wide variety of courses provided by the Honors College encouraged me to engage in subjects that I would not normally explore. For example, last Fall I took a course relating to the art history of Imperial China. Although art nor history is typically my area of interest, this course really opened my eyes to the impact that social, cultural, and political climate have on behavior. I was able to use the broader concepts discussed in this course to enhance my knowledge of the socioecological model and social determinants of health as they relate to my public health major.

The Honors College has also enriched my experience as a student by encouraging me to immerse myself in the Columbia and campus community. As an SEC school with roughly 30,000 students, it can be overwhelming to find your place in such a chaotic environment with so many new people. However, the Honors College has allowed me to make such a large campus feel a little bit smaller. The service learning classes specifically, have really opened my eyes to the close-knit community we have in Columbia and allowed me to give back to the community that has given me so many friends, mentors, experiences, and opportunities. Being an out-of-state student from the north, I have gained an immense amount of appreciation and relationship building skills while working with Columbia locals and their welcoming and accepting attitudes towards USC students.



Finally, being in the South Carolina Honors College has also helped me develop confidence. Coming out of high school, I was very unsure of myself and did not really know what made me, me. However, the Honors College curriculum encouraged me to reflect on what I valued and to pursue interests and concepts that I was passionate about. In doing so, I was able to form a much clearer perception of who I am as an individual, what legacy I want to leave, and what I bring to the table. Although it may have taken four years, I am finally confident in my abilities, skills, and personality, and I know that I can make a meaningful impact on others, as well as the community at large.

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## Appendix

### CON Research & Scholarship Day – Poster

# The Impact of the COVID-19 Pandemic on Pediatric Emergency Department Visits for Asthma: A Scoping Review

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## Introduction

- COVID-19, caused by SARS-CoV-2, is a strain of the species *severe acute respiratory syndrome-related coronavirus*
- Symptoms include fever, fatigue, dry cough, and difficulty breathing, etc.<sup>1</sup>
- Asthma was the most common reason for emergency department (ED) visits before the pandemic, with a rate of 88.1 visits per 10,000 people.<sup>2</sup>
- Asthma triggers include exercise, environmental allergens, infection, pollutants, and stress.<sup>3</sup>
- As a primarily respiratory disease, initial assumptions regarding COVID-19 and asthmatic children anticipated an increase in asthma symptoms and impairment

## Purpose

- To evaluate and characterize research focused on pediatric asthma ED visits after the onset of the COVID-19 pandemic

## Methods

- Scoping review followed PRISMA-ScR guidelines.
- Databases used: Embase, CINAHL, and PubMed.
- Key words: *asthma, pediatric, emergency/emergency department/emergency room, and COVID/coronavirus/pandemic*.
- Initial search yielded 187 articles; 30 duplicates and an additional 76 articles (e.g., did not examine ED visits) were removed.
- Remaining 76 full-text articles were screened; 43 met inclusion criteria and were sorted into 3 themes.

## Results

### Theme 1 – Government Mandated Lockdowns

- 28 articles
- Pediatric ED visits for AE during government mandated lockdowns, social-distancing, and stay-at-home orders
- Significant reductions in 2020 after federal mitigation policies enforced in U.S., Jordan, Italy, Spain, Israel, and Ecuador
- Only 1 study in Taiwan failed to show a statistically significant difference in ED visits in 2020 compared to 2017-2019

### Theme 2 – School Closures

- 5 articles
- Pediatric ED visits for AE during the periods when school closures were implemented
- All 5 studies showed a significant reduction in pediatric visits to the ED after local home-based schooling was enforced in the U.S. and Turkey

### Theme 3 – Changes in the Environment Related to Lockdowns

- 10 articles
- Pediatric ED visits for AE in relation to environmental factors including PM2.5, PM10, sulfur dioxide, nitrogen dioxide, carbon monoxide, TRAP levels, pollen levels, and virus levels
- All 10 studies showed significant reductions in accordance with declines in PM, pollen, and airborne viruses in the U.S., Taiwan, Italy, China, and Japan



## Discussion

- Stay-at-home orders and social distancing measures likely caused reductions in time spent out of the house and increased hygiene measures, leading to fewer URIs, as well as fewer exercise or allergy induced asthma symptoms.<sup>4</sup>
- School closures contributed to the consequent decline in ED visits due to decreased participation in sports and exercise, decreased viral exposure, and greater adherence to medication.<sup>5</sup>
- Improved air quality during the pandemic possibly contributed to children experiencing fewer asthma symptoms, and lead to a reduced need for asthma exacerbation treatment.<sup>6</sup>

## Conclusion

- All but one article showed sharp reductions in ED visits regarding asthma, leading to the conclusion that COVID-19 mitigation strategies resulted in the avoidance of asthma triggers.
- Connection to social determinant of health should be explored, as stressors outside of the home can be associated with asthma.
- Due to the ongoing nature of this disease and the pandemic itself, data collection relating to pediatric asthma ED visits should continue to take place.

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