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### Publication Date

2024-05-01

### DOI

10.1016/j.jacig.2024.100239

Peer reviewed

# Trends in telemedicine visits among pediatric asthma patients during COVID-19



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**Background:** Environmental and social factors, including lack of access to asthma care, contribute to persistent inequities in asthma outcomes among children from historically marginalized ethn racial groups. Telemedicine, which expanded rapidly during the coronavirus disease 2019 (COVID-19) pandemic, may be an approach to augment access to pediatric asthma care.

**Objectives:** We sought to describe characteristics of pediatric (0-17 years) telemedicine users with asthma and characterize use trends throughout the COVID-19 pandemic.

**Methods:** We conducted a retrospective analysis using electronic health record data of pediatric patients with asthma seen at University of California, Los Angeles, Medical Center between March 2019 to March 2022 describing telemedicine user characteristics, trends of asthma-related telemedicine use, and associations between user characteristics and having a telemedicine visit.

**Results:** Among 6,777 patients with asthma, the percentage of asthma-related telemedicine visits peaked early in the pandemic, comprising 74.3% of visits, before decreasing to 13.6% in 2022. Compared to White patients, Black patients had lower odds of an asthma telemedicine visit (odds ratio [OR], 0.49; 95% confidence interval [CI], 0.26, 0.94). Those with public insurance (OR, 1.7; 95% CI, 1.19, 2.43), severe persistent asthma (OR, 3.03; 95% CI, 1.70, 5.42), or comorbidities (OR, 1.59; 95% CI, 1.08, 2.33) had higher odds. Time to first emergency department visit and hospitalization comparing those with at least one telemedicine visit to those with none were similar.

**Conclusions:** More pediatric asthma patients are using telemedicine since the COVID-19 pandemic, particularly those with medical complexity and comorbidities, and outcomes appear similar. However, Black patients at our institution have lower odds of using telemedicine. (*J Allergy Clin Immunol Global* 2024;3:100239.)

**Key words:** *Telemedicine, asthma, pediatrics, follow-up care, health equity*

## Abbreviations used

CI:	Confidence interval
COVID-19:	Coronavirus disease 2019
ED:	Emergency department
EHR:	Electronic health record
NH:	Non-Hispanic
OR:	Odds ratio
SVI:	Social vulnerability index
UCLA:	University of California, Los Angeles

Asthma is one of the most common chronic diseases of childhood and remains prevalent throughout the United States.<sup>1</sup> Environmental and social factors work together to affect asthma severity and control, and consequently, there are persistent disparities in asthma outcomes among children from lower socioeconomic statuses and historically marginalized ethn racial backgrounds.<sup>1-3</sup> Inequitable access to quality asthma care, in addition to other social determinants of health, is a known driver of these disparities and remains a barrier to providing optimal care and improving asthma outcomes and control for all patients.<sup>1-4</sup>

One attempt to expand access for asthma care for patients, including historically marginalized communities,<sup>5-8</sup> has been incorporation of telemedicine.<sup>9-11</sup> Telemedicine may also be beneficial for management of chronic conditions, especially those with a component of self-management such as asthma.<sup>10</sup> Prior studies have shown improved asthma outcomes including improved asthma control, self-efficacy, knowledge, and patient and practitioner acceptance,<sup>5</sup> as well as improvements through school-based implementation initiatives.<sup>12,13</sup>

The coronavirus disease 2019 (COVID-19) pandemic triggered rapid expansion of telemedicine throughout many health care systems out of necessity to serve patients and minimize patient and practitioner exposure risks.<sup>14-19</sup> During this time, telemedicine enabled continuity of care and potentially easier access to services when in-person visits were not possible, either because a patient had a suspected COVID-19 infection or because accessing an in-person visit was too difficult.<sup>8</sup> There remains debate about whether this has reduced disparities in access to care or resulted in more inequity,<sup>11,17-19</sup> as well as whether telemedicine care was effective for improving asthma outcomes. Access to telemedicine could be inequitable among those with lower incomes, those with low literacy and digital literacy, those from marginalized ethn racial groups, and those whose primary language is not English.<sup>11,17-19</sup> However, given the potential telemedicine has to increase access, improve outcomes, and reduce disparities, we sought to better understand who is using telemedicine among

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Received for publication September 19, 2023; revised December 24, 2023; accepted for publication January 7, 2024.

Available online March 1, 2024.

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2772-8293

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<https://doi.org/10.1016/j.jacig.2024.100239>

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our pediatric asthma patients and whether groups with historically decreased access to care are using this modality.

This study aims to describe characteristics of telemedicine users among pediatric patients with asthma, characterize trends of use for asthma before and through the pandemic, assess associations between those user characteristics and having a telemedicine visit for asthma, and evaluate associations with asthma-related health utilization, including emergency department (ED) visits and hospitalizations.

**METHODS****Conceptual framework**

Antonio and Petrovskaya's e-health equity framework adapted from the World Health Organization's *Conceptual Framework for Action on the Social Determinants of Health*<sup>20</sup> informed this study and informed for use in our statistical models the selection of covariates that we thought might influence telemedicine use of pediatric patients with asthma. Fig 1 illustrates our adaptation of the model for pediatric asthma.

**Study design and sample selection**

This retrospective electronic health record (EHR) analysis was performed at the University of California, Los Angeles (UCLA), Medical Center, a quaternary-care hospital located on the west side of Los Angeles, which is a large, urban, densely populated city with a catchment area of over 600,000 people, with 0- to 17-year-olds making up approximately 16% of the population. The UCLA service area is 60.2% White, 16.5% Hispanic/Latino, 13% Asian, and 6.2% Black. Approximately a quarter of the area is at or below 100% of the federal poverty level.<sup>21</sup>

Our inclusion criteria were pediatric patients aged 0 to 17 years with an asthma diagnosis seen at a UCLA outpatient clinic within 1 year before the pandemic (March 19, 2019) until March 31, 2022. Three time periods were designated: before the pandemic, from March 19, 2019, to February 29, 2020; early pandemic, from March 1, 2020, to August 31, 2021; and current state, from September 1, 2021, to March 31, 2022. The early pandemic period includes the time from the initial stay-at-home orders to the school year following, which was conducted via distance learning at most local schools in the region. September 2021 was designated as the start of the current state because most Los Angeles school districts' academic years had started by August 31, 2021, with a return to in-person instruction; and for many children, in-person school attendance results in increased exposure to asthma triggers such as upper respiratory infections and environmental allergens. The study was reviewed and approved by the UCLA institutional review board (approval 21-002138).

**Variables**

Outpatient visits were categorized as telemedicine if labeled as such under "visit type" in the EHR; otherwise, visits were considered to be in person with the physician and were categorized as office visits. Whether telemedicine or office, visits were determined to be asthma related according to the primary International Classification of Diseases, Tenth Revision (aka ICD-10), code filed for the encounter's visit diagnosis. Asthma-related ED visits and hospitalizations were defined by having asthma as a primary, admission, or final diagnosis. Sociodemographic variables assessed included age, sex, race and ethnicity, preferred language (English, Spanish, other), insurance type (private, public, other), and social vulnerability index (SVI). The SVI uses US census variables to determine a community's vulnerability due to negative effects of external stressors such as natural disasters or disease outbreaks.<sup>22</sup> SVI was categorized by quartile, with the highest quartile indicating the highest level of vulnerability. Clinical characteristics evaluated using ICD-10 codes were asthma severity (intermittent, mild persistent, moderate persistent, severe persistent) and comorbidities/chronic conditions (at least one, none). Whether a patient had comorbidities was determined using the pediatric complex chronic conditions classification system, version 2. The system consists of 10 categories including cardiovascular, respiratory, neuromuscular, renal, gastrointestinal, hematologic or immunologic, metabolic, other congenital or genetic, malignancy, and conditions arising in the perinatal period that are indicative of a likely complex chronic condition.<sup>23</sup>

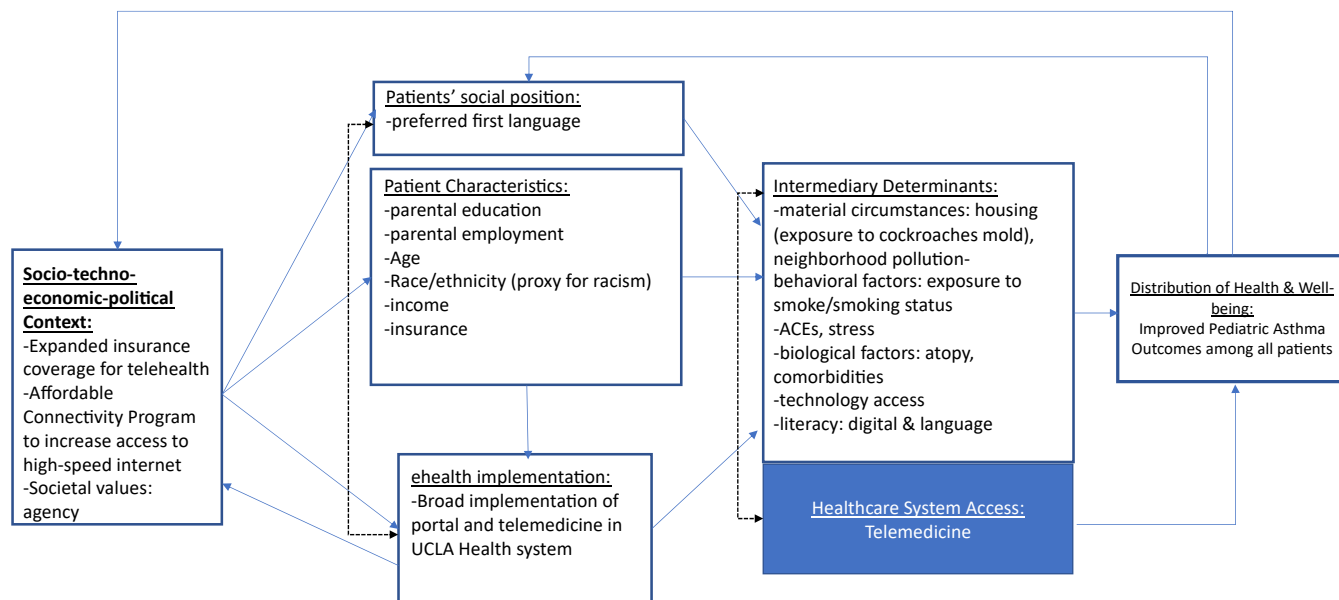
**Telemedicine modality**

Telemedicine visits were conducted using the EPIC Systems EHR. Telemedicine visits in this study are defined as video visits, and a laptop, tablet, or cell phone with video-conferencing capabilities is required to conduct the visit. Patients are offered telemedicine visits by self-request, by the provider, or by administrative staff, depending on what the visit is for and whether the visit is for a new patient or a follow-up visit. Interpreters are offered to non-English-speaking patients for video visits. During the pandemic, telemedicine visits were not mandatory.

**Statistical analyses**

Analyses were conducted by SAS v9.4 software (SAS Institute, Cary, NC). Descriptive statistics and bivariate analyses assessed trends in telemedicine visits for asthma among asthma patients and associations of demographic variables with visits. Descriptive analyses were conducted by calculating means and medians for continuous variables and frequencies and proportions for categorical variables. Bivariate analyses by Student *t* test for continuous variables and chi-square test for categorical/binary variables were conducted to assess associations with the outcome variable of telemedicine visits.

Total numbers of telemedicine visits for each time period were determined, and trends of telemedicine visits for asthma were graphed over time as a proportion of all asthma-related visits (both in person and telemedicine). Multivariable mixed-effects logistic regression was used to identify sociodemographic and clinical factors associated with having an asthma-related telemedicine visit. All variables from Table 1 were included as covariates in the model. A complete case analysis was done. Multicollinearity between cofactors was assessed, and based on



**FIG 1.** Conceptual framework for telemedicine use among pediatric asthma patients. Adapted from eHealth Equity Framework.<sup>20</sup>

variance inflation factors' all being less than 2, it was determined there was no multicollinearity between variables. A random intercept for patients was included in the model to account for within-patient correlation. Outcomes were only assessed in the current period to account for expected confounding between the outcomes of interest and the effects of prior decreased asthma exacerbations due to social distancing, mask wearing, school closures, and improved hand hygiene during the early pandemic.<sup>24,25</sup>

Mixed-effect Cox proportional hazards regression was used to compare the time to first ED visit or hospitalization for asthma for those with only office visits and those with at least one telemedicine visit. Unadjusted Kaplan-Meier curves are presented.

## RESULTS

### General telemedicine visits

There were 6,777 pediatric patients with asthma identified as having an outpatient clinical visit for asthma during the study period. Of these, 1,117 (16.5%) had at least one asthma telemedicine visit, and 5,659 (83.5%) had only office visits (ie, no telemedicine visits) (Table I). The total number of visits for asthma overall was 14,834, with a median number of visits (telemedicine and office) per patient for those who had a telemedicine visit of 4 (interquartile range, 2-7) compared to 1 (interquartile range, 1-2) for patients without any telemedicine visit ( $P < .001$ ).

### Descriptive statistics

Details of descriptive statistics can be found in Table I. Patients with at least one asthma-related telemedicine visit compared to patients with no asthma-related telemedicine visit were less likely to be non-Hispanic (NH) Black (5.4% vs 7.1%). Among those without a telemedicine visit for asthma, there was a higher proportion of patients whose preferred language was Spanish compared to those with a telemedicine visit (3.0% vs 3.5%). Children with persistent (mild, moderate, severe) asthma comprised a greater

proportion of the telemedicine group compared to the office visit only group (13.1%, 22.8%, 2.9% of telemedicine group vs 8.5%, 8.0%, 0.7% of office visit only group, respectively). Those with intermittent asthma comprised a greater proportion of the office visit only group than the telemedicine group (41.3% vs 38.9%). There was a greater proportion of children with at least one comorbidity in the telemedicine group versus the office visit only group (15.0% vs 9.8%). Distribution of male and female patients was similar between groups. Distribution of SVI quartiles (quartile 1, 2, 3, 4) was similar between groups (40.8%, 23.0%, 14.2%, 11.5% in the telemedicine group vs 41.2%, 24.7%, 13.6%, 11.8% in the office visit only group, respectively).

Over 60% of all telemedicine visits for asthma were conducted by asthma specialists (pulmonology and allergy/immunology), and 35% were with primary and urgent care specialists. More in-person visits (55.3%) were conducted by primary and urgent care practitioners, with approximately 40% completed by specialists.

### Telemedicine visits over time

The frequency of telemedicine visits for asthma over time is depicted in Fig 2. Before the COVID-19 pandemic (March 19, 2019, to February 29, 2020), there were only 24 asthma-related telemedicine visits. During the first 1.5 years of the pandemic, this increased to 1,384 telemedicine visits for asthma, with up to 70% of pediatric visits for asthma being telemedicine in April 2020. Between September 1, 2021, and March 31, 2022, the total number of telemedicine visits for asthma decreased to 435, but over 10% of asthma visits remained telemedicine visits. The spikes in the number of visits coincided with COVID-19 case surges in California.<sup>26</sup>

During the prepandemic period, 0.38% (24/6342) of all asthma visits were telemedicine. During the early pandemic period, 24.8% (1384/5580) of all asthma visits were telemedicine; and in the current period, 14.9% (435/2912) of all asthma visits were

**TABLE I.** Baseline characteristics of children with asthma and bivariate analyses assessing association between telemedicine visits and patient characteristics

Covariate	Variable	Telemedicine visit for asthma	No telemedicine visit (only office visits for asthma)	P value*
Total no. of subjects		1117	5659	
Total no. of asthma-related visits per patient (office + telemedicine)	Median (IQR)	4 (2-7)	1 (1-2)	<.001
Age (years)	Mean (SD)	9.5 (4.5)	10.1 (4.6)	<.001
Sex	Male	665 (59.5)	3366 (59.5)	.97
	Female	452 (40.5)	2293 (40.5)	
Race and ethnicity	NH White	318 (28.5)	1597 (28.3)	.002
	Hispanic/Latino	278 (24.9)	1206 (21.3)	
	NH Black	60 (5.4)	403 (7.1)	
	NH Asian	112 (10.0)	539 (9.5)	
	American Indian/Alaskan Native	2 (0.2)	14 (0.3)	
	Middle Eastern/North African	0	7 (0.1)	
	Native Hawaiian/Pacific Islander	2 (0.2)	10 (0.2)	
	Multiple races	52 (4.7)	179 (3.2)	
	Unknown/missing	80 (7.2)	580 (10.3)	
	Patient refused/did not identify with race	88 (7.9)	537 (9.5)	
Preferred language	Other	125 (11.2)	587 (10.4)	.69
	English	1070 (95.8)	5392 (95.3)	
	Spanish	33 (3.0)	196 (3.5)	
Asthma severity	Other†	14 (1.3)	71 (1.3)	<.001
	Intermittent	435 (38.9)	2336 (41.3)	
	Mild persistent	146 (13.1)	480 (8.5)	
	Moderate persistent	255 (22.8)	452 (8.0)	
	Severe persistent	32 (2.9)	38 (0.7)	
Comorbidities§	Unspecified/other‡	249 (22.3)	2353 (41.6)	<.001
	Yes	168 (15.0)	554 (9.8)	
Insurance type	No	949 (85.0)	5105 (90.2)	.16
	Private	880 (78.8)	4556 (80.5)	
	Public	224 (20.1)	1001 (17.7)	
	Other	12 (1.1)	74 (1.3)	
SVI	Unknown/missing	1 (0.1)	28 (0.5)	.70
	Quartile 1 (0-0.249)	456 (40.8)	2273 (40.2)	
	Quartile 2 (0.25-0.499)	257 (23.0)	1396 (24.7)	
	Quartile 3 (0.50-0.749)	158 (14.2)	769 (13.6)	
	Quartile 4 (0.75-1.00)	128 (11.5)	668 (11.8)	
	Unknown/missing	118 (10.6)	553 (9.8)	

Percentages in parentheses are column percentages unless otherwise noted. Percentages may not add up to 100% as a result of rounding.

\* $P < .05$  was considered statistically significant.

†Other race and ethnicity were obtained from electronic health records; race and ethnicity were self-reported by patients. No further clarification is available.

‡Other asthma severity includes: chronic obstructive asthma with exacerbation, chronic obstructive asthma-unspecified, cough variant asthma, exercise induced bronchospasm, extrinsic asthma with exacerbation, extrinsic asthma with status asthmaticus, extrinsic asthma-unspecified, intrinsic asthma with exacerbation, intrinsic asthma with status asthmaticus, intrinsic asthma-unspecified, other asthma, unspecified asthma with (acute) exacerbation, unspecified asthma with status asthmaticus, unspecified asthma, unspecified asthma uncomplicated, unspecified asthma with exacerbation, and unspecified asthma with status asthmaticus.

§Comorbidities were based on pediatric complex chronic conditions classification system, version 2.<sup>22</sup>

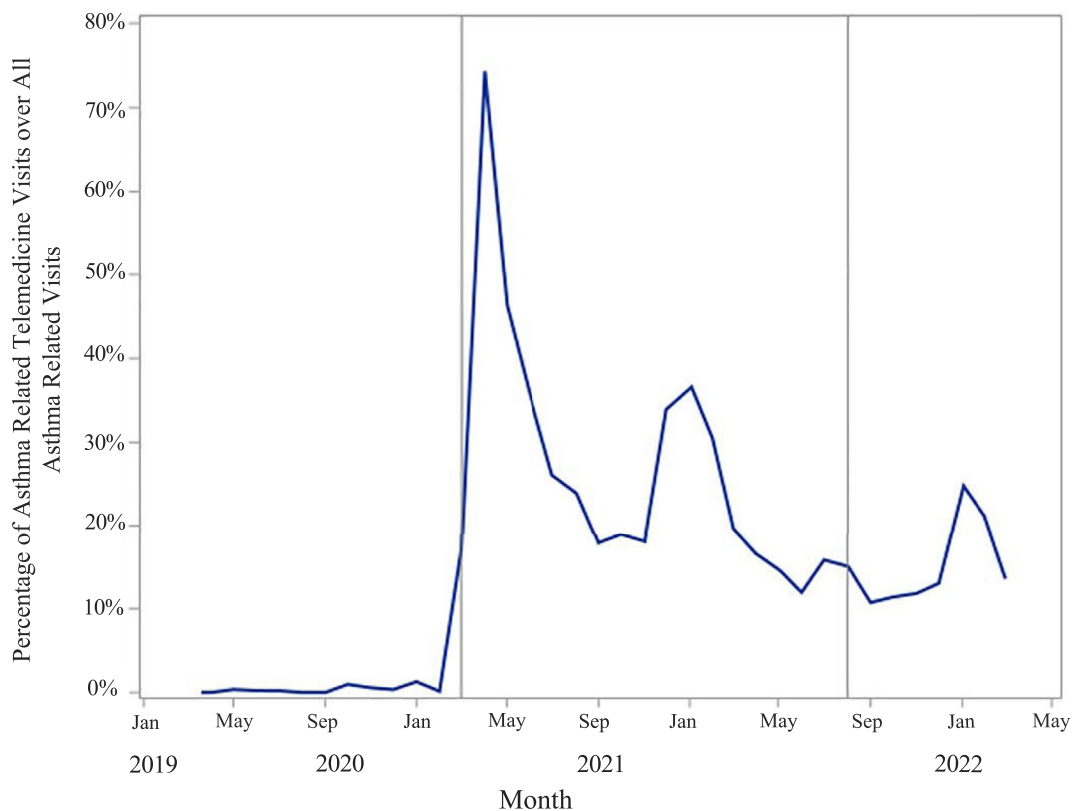
telemedicine. Fig 3 depicts all asthma visits, both telemedicine and office, over time. In the prepandemic period, there were significantly more visits compared to both the early pandemic period ( $P < .001$ ) and the current period ( $P < .001$ ).

### Multivariable mixed-effects logistic regression

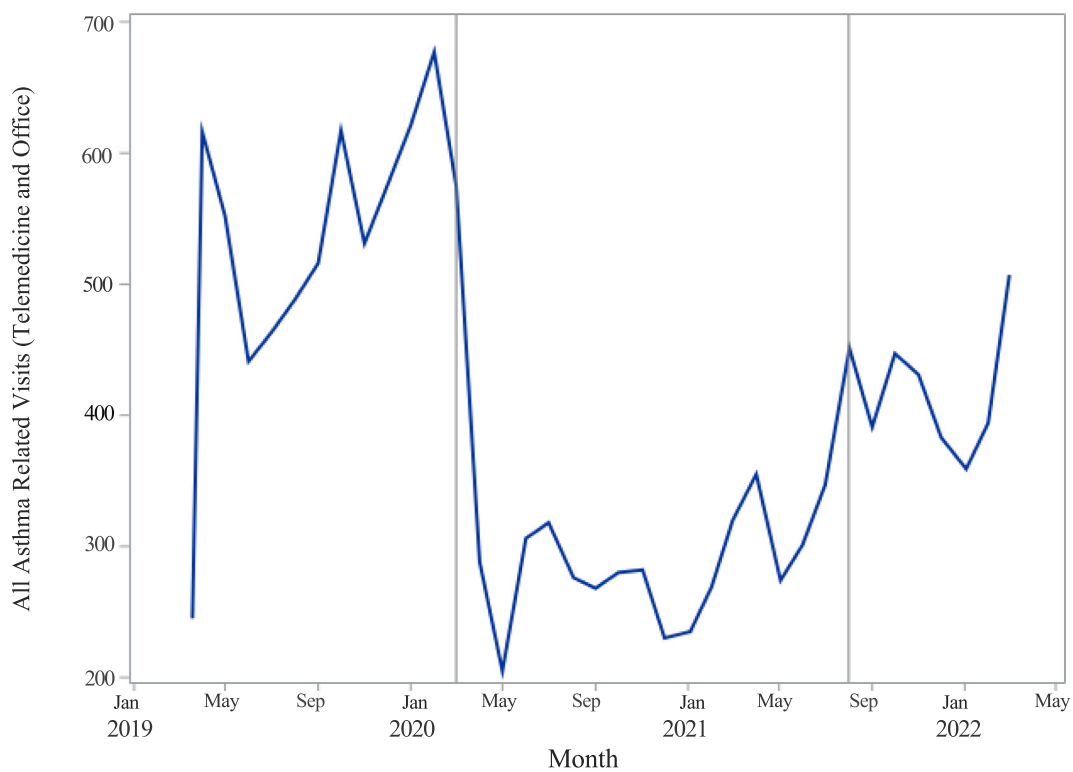
**Factors associated with telemedicine visits.** NH Black patients had lower odds than NH White patients of having at least one asthma-related telemedicine visit (odds ratio [OR], 0.49; 95% confidence interval [CI], 0.26, 0.94) (Table II). Those whose preferred language was Spanish had lower odds of having at least

one asthma-related telemedicine visit (OR, 0.46; 95% CI, 0.20, 1.04), although this was not statistically significant. Children with moderate and severe persistent asthma had significantly higher odds of having an asthma-related telemedicine visit compared to those with intermittent asthma (OR, 1.81; 95% CI, 1.32, 2.47; and OR, 3.03; 95% CI, 1.7, 5.42, respectively).

Having at least one complex comorbid condition was associated with higher odds of having a telemedicine visit for asthma (OR, 1.59; 95% CI, 1.08, 2.33). Public insurance compared to private insurance was associated with higher odds of having a telemedicine visit for asthma (OR, 1.7; 95% CI, 1.19, 2.43). SVI quartile was not associated with having a telemedicine visit for asthma.



**FIG 2.** Telemedicine visits for asthma over time as proportion of all asthma visits. *Vertical lines* divide graph into 3 periods: pre-pandemic, early pandemic, and current state.



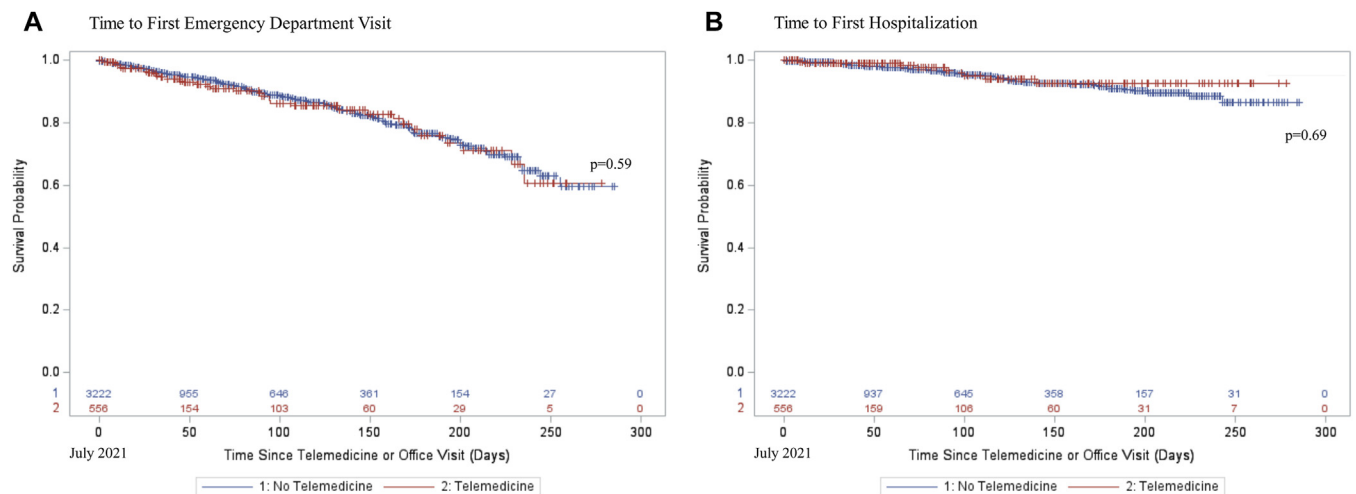
**FIG 3.** All asthma visits (office and in person) over time.  $P < .001$  comparing pre-pandemic and early pandemic periods, and  $P < .001$  comparing pre-pandemic and current state periods.

**TABLE II.** Mixed-effects multivariable logistic regression evaluating relationship between patient characteristics and telemedicine visits for asthma

Predictor	Variable	Crude				Adjusted			
		OR*	Lower 95% CI	Upper 95% CI	P value†	OR	Lower 95% CI	Upper 95% CI	P value†
Age		1.01	0.99	1.04	.275	1.02	0.99	1.04	.228
Sex	Male	1 (Ref)				1 (Ref)			
	Female	0.95	0.75	1.21	.681	0.93	0.72	1.22	.612
Race and ethnicity	NH White	1 (Ref)				1 (Ref)			
	NH Asian	1.02	0.16	6.33	.932	1.12	0.71	1.76	.631
	NH Black	0.71	0.46	1.09	.222	0.49	0.26	0.94	.033
	Hispanic/Latino	1.04	0.22	5.03	.803	0.93	0.63	1.37	.713
	Other race	0.84	0.52	1.35	.246	0.85	0.61	1.19	.343
Preferred language	English	1 (Ref)				1 (Ref)			
	Spanish	0.73	0.36	1.48	.379	0.46	0.2	1.04	.061
Asthma severity	Intermittent	1 (Ref)				1 (Ref)			
	Mild persistent	1.11	0.77	1.59	.571	1.04	0.7	1.53	.852
	Moderate persistent	1.81	1.36	2.41	<.001	1.81	1.32	2.47	<.001
	Severe persistent	3.18	1.88	5.39	<.001	3.03	1.7	5.42	<.001
	Unspecified severity	0.77	0.56	1.07	.124	0.87	0.61	1.23	.422
Comorbidities (≥1)‡	No	1 (Ref)				1 (Ref)			
	Yes	1.88	1.34	2.63	<.001	1.59	1.08	2.33	.02
Insurance type	Private	1 (Ref)				1 (Ref)			
	Public	0.61	0.46	0.8	<.001	1.7	1.19	2.43	.004
	Other	0.62	0.16	2.4	.494	1.06	0.27	4.18	.939
SVI	Quartile 1	1 (Ref)				1 (Ref)			
	Quartile 2	0.79	0.58	1.07	.126	0.77	0.56	1.06	.104
	Quartile 3	1.16	0.81	1.65	.415	1.01	0.68	1.49	.969
	Quartile 4	1.11	0.76	1.62	.574	0.92	0.59	1.42	.698

\*Each predictor was entered separately in its own model.

†P &lt; .05 was considered statistically significant.

‡Comorbidities were based on pediatric complex chronic conditions classification system, version 2.<sup>22</sup>**FIG 4.** Unadjusted time to event graphs comparing time to (A) first ED visit and (B) time to first hospitalization for asthma exacerbations after having at least one telemedicine visit compared to those with no telemedicine visit. Numbers listed above x-axis reflect number of visits among those with no telemedicine (blue) and telemedicine (red) visits that are still being followed at each time point.

Of note, children 12 years and older in the state of California have access to their own medical records, so we also performed a *post hoc* sensitivity analysis related to age (≥12 vs <12 years), which was not a significant predictor for having a telemedicine visit.

**Asthma-related health utilization.** Unadjusted time-to-event analyses indicated there were minimal differences in time to first ED visit or hospitalization for asthma after office visits versus telemedicine visits (Fig 4). There were 204 ED visits overall in the

office-only group and 36 ED visits in the telemedicine group. There were 72 hospitalizations in the office-only group and 10 hospitalizations in the telemedicine group.

## DISCUSSION

Telemedicine visits among children with asthma at an academic quaternary care center were found to increase substantially

throughout the pandemic, reaching a peak in April 2020 and never falling back to prepandemic levels. While telemedicine visits increased across multiple patient sociodemographic and clinical attributes, visits did not increase equally. NH Black patients compared to NH White patients were less likely to have any telemedicine visit. Those with public insurance, higher asthma severity, and comorbidities were more likely to have a telemedicine visit. There were no differences in time to an ED visit or hospitalization for asthma for patients who had telemedicine visits compared to those who had none, although the number of visits was overall fairly low in both groups.

The increase in telemedicine visits is consistent with a prior study done at the same institution that found portal access increased during the pandemic as well.<sup>27</sup> While the proportion of telemedicine visits noticeably increased during pandemic's peak, the number of telemedicine visits ultimately decreased, and most asthma patient visits now appear to have returned to in-person office visits. However, our data show that even with fewer asthma visits overall after the start of the pandemic, a higher percentage than before are conducted via telemedicine, thus suggesting that telemedicine is replacing some in-person asthma visits—and thereby offering another way to access care.

Additionally, our data suggest that telemedicine offers an alternative visit option for those with increased needs such as higher asthma severity (moderate to severe) and complex chronic medical comorbidities. Telemedicine may be facilitating easier access to care for patients who require more frequent follow-up given the complexity of their medical conditions, or who face transportation barriers related to medical complexity. Similar to our study findings, Haynes et al<sup>28</sup> found that those whose asthma was managed by specialists had higher odds of a telemedicine visit, suggesting that telemedicine may have been more readily adapted by subspecialists compared to generalists, or that it is perhaps inherently related to asthma severity.

Our data also suggest there is room for improvement regarding who is accessing telemedicine, given that NH Black patients had significantly lower odds of having a telemedicine visit. A study among adults evaluating whether inequities exist in telemedicine usage at a large academic health system also found that Black patients had lower odds of video use for telemedicine visits.<sup>29</sup> Within our sample, those whose preferred language was Spanish also had lower odds of having an asthma-related telemedicine visit compared to those whose preferred first language was English, although the effect size was not statistically significant. These findings are consistent with previously described inequities seen among historically marginalized communities in the United States regarding access to telemedicine<sup>11,17,19,29,30</sup>—inequities among the very groups that we aim to reach with this expanding modality. A mixed methods study analyzing factors associated with telemedicine use for asthma among children and young adults similarly found that telemedicine use was lower among those whose primary language was not English.<sup>28</sup>

There may be many reasons for this, including reasons related to systemic biases such as some families not being offered portal access or telemedicine visits as an option to begin with, and, as mentioned above, among Spanish-speaking and non-White patients.<sup>30,31</sup> Societal inequity may limit access to high-speed internet or video-conferencing capabilities, which comprise our institution's telemedicine visits, as data have shown that a higher

percentage of Black and Latino households do not have access to a computing device at home compared to White and Asian households.<sup>32</sup> There may be cultural considerations stemming from a mistrust of the health care system due to institutional biases and mistreatment of marginalized groups.<sup>33-35</sup> Patients may also think that adequate care is not able to be provided through a video visit. Additionally, there are many clinic locations within Los Angeles County outside of the UCLA Health system, so some follow-up data may not have been captured. However, many of our patients are assigned to UCLA Health by their insurance, making it more likely that patients would follow up in our institution.

However, those with public insurance had higher odds of having an asthma-related telemedicine appointment, and those with increased social vulnerability had similar odds of having an asthma-related telemedicine visit as those with decreased social vulnerability, contrary to other studies that found those with lower socioeconomic status and/or public insurance were less likely to use telemedicine or virtual visits.<sup>29,36,37</sup> This may indicate that measures of socioeconomic status are influencing telemedicine usage in a different way than race, ethnicity, and preferred language, thus suggesting that telemedicine may be a viable option to deliver care for many. In addition, to our knowledge, all insurance companies covered telemedicine visit fees. However, our data did not explicitly capture why some patients use telemedicine less often than others, so further exploration is needed to better understand why some patients with pediatric asthma are opting to use telemedicine while others are not, particularly among populations that historically have had less access to health care.

Consistent with previous literature that did not find adverse impacts of virtual care among adults with asthma,<sup>36</sup> we found that those with at least one asthma-related telemedicine visit had similar times to an ED visit or hospitalization, compared to those who had only in-person visits. This provides further evidence that despite the lack of an in-person physical examination and lung function tests, telemedicine may be an appropriate and safe tool for health care practitioners to treat more patients with chronic conditions like asthma, particularly for patients who may have difficulty accessing health care.

While our study captured many patients with and without telemedicine visits, there are several limitations. The study was observational, which limits our ability to make causal assumptions. We do not have data on patients without visits for their asthma (telemedicine or otherwise) that they should have during this time. In addition, this analysis did not include manual chart review and is based on EHR data coded by health care practitioners, which may inherently contain input errors or inaccuracies, such as primary reason for visit. Also, there were some variables with less granular information (eg, ethnoracial data within the Latino ethnicity group), and there were many with unspecified asthma severity diagnoses. Although we focused on a more recent time period to account for the effect of the COVID-19 pandemic on known improved asthma management and outcomes due to pandemic policies such as stay-at-home orders and school closures,<sup>24,25</sup> we were not able to further adjust for additional effects the pandemic might have had on health care utilization and asthma outcomes. While we found that patients with medical complexity and comorbidities were more likely to have telemedicine visits, we also found that asthma specialists, who are more likely to treat complex asthma patients, were more likely to use



telemedicine as a visit modality than generalists, so there is uncertainty regarding which was the driving factor for more telemedicine visits. Finally, our data are from a single academic quaternary-care system, which may limit the generalizability of our findings.

Our study provided novel insight into the long-term trends in telemedicine outpatient usage specifically among pediatric asthma patients before, during, and later in the COVID-19 pandemic. While telemedicine is generally inexpensive and may be an easily accessible way to treat one of the most common pediatric chronic diseases, our findings indicate that not all patients are using telemedicine, and there may be room for improvement to make access to telemedicine visits more equitable for all patients. Future studies are needed to clarify why some patient populations, such as NH Black patients and those whose preferred language is Spanish, are at risk to have lower odds of using the modality, as well as to further understand the relationship between telemedicine visit and health outcomes.

## DISCLOSURE STATEMENT

Supported by Health Resources and Services Administration Ruth L. Kirschstein Institutional National Research Service award T32HP19001; the National Center for Advancing Translational Sciences, National Institutes of Health (NIH), under UCLA Clinical and Translational Science Institute grant UL1TR001881; and the National Heart, Lung, and Blood Institute, NIH, award 1K23HL148502-01A1.

Disclosure of potential conflict of interest: The authors declare that they have no relevant conflicts of interest.

**Clinical implications: In an academic health system, we found pediatric patients with asthma to have higher odds of receiving virtual care if they have more comorbidities or more severe asthma, while Black patients had lower odds of using telemedicine.**

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