Multidisciplinary care in pediatric severe asthma: A comparative outcomes analysis

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Background: There are limited data comparing the effectiveness of multidisciplinary severe asthma clinics (SACs) with that of conventional single-discipline clinics (SDCs) for pediatric severe asthma.

Objective: Our aim was to compare asthma outcomes between SACs and SDCs clinics and examine longitudinal health outcomes for patients with severe asthma who were followed in SACs.

Methods: We conducted a retrospective cohort study comparing pediatric asthma outcomes among patients with severe asthma between 2018 and 2022 who were treated at the multidisciplinary Arkansas Children's SAC with those of patients with severe asthma treated at SDCs. The primary outcome was acute health care utilization, including hospitalizations and emergency department visits. Secondary outcomes included systemic corticosteroid prescriptions and controller medications. For SAC enrollees, longitudinal outcomes including health care utilization, symptom control, and spirometry were evaluated 12 months before and after enrollment. Data sources included the electronic health record and SAC patient registry.

Results: The study population included 280 patients with severe asthma, aged 5 to 18 years, from the SAC (n = 56) and SDCs (n = 224). The SAC patients were more likely to be Black (79% vs 52% [$P = .0002$]), be non-Hispanic (100% vs 88% [$P = .01$]), have had at least 1 hospitalization (21% vs 10% [$P = .04$]), and have received at least 2 prescriptions for a systemic corticosteroid (34% vs 17% [$P = .01$]). Longitudinal outcomes among patients for the 12 months before SAC enrollment versus 12 months after SAC enrollment demonstrated significant reductions in acute exacerbations (from 35 to 8 [$P < .001$]), hospitalizations (from 21 to 1 [$P < .001$]), and intensive care unit admissions (from 8 to 1 [$P = .02$]).

Conclusions: The study highlights significant morbidity among predominately Black pediatric patients with severe asthma, particularly those followed in a SAC versus in SDCs at a tertiary care referral center. The findings demonstrate the value of targeted multidisciplinary approaches to reduce asthma utilization and improve outcomes among high-risk patients. (J Allergy Clin Immunol Global 2025;4:100417.)

Key words: *Severe asthma, pediatrics, multidisciplinary clinic, asthma outcomes, electronic health record, acute health care utilization, ancillary services*

Asthma is one of the most common chronic childhood diseases, and severe asthma in children is associated with a significantly increased risk for morbidity and mortality.[1-3] Furthermore, although only 5% to 10% of the 7 million children with asthma in the United States have severe disease,[4,5] those children disproportionately account for half of the estimated $81.9 billion annual costs of asthma care.[6] Prior studies have established that improved asthma control and reduced morbidity are significantly more likely if an asthma specialist, such as an allergist or pulmonologist, is involved in the diagnostic assessment and development of treatment plans for children with asthma,[7-9] but significant gaps remain in knowledge regarding the most effective care model for children with severe disease.

Multidisciplinary clinics have emerged as an alternative care model to provide personalized and comprehensive care for patients with complex and refractory asthma. Multidisciplinary care for severe asthma involves a team of specialists, typically led by allergists and pulmonologists, who focus on an accurate diagnosis of severe asthma, classification of asthma phenotype, tailored pharmacologic treatments, and provision of ancillary services to address socioeconomic and psychological factors (eg, social determinants of health).[10,11] Multidisciplinary clinic staffing varies by institution and provider availability but generally includes 2 or more asthma specialists from different specialties (typically allergy or pulmonology), respiratory therapists, pharmacists, psychologists, and social workers.[12,13] A fundamental benefit is the consolidation of expertise into a single visit with the aim of improving care coordination and reducing fragmented decision making.[14] Despite the goal of decreasing health care utilization and improving asthma outcomes, there are limited data comparing the effectiveness of multidisciplinary clinics with conventional specialty single-discipline clinics (SDCs) for managing severe asthma in children.

The recognition of psychosocial factors that contribute to health outcomes is a critical component of multidisciplinary care, as they are unique to each patient and family and have a profound influence on all aspects of health, particularly in chronic diseases. To address these challenges, multidisciplinary asthma care commonly incorporates key collaborative services, including

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Abbreviations used
AC: Arkansas Children's
ACT: Asthma Control Test
ED: Emergency department
EHR: Electronic health record
ICD-10: *International Classification of Diseases*, 10th Revision
ICU: Intensive care unit
IQR: Interquartile range
NHLBI: National Heart, Lung, and Blood Institute
SAC: Severe asthma clinic
SCS: Systemic corticosteroid
SDC: Single-discipline clinic

clinical psychology and social work. The impact, either clinically or economically, of psychological services is unclear, with few studies examining the relationship of psychosocial factors to health outcomes in severe asthma; however, benefits of multidisciplinary clinics have been shown for other chronic diseases.[15] Furthermore, despite the significant influence of social determinants of health, research exploring the impact of social services consultation on health outcomes in children is limited.[16] Nonetheless, it is clear that addressing socioeconomic and psychological factors is a critical component of effective severe asthma care. By integrating wraparound ancillary services, multidisciplinary care can effectively address the diverse needs of patients and families, leading to improved outcomes and reduced health care utilization.

This study's overarching goal is to characterize asthma outcomes for children with severe disease who are being followed at Arkansas Children's (AC) tertiary specialty care clinics. Herein, we compare outcomes between pediatric patients managed in the AC multidisciplinary severe asthma clinic (AC SAC) versus in specialty single-discipline (SDCs) clinics and describe longitudinal outcomes for children followed in the SAC for at least 12 months.

METHODS

Study design

This retrospective cohort study, which was approved by the University of Arkansas for Medical Sciences Institutional Review Board for Humans Subjects Research, investigated health outcomes over a 12-month period among 2 groups of children with severe asthma who were managed in either the multidisciplinary AC SAC or specialty SDCs (ie, the AC allergy or pulmonary clinic). A comparative analysis was performed on the SAC and specialty SDC outcomes, including acute health care utilization (ie, hospitalizations and emergency department [ED] visits) and exposure to psychosocial services, systemic corticosteroid (SCS) prescriptions, controller medications, and biologic therapies. The study period for the comparative analysis between the SAC and the specialty SDCs spanned a duration of 12 months and had to have included at least 2 visits. The earliest visit within the 12-month period was defined at the start of the study. A separate longitudinal analysis was conducted to characterize the impact of multidisciplinary care on outcomes, including asthma exacerbations, inpatient health care utilization (ie, hospitalizations and intensive care unit [ICU] admissions), asthma symptom control, and spirometry 12 months (± 3 months) after the initial visit to the SAC.

Participants

The study population included patients who were enrolled in the AC SAC and the specialty SDCs between January 1, 2018, and July 1, 2022. The population was identified by using either the AC electronic health record (EHR) database repository or the AC SAC patient registry. Those with severe asthma from specialty SDCs were identified by using the *International Classification of Diseases*, 10th Revision (ICD-10), codes for severe persistent asthma (J45.5*), as coded by asthma specialists in the allergy and pulmonary subspecialty disciplines. Patients enrolled from the multidisciplinary SAC were referred by allergy or pulmonary specialists because of concerns for poorly controlled asthma despite advanced asthma treatments and extensive diagnostic evaluation performed to ensure an accurate diagnosis of severe asthma. All participants were between 5 and 18 years old at enrollment and had at least 2 visits to either the SAC or an SDC within a 12-month period. A subset of the SAC participants were included for longitudinal analysis if they had a follow-up visit 12 months (± 3 months) after their initial visit to the SAC. Any patient having significant underlying respiratory disease other than asthma, such as cystic fibrosis or bronchiectasis, was excluded. To prevent overlapping study populations, the participants who were initially followed in allergy or pulmonology SDCs and subsequently referred to the SAC were included in the SAC cohort.

To measure alignment of prescribed controller medications with guideline-based recommended therapies for severe asthma, asthma medications were identified by using the AC EHR and assessed in accordance with the preferred step therapies outlined in the National Heart, Lung, and Blood Institute (NHLBI) 2020 Asthma Management Guidelines.[17] Controller medications were grouped into 2 categories based on age and prescribed therapies: group 1 consisted of step 3 and step 4 preferred therapies and group 2 consisted of step 5 and step 6 preferred therapies. No patients were receiving step 1 or step 2 therapy.

Outcome measures

Primary outcome measure. In this study, specific criteria were used during EHR data collection to clearly define both hospitalizations and ED visits within the AC health system. Hospitalizations were defined as those encounters with a severe asthma diagnosis (ICD-10 J45.5*) and an AC Asthma Protocol order. The AC Asthma Protocol is a provider-ordered institutional protocol that is routinely used during hospitalizations for asthma exacerbations to guide the administration of acute therapies by respiratory therapists. ED visits were identified by an associated severe asthma diagnosis (ICD-10 J45.5*) for the encounter and a provider order for albuterol-ipratropium administration.

The primary outcome was the median difference in acute health care utilization, based on hospitalizations and ED visits, because of asthma exacerbations among patients followed in the SAC versus among those followed in SDCs. All acute exacerbations included for analysis were defined as asthma-related hospitalizations and ED visits.

Secondary outcome measures. Secondary outcomes were compared among those seen at the SAC and those seen at specialty SDCs and included SCS prescriptions and psychology or social worker service utilization. Prescriptions for an SCS, either intramuscular or oral, form a critical component in treating acute asthma exacerbations; thus, the number of SCS

prescriptions was compared between the SAC patients and specialty SDC patients. Analysis of the utilization of psychology and social work services was attempted; however, because of limitations with EHR data collection, reliable characterization could not be performed.

For longitudinal secondary outcomes among the SAC patients only, asthma exacerbations (ED or acute care visits), hospitalizations, ICU admissions, asthma symptom control, and spirometry were examined over a 12-month period starting from the initial visit. An asthma exacerbation was defined as any acute (ie, ED or ambulatory) visit requiring the patient to be seen by a health care provider within the AC health system. Asthma symptom control was assessed using the Asthma Control Test (ACT), a validated survey that measures asthma control in adults and children, with a score of 19 or lower indicating poorly controlled asthma.[18,19] A change in ACT score as indicated by at least a 3-point increase was considered to be clinically significant.[20,21] Spirometry, a vital tool for assessing asthma-related risk and impairment, was used to measure FEV_1% value, expressed as percent predictive of reference population values. A clinically important improvement in FEV_1% value was defined as more than a 12% increase.[18,22]

Statistical analysis

Descriptive statistics were used to summarize the characteristics of the study population. Comparisons between the 2 study populations were performed using the Fisher exact test for categoric variables and Welch *t* test for continuous variables. Nonparametric Wilcoxon rank sum tests were used for comparing the median of count variables between the groups. Multiple logistic regression models were used to examine the association between study populations and acute health care use, SCS prescriptions, and wraparound ancillary service exposure, with adjustments for imbalances by including a covariate for the SAC group indicator. Longitudinal assessment of outcome measures in the SAC study population was performed by using paired *t* tests.

RESULTS

Comparative analysis of the SAC and specialty SDCs: Study population

The comparative cohort (n = 280) shown in Table I included 56 children from the SAC and 224 children from the specialty SDCs. Sex distributions were predominantly male in both the SAC (54%) and specialty SDC (58%) groups. Statistically significant differences were identified for ethnicity and race. No Hispanic patients were identified in the SAC, whereas Hispanic patients comprised 10% of the specialty SDC group ($P = .01$). Regarding race, 79% of patients in the SAC identified as Black, versus 52% in the specialty SDCs ($P = .0002$). The median age at study entry was slightly higher for the SAC group (11 years [interquartile range (IQR) = 8-13]) than for the specialty SDC group (10 years [IQR = 6-14]); however, the difference was not statistically significant ($P = .09$).

In the longitudinal SAC cohort, shown in Table II, 27 patients were identified as having follow-up visits within 12 months (± 3 months). The mean follow-up interval was 11.3 months from the initial visit. The cohort was predominantly male (52%), with a median age of 10.6 years (IQR = 9.1-13.3). The majority of SAC patients were Black (71%), mirroring the racial distribution of the comparative cohort.

TABLE I. Comparative analysis demographics of the AC SAC and specialty SDCs

Characterisic	SAC (n = 56)	SDC (n = 224)	*P* value
Age (y) median (range)	11 (8-13)	10 (6-14)	.09*
Sex			.55†
Male	55%	60%	
Female	45%	40%	
Race			<.001†
Black	79%	52%	
White	21%	36%	
Other	0%	12%	
Ethnicity			.01†
Non-Hispanic	100%	88%	
Hispanic	0%	10%	
Other	0%	2%	

*Wilcoxon rank sum test.
†Fisher exact test.

TABLE II. Demographics of the SAC participants included in the longitudinal analysis

Characteristic	SAC (n = 27)
Mean follow-up time (mo)	11.3
Age (y), median (range)	10.6 (9.1-13.3)
Sex	
Male	52%
Female	48%
Race	
Black	71%
White	25%
Other	4%
Ethnicity	
Non-Hispanic	100%
Hispanic	0%

Comparative analysis of the SAC and specialty SDCs: Acute health care utilization

The majority of patients had no ED visits or hospitalizations during the 12-month study period. ED visits were observed in 19.6% of the SAC group and 11.6% of the specialty SDC group, whereas 21.4% of patients in the SAC group and 10.3% of patients in the specialty SD group experienced hospitalizations. Assessment of the proportions of patients with ED visits and hospitalizations revealed a significant difference in hospitalization rates between the 2 groups, but not in ED visits. As seen in Fig 1, the percentages of SAC patients who had 1 (10.7%) or 2 (8.9%) hospitalizations were higher than the percentages of specialty SDC patients (8.5% and 1.3%, respectively) ($P = .04$). The percentage of SAC patients who had at least 1 ED visit (19.7%) was higher than the percentage of specialty SDC patients (11.5%), but this difference was not statistically significant ($P = .12$).

Comparative analysis of the SAC and specialty SDCs: Ambulatory visits and asthma medications

Significant differences were also seen for total ambulatory visits between groups based on a *post hoc* analysis. The percentage of patients of the SAC who had 4 or more ambulatory visits (55.4%) was higher than the percentage of specialty SDC patients (37.1%) ($P = .02$). Regarding asthma medications, the numbers of SCS prescriptions between groups were significantly different (Fig 2). The proportion of SAC patients who required 2 or more

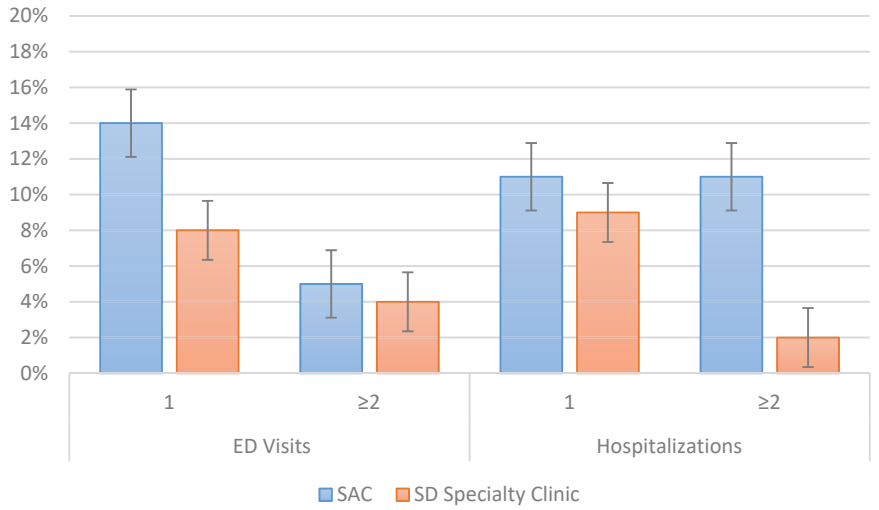

FIG 1. ED visits and hospitalizations in the SAC and specialty SDCs. Percentages of patients from both groups over 12 months with 1 or at least 2 ED visits and hospitalizations.

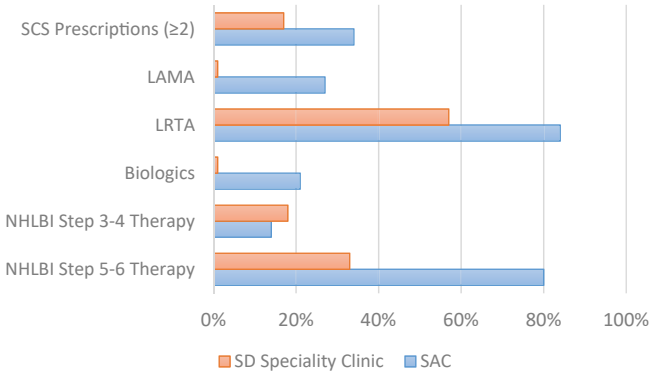

FIG 2. Comparison of asthma treatments between the SAC and specialty SDCs. Proportions of patients prescribed various treatments, including SCSs (≥2 prescriptions), long-acting muscarinic antagonists (LAMAs), leukotriene receptor antagonists (LTRAs), and biologic therapies. Also shown are the percentages of patients receiving NHLBI steps 3 and 4 and steps 5 and 6 therapies.

prescriptions (34%) was larger than the proportion of specialty SDC patients (17%) ($P = .01$). In terms of controller medications, the SAC patients also demonstrated higher use of certain treatments. As shown in Fig 2, long-acting muscarinic antagonists, leukotriene receptor antagonists, and biologic therapies were used substantially more among the SAC patients than among the patients of specialty SDCs ($P < .001$). Furthermore, of those seen in the specialty SDCs, 17.86% (n = 40) were prescribed NHLBI step 3 or step 4 therapies and 32.59% (n = 73) were prescribed step 5 or step 6 therapies. Among the SAC patients, the respective proportions were 14.3% (n = 8) for step 3 or step 4 and a notably higher 80.4% (n = 45) for step 5 or step 6.

Longitudinal analysis of the SAC

As shown in Fig 3, compared with the 12-month period before enrollment in the SAC, there was a significant reduction in acute exacerbation rates (from 35 to 8 [$P < .001$]), number of hospitalizations (from 21 to 1 [$P < .001$]), and ICU admission rates (from 8 to 1 [$P = .02$]) after enrollment. Further, there was a median reduction of 2 SCS prescriptions per patient (IQR = 1-3) ($P = .0007$). Despite a median ACT score increase of 2 points ($P = .043$ [IQR = 0-6]), a minimally clinically important improvement (≥3-point increase) was not seen. FEV_1% value demonstrated a negligible median increase of 1% ($P > .9$ [IQR = 71-98]).

DISCUSSION

Our findings suggest that although a multidisciplinary approach to management of severe asthma such as that implemented in the AC SAC shows higher health care utilization when compared with the approach taken at specialty SDCs, an overall significant reduction in acute utilization over time was observed in the SAC patients. Thus, dalthough the SAC patients exhibited a higher likelihood of multiple hospitalizations and SCS prescriptions, it is important to note that this does not necessarily indicate a shortcoming in multidisciplinary management. Rather, we believe that it emphasizes the considerable disease severity and associated morbidity among patients referred to the AC SAC. Furthermore, the strikingly higher health care utilization observed in our predominantly Black SAC population signals a critical health care disparity that is likely shaped by inequities related to social determinants of health, underscoring the importance of multidisciplinary expertise.

Despite the higher health care utilization seen among the SAC patients, longitudinal analysis revealed significant reductions in asthma exacerbations, hospitalizations, ICU admissions, and SCS prescriptions 12 months after the initial visit. Similar findings have been noted among pediatric cohorts followed in other SACs nationwide. Molina et al observed a significant decrease in average exacerbation frequency (per patient) among 110 children receiving multidisciplinary care for severe asthma at the Children's Hospital of Pittsburgh.[23] A study by Patel et al also demonstrated significant declines in hospitalizations and SCS prescriptions among 54 Medicaid-eligible children (aged 5-18 years) 12 months after enrollment in the multidisciplinary SAC at the Children's Hospital of Michigan.[24] Furthermore, no differences were identified for FEV_1% value after 12 months, which is similar to the lack of change observed in our study. In contrast to

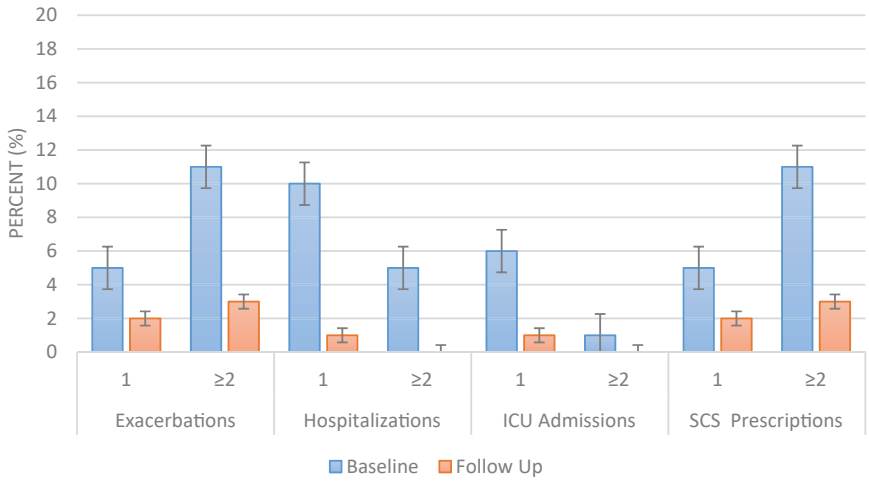

FIG 3. Longitudinal health outcomes at baseline and follow-up in the SAC. The data show a significant reduction in the percentage of patients with exacerbations, hospitalizations, ICU admissions, and systemic SCS prescriptions from baseline to follow-up.

our findings, significant reductions in ED visits were also observed.[24] A separate prospective 3-year longitudinal study of 111 children with severe asthma by Ross et al also demonstrated improvements in exacerbation frequency and symptom control, but not for lung function.[2]

All new patients in the SAC are routinely seen by a psychologist and social worker, with psychosocial screening measures and an initial semistructured interview conducted. Follow-up is determined on the basis of the screening measures, patient- and family-identified needs, and known barriers to accessing care (eg, transportation problems, refill history, school attendance). Comparison of psychosocial services between SAC and the specialty SDCs was attempted, but because of EHR data limitations, reliable characterization could not be performed for the specialty SDCs. Psychology and social work services are commonly recorded less systematically within the EHR, predominantly as free-text narrative notes. This presents significant challenges for accurate data collection and analysis, consequently limiting the insights regarding the impact on severe asthma at our institution. Nevertheless, previous studies suggest higher rates of anxiety and depression among children with asthma than among those without asthma.[2] Mechanistic studies have also identified biologic, individual, family, and community psychosocial factors that contribute to increased asthma morbidity,[25] with a greater number of ambulatory and ED visits seen in those with comorbid depression.[26,27] Past research also suggests screening for social determinants of health, particularly for shelter, food, and utility assistance, as associations with decreased hospitalizations and ED visits in the multidisciplinary SAC at Rady Children's Hospital are noted.[11] Therefore, incorporation of these psychosocial services likely contributed to the significant improvements seen in asthma outcomes among this high-risk population receiving multidisciplinary care.

A fundamental advantage of multidisciplinary care is the capacity to streamline expertise across multiple subspecialties into a single appointment. Interestingly, our *post hoc* findings demonstrated a larger proportion of patients from the SAC group having 4 or more outpatient visits. Although our analysis included all ambulatory visits, irrespective of whether these were routine visits or visits for acute indications, this finding suggests that multidisciplinary care may require more ambulatory visits to effectively manage severe asthma despite consolidation of expertise. Another significant finding was the difference seen in provider prescribing patterns for controller medications in the SAC and specialty SDCs. The patients in the SAC were prescribed leukotriene receptor antagonists, long-acting muscarinic antagonists, and biologic therapies, including NHLBI step 5 and step 6 therapies, more frequently than their SD group counterparts were. Exploring prescribing patterns in severe asthma is important because it can identify potential disparities in access to these therapies, particularly with regard to emerging biologic therapies.

It is important to acknowledge several limitations in this study. First, because of its retrospective single-institution study design, our study's ability to establish causality or control for potential confounding variables is limited. Another limitation is the potential underrepresentation of health care utilization, as patients might have sought care from a non-AC ED, urgent care, or primary care setting, which would not have been accounted for in our data. The study also had a relatively short follow-up period of 12 months, which may not be sufficient to compare sustained improvement in outcomes between the SAC and specialty SDCs over time. Further, the comparative analysis between the SAC and the specialty SDCs was a snapshot in time and did not examine outcomes over the 12 months preceding study period. As such, future investigations should aim to compare these differences in both groups over time to characterize the difference in outcomes among pediatric patients with severe asthma. The SAC participants may have been subject to selection bias, as patients referred to the SAC may have been previously followed at an AC SDC and were referred to the SAC owing to the severity and complexity of their asthma. Lastly, the study relied on EHR data, which has previously been noted as a concern regarding data quality. A significant decline is noted in those included for longitudinal analysis from the SAC owing to a lack of available data on key outcome measures from the SAC registry over the 12-month study period. Highlighting a lack of consensus guidance for EHR-based investigations on asthma outcomes, a recent systemic review by Bonini et al noted the

considerable variability among data collected from EHRs, including variability in severity documentation, prescription data, and acute care visits (eg, ED visits and hospitalizations).[18] As the data utilized in this analysis were sourced primarily from a single health system in which the majority of care was delivered, there is potential for incomplete data owing to the possibility of health care utilization outside AC.

Despite these limitations, our findings suggest that health care providers and institutional stakeholders should consider the value of multidisciplinary care when managing patients with severe asthma. Furthermore, we believe that there is a significant potential for collaboration with community-based allergy and immunology providers to strengthen severe asthma management. The findings of this study provide evidence that although certain children with severe asthma achieve disease control in specialty SDCs, there is a subset that may benefit significantly from a multidisciplinary approach. Future investigation is needed to further understand the mechanisms underlying the benefits of multidisciplinary care, as well as to identify strategies for optimizing the delivery of care that improve morbidity and mortality for this vulnerable population.

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REFERENCES

1. Pike KC, Levy ML, Moreiras J, Fleming L. Managing problematic severe asthma: beyond the guidelines. Arch Dis Child 2018;103:392-7.
2. Ross KR, Gupta R, DeBoer MD, Zein J, Phillips BR, Mauger DT, et al. Severe asthma during childhood and adolescence: a longitudinal study. J Allergy Clin Immunol 2020;145:140-6.e9.
3. Busse WW, Kraft M. Current unmet needs and potential solutions to uncontrolled asthma. Eur Respir Rev 2022;31:210176.
4. Chung KF, Wenzel SE, Brozek JL, Bush A, Castro M, Sterk PJ, et al. International ERS/ATS guidelines on definition, evaluation and treatment of severe asthma. Eur Respir J 2014;43:343-73.
5. *2019* National Health Interview Survey (NHIS. Data, 2019, US Centers for Disease Control and Prevention, Table 1-1. Available at: https://www.cdc.gov/asthma/nhis/2019/table1-1.htm. Accessed March 5, 2023.
6. Nurmagambetov T, Kuwahara R, Garbe P. The economic burden of asthma in the United States, 2008-2013. Ann Am Thorac Soc 2018;15:348-56.
7. Tay TR, Lee J, Radhakrishna N, Hore-Lacy F, Stirling R, Hoy R, et al. A Structured approach to specialist-referred difficult asthma patients improves control of comorbidities and enhances asthma outcomes. J Allergy Clin Immunol Pract 2017;5:956-64.e3.
8. Diette GB, Skinner EA, Nguyen TTH, Markson L, Clark BD, Wu AW. Comparison of quality of care by specialist and generalist physicians as usual source of asthma care for children. J Pediatr (Evanston) 2001;108:432-7.
9. Filler G, Kovesi T, Bourdon E, Jones SA, Givelichian L, Rockman-Greenberg C, et al. Does specialist physician supply affect pediatric asthma health outcomes? BMC Health Serv Res 2018;18:247.
10. Burke H, Davis J, Evans S, Flower L, Tan A, Kurukulaaratchy RJ. A multidisciplinary team case management approach reduces the burden of frequent asthma admissions. ERJ Open Res 2016;2:39.
11. Leibel S, Geng B, Phipatanakul W, Lee E, Hartigan P. Screening social determinants of health in a multidisciplinary severe asthma clinical program. Pediatr Qual Saf 2020;5:e360.
12. McDonald VM, Maltby S, Reddel HK, King GG, Wark PAB, Smith L, et al. Severe asthma: current management, targeted therapies and future directions—a roundtable report. Respirology 2017;22:53-60.
13. McDonald VM, Vertigan AE, Gibson PG. How to set up a severe asthma service. Respirology 2011 Aug;16:900-11.
14. Meguid C, Ryan CE, Edil BH, Schulick RD, Gajdos C, Boniface M, et al. Establishing a framework for building multidisciplinary programs. J Multidiscip Healthc 2015;8:519-26.
15. Giusti EM, Pietrabissa G, Manzoni GM, Cattivelli R, Molinari E, Trompetter HR, et al. The economic utility of clinical psychology in the multidisciplinary management of pain. Front Psychol 2017;8:1860.
16. Steketee G, Ross AM, Wachman MK. Health outcomes and costs of social work services: a systematic review. Am J Public Health 2017;107:S256-66.
17. Cloutier MM, Baptist AP, Blake KV, Brooks EG, Bryant-Stephens T, DiMango E, et al. 2020 focused updates to the asthma management guidelines: a report from the National Asthma Education and Prevention Program Coordinating Committee Expert Panel Working Group. J Allergy Clin Immun 2020;146:1217-70.
18. Bonini M, Di Paolo M, Bagnasco D, Baiardini I, Braido F, Caminati M, et al. Minimal clinically important difference for asthma endpoints: an expert consensus report. Eur Respir Rev 2020 30;29:190137.
19. Nathan RA, Sorkness CA, Kosinski M, Schatz M, Li JT, Marcus P, et al. Development of the asthma control test: a survey for assessing asthma control. J Allergy Clin Immun 2004;113:59-65.
20. Pellegrino R, Viegi G, Jensen R, Johnson DC, Maclntyre N, Mckay R, et al. Interpretative strategies for lung function tests. Eur Respir J 2005;26:948-68.
21. Schatz M, Kosinski M, Yarlas AS, Hanlon J, Watson ME, Jhingran P. The minimally important difference of the asthma control test. J Allergy Clin Immunol 2009;124:719-23.e1.
22. Pennock BE, Rogers RM, McCaffree DR. Changes in measured spirometric indices. What is significant? Chest 1981;80:97-9.
23. Forero Molina M, Okoniewski W, Puranik S, Aujla S, Celedón JC, Larkin A, et al. Severe asthma in children: description of a large multidisciplinary clinical cohort. Pediatr Pulmonol 2022;57:1447-55.
24. Patel PP, Munzenberger P, Marocco R, Taormina S, Alame W, Montejo J, et al. Update on the effect of a multidisciplinary team clinic on asthma outcome for Medicaid-eligible inner city children with moderate to high-risk asthma. J Allergy Clin Immun 2007;119:S10.
25. Goodwin RD, Fergusson DM, Horwood LJ. Asthma and depressive and anxiety disorders among young persons in the community. Psychol Med 2004;34:1465-74.
26. Yonas M, Lange N, Celedón J. Psychosocial stress and asthma morbidity. Curr Opin Allergy Clin Immunol 2012;12:202-10.
27. Richardson LP, Russo JE, Lozano P, McCauley E, Katon W. The effect of comorbid anxiety and depressive disorders on health care utilization and costs among adolescents with asthma. Gen Hosp Psychiatry 2008;30:398-406.