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Leveraging Electronic Health Records for Guideline-Based Asthma Documentation

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Abstract

BACKGROUND: Asthma is the most common pediatric chronic disease; thus, clinical guidelines have been developed for its assessment and management, which rely on systematic symptom documentation. Electronic health records (EHR) have the potential to record clinical data systematically; however, variability in documentation persists.

OBJECTIVE: To identify if the use of a structured asthma template is associated with increased guideline-based asthma documentation and clinical outcomes when compared with the use of nonstructured ones.

METHODS: We performed a retrospective case-control study comparing the use of nonstructured templates (NSTs) and asthma-structured templates (ASTs) in new patient and first follow-up encounters, evaluated by pediatric pulmonologists between March 2016 and December 2021. Asthma history items were selected following clinical guidelines, summarized in 29 items for new and 22 items for follow-up encounters. Associations with demographic, spirometry, and health care utilization were explored.

RESULTS: A total of 546 initial encounters were included; 450 used structured templates. The use of an AST was associated with higher documentation of asthma items in initial and follow-up encounters. Linear regression analysis showed that the use of ASTs was associated with a 28.2% and 39.65% increase in asthma history completeness (in initial and follow-up encounters, respectively), compared with the use of NSTs. AST use was associated with higher rates of systemic steroid prescriptions within 12 months. No other differences were observed after adjusting for asthma severity.

CONCLUSIONS: Using asthma-specific structured templates was associated with increased guideline-based asthma documentation. Leveraging the EHR as a clinical and research tool has the potential to improve clinical practice.

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Keywords

Asthma; Children; Electronic health records; Documentation; Guideline-based documentation; Structured data entry systems; Structured templates; Pediatric pulmonology

Asthma is the most common chronic disease in children,[1] and consequently, standardized clinical guidelines have been developed for its care, which rely on thorough and systematic history taking for accurate diagnosis, severity assessment, and management.[2,3] Electronic health records (EHR) have the potential to record key clinical data systematically and at a large scale. Despite this readily available technology, variability in documentation exists, which may negatively impact evidence-based care and limit the utility of the EHR data.[4]

With the wide use of EHR in most health systems in the United States,[5] great effort and time are invested by clinicians into the documentation process on a daily basis;[6,7] thus, a robust amount of clinical data is recorded. Despite these efforts, resources to standardize documentation in a systematic and user-friendly way are still limited. The absence of such tools can lead to substantial documentation variability[8,9] within and between subjects, negatively affect physician's workflow,[10] while also impose limitations in the secondary use of the recorded clinical data.

The high prevalence of asthma in our communities and the standardization of its care gives an excellent opportunity for leveraging the resources the EHR provides for documentation that can be used as both clinical and research tools. Efforts have been made to help standardize asthma documentation; for instance, National Asthma Education and Prevention Program Expert Panel Report 3 (NAEPP EPR-3) asthma guidelines[11] suggested a list of medical history taking items for both initial and follow-up encounters to help guide asthma diagnosis and management. In addition, specifically for asthma severity assessment and management, the frequency of symptoms are determining factors for adequate classification as described by the NAEPP EPR-3 guidelines[11] and the Global Initiative for Asthma,[3] which can potentially be captured in documentation consistently. Moreover, in an effort to facilitate structured asthma documentation, the Agency for Healthcare Research and Quality[12] has made available tools that can be used by medical practices following asthma guidelines.

Currently, there is limited evidence on the use of asthma-specific structured templates and their impact in guideline-based documentation, diagnosis, and clinical outcomes in ambulatory settings.[8,13–17] We hypothesize that using structured asthma-structured templates (ASTs) is associated with a significant increase in guideline-based documentation when compared with using nonstructured templates (NSTs) in both initial and follow-up encounters in a subspecialty outpatient center. In addition, we propose to explore the association between the type of template used and clinical outcomes.

METHODS

We performed a retrospective case-control study of patients evaluated by pediatric pulmonologists at Rady Children's Hospital of San Diego (RCHSD), comparing the use

of ASTs (cases) versus NSTs (controls) in new asthma outpatient encounters and their subsequent first follow-up encounter.

Data sources

For patients diagnosed with asthma, we queried patient and encounter information from the EHR (Epic) for those who had their first asthma-related visit between March 2016 and December 2021. To qualify for inclusion, these patients also needed to have at least 1 asthma follow-up visit within 12 months of their initial visit. Asthma-related visits were identified by the International Classification of Diseases, Tenth Revision (ICD-10) code J45.X being documented as an encounter or billing diagnosis. Encounters associated with significant chronic lung diseases as their primary diagnosis were excluded (eg, cystic fibrosis, bronchopulmonary dysplasia, and chronic lung disease).

Looking at the qualifying asthma-related encounters, we investigated the methods in which the notes were composed. The EHR Epic provides functionality to create and use templates that have predefined fields that correspond to common attributes relevant to the patient evaluation. Under this structured framework, an asthma-specific structured template, other respiratory disease-related templates, and a nonstructured template ("free text history taking note") were previously created in our EHR. Of note, the AST at RCHSD was designed through a collaborative effort with associated stake-holders including general pediatricians, pediatric allergists, and pediatric pulmonologists. This template was identified as the most comprehensive by the authors and selected for analysis. The NST did not have any asthma-specific discrete data elements (check boxes); history intake was inserted as free text by physicians, except for sections pertaining to review of symptoms, past medical history, family history, physical examination, and chest x-rays. Among the encounters included for the analysis of new patients with asthma, the first subsequent follow-up encounter within 12 months was included for analysis.

For the evaluation of asthma history completeness, the items included in this study were selected following the recommendations by the NAEPP EPR-3,[11] summarized by the authors in 29 history items for new patient encounters and 22 items for follow-up encounters (see Table I).

Outcome variables

Asthma history "completeness" was measured by calculating the percentage of asthma items included in each encounter document. All NSTs were manually reviewed by a physician investigator. AST items were queried using Microsoft SQL Server and Epic Clarity Database, with a random subset of them also manually reviewed for validation of automated variable counting. Encounters that used ASTs but that had less than 10 items included were manually reviewed to identify "free text" data items by a physician investigator and were still considered in the structured template group.

The use of ICD-10 codes in all included new patient and follow-up encounters were analyzed. The ICD-10 codes included the following: mild intermittent asthma (J45.2), mild persistent asthma (J45.3), moderate persistent asthma (J45.4), severe persistent asthma (J45.5), asthma unspecified (J45.90), exercise-induced asthma (J45.99), and cough variant

asthma (J45.991). Encounters associated with more than one of these ICD-10 codes were manually reviewed by a physician investigator, and the primary diagnosis code associated with the visit was chosen for analysis.

The association between the type of template used and clinical outcomes recorded in the EHR after the initial encounter was explored. Clinical outcomes available in the EHR were retrieved and included the following: systemic steroid prescription orders, albuterol orders, emergency department evaluations, hospitalizations, and pulmonary function testing (PFT). Finally, associations between the type of template used and ethnicity and language preference were examined in both initial and follow-up encounters. This study was approved by institutional board reviews at the University of California San Diego and RCHSD.

Statistical analysis

Bivariate analyses were conducted using the χ^2 test for categorical variables and 2 sample *t* tests for binary and continuous variables. Nonparametric tests were used for analyzing binary and non-normally distributed continuous variables. Linear regression was used for the bivariate analyses of history completeness and AST use. Logistic regression analysis was used for binary outcomes and AST use. Poisson regression analysis was used for modeling count outcomes and AST use. Statistical data analyses were performed using the software IBM Statistical Package for Social Sciences (SPSS) version 28.0.1.1, Armonk, NY.

RESULTS

A total of 847 new asthma encounters were queried. The AST was the most commonly used (54.8%) followed by a different structured template (“cough template,” 22.9%), whereas the nonstructured template was used in 15.8% of all encounters. Inclusion criteria were met by 546 of new asthma encounters; in 96 of them (17.5%) an NST was used and in 450 (82.5%) the AST was used. Including initial and their corresponding follow-up encounters, a total of 1092 notes were evaluated. The demographic characteristics of the subjects whose encounters were included in the analysis are summarized in Table I. No differences in age, sex, or ethnicity were observed between types of templates used.

The differences in asthma history items in both initial and follow-up encounters are summarized in Table II. Of the 96 initial encounters in which an NST was used, 58 also had an NST used in the follow-up encounter. In contrast, among the 450 initial encounters in which an AST was used, only 12 had an NST used in the follow-up encounter. The use of an AST was associated with higher documentation in 25 of 29 history items in initial encounters and in 17 of 22 items in follow-up encounters, when compared with using an NST. Using an NST was associated with higher documentation of 2 history items only in follow-up encounters. Moreover, history items and completeness were significantly higher in initial and follow-up encounters when using an AST (Figure 1). Of note, a subgroup analysis of only core elements needed for asthma assessment was made.[3,11] Core items were classified into any respiratory symptom frequency (merging “cough,” “wheezing,” and “shortness of breath”), any activity limitation (merging “interference with activity” and “exertional symptoms”), and “bronchodilator use frequency.” Table E1 (available

in this article's Online Repository at www.jaci-inpractice.org) shows consistently higher documentation even in this subgroup of core items in ASTs compared with NSTs.

Linear regression analysis (Table III) showed that the use of ASTs was associated with a 28.2% and 39.7% increase in history completeness in initial and follow-up encounters, respectively, when compared with using NSTs. This association persisted after adjusting for moderate-to-severe asthma severity. Among those who used an NST in the initial encounter, switching to an AST in the follow-up encounter was associated with higher history completeness percentage (54.3%) compared with those who used an NST follow-up template (29.8%); see Table E2 in this article's Online Repository at www.jaci-inpractice.org.

Table IV shows the asthma ICD-10 codes associated with ASTs and NSTs in initial and follow-up encounters. Asthma severity was documented in 94.4% of all evaluated notes. The use of asthma ICD code that described any severity was higher in initial encounters that used an AST. Compared with NSTs, ASTs were associated with higher moderate and severe persistent asthma ICD-10 codes, whereas NSTs were associated with higher mild intermittent and mild persistent asthma codes. Among follow-up encounters, using an AST was associated with a higher moderate persistent asthma code, whereas using an NST was associated with the mild intermittent asthma code. No differences were observed between the type of template and exercise-induced and cough variant asthma codes. Moreover, encounters with a moderate or severe persistent asthma associated with ICD-10 code had higher completeness percentage (mean of 62.2% for initial encounters and 67.1% for follow-up encounters) than encounters with an intermittent asthma or mild persistent asthma diagnosis (mean of 51.7% for initial encounters and 61.2% for follow-up encounters); see Table E3 in this article's Online Repository at www.jaci-inpractice.org for more details. On logistic regression analysis, the use of an AST in an initial encounter was associated with the 4-fold increase in odds of using any ICD-10 code specifying asthma severity compared with the use of an NST, whereas this association was not seen in follow-up encounters (see Table E4 in this article's Online Repository at www.jaci-inpractice.org).

Table V summarizes rate ratio estimates of clinical outcomes and AST use, obtained through Poisson regression analysis. Unadjusted models showed associations between AST use and the number of asthma-related follow-up visits, systemic steroid orders, and albuterol orders within 12 months of the initial encounter. After adjusting for moderate-to-severe asthma severity, only the association with systemic steroid orders remained significant to both predictors, whereas emergency department visits, asthma outpatient encounters, and albuterol orders were associated with more severe asthma but not with the type of template used. No associations between template use and hospitalizations and pulmonology evaluations were identified. Finally, we did not identify any clinically significant differences between any components of spirometry parameters and the type of template used in initial and follow-up encounters, and changes between encounters (Table E5, available in this article's Online Repository at www.jaci-inpractice.org).

The characteristics of the templates used in encounters and their association with subjects' Hispanic ethnicity and language preference are presented in Table VI. Of the included

encounters, approximately 50% were evaluations of Hispanic children. No differences between the type of template used and ethnicity or language preference were identified. Similarly, no differences in history items, completeness percentage, or ICD-10 codes were observed between Hispanics and non-Hispanics or in those who had a non-English preferred language (Tables E6 and E7, available in this article's Online Repository at www.jaci-inpractice.org).

DISCUSSION

The use of an EHR AST was associated with increased guideline-based documentation in a consistent manner through initial and follow-up encounters, even after adjusting for asthma severity. In addition, switching from an NST in an initial encounter to an AST on a follow-up was associated with a significant increase in asthma documentation items (Table E1, available in this article's Online Repository at www.jaci-inpractice.org). Conversely, a decrease in history completeness was observed when an NST was used in a follow-up encounter. Notably, the use of an AST was increased in visits encoding moderate-severe asthma, suggesting that physicians assign value to increased documentation in more severe patients.

To the best of our knowledge, this is the first and largest pediatric study with a comprehensive comparison of documentation using an asthma-specific template and a nonstructured one, in initial and follow-up outpatient encounters by a subspecialty group. In our study, we assessed specific history items pertinent to pharmacological interventions needed, severity of asthma exacerbations, impact in quality of life, asthma contributors, asthma symptom control, and asthma management assessment (Tables II and III). In all these history fields, we showed significantly higher inclusion of asthma items when ASTs were used. We identified a few prior studies exploring asthma documentation in different clinical settings. For instance, retrospective studies have identified poor documentation in asthma control, medication adherence assessment, asthma precipitants,[8,13] and activity limitations[13] when using non–disease-specific templates in the care for children and adults with asthma. The utility of asthma-specific templates in ambulatory care has not been widely studied. This was explored in a limited fashion in a study assessing documentation of trainees in the outpatient setting that identified poor use of asthma-specific templates, which was associated with increased asthma severity documentation and inhaled steroid prescription.[14] Moreover, the use of an asthma-specific template has been associated with increased documentation of severity, precipitating factors, and prior intensive care unit admissions in the emergency department,[15] whereas in the inpatient setting its use has been associated with increased documentation of health care utilization and environmental exposures.[16] Although these studies found an improvement in asthma documentation when using a structured template, only a discrete number of variables were explored and consistency of documentation in subsequent encounters was not evaluated. The use of disease-specific structured templates may also allow for a decrease in history taking variability in academic centers where both subspecialists and trainees can document in the EHR,[17] or in nonacademic practices where more than 1 physician or advanced provider may evaluate the same patient over time.

We identified that using an AST was associated with a 4-fold increase odds of asthma severity documentation in initial encounters. In addition, we found high documentation of asthma severity by our group in 94.4% of included notes, which surpassed the previously reported 33.8% in the 2012–2015 National Ambulatory Medical Care survey,[9] including the reported 60.8% among pulmonologists.[9] Of importance, we observed higher moderate and severe persistent asthma diagnosis among the encounters that had an AST, compared with those with NSTs. This association may be explained by physicians choosing a "general" template when a patient is perceived to have milder disease on chart review before an encounter, or if patients did not already have an established asthma diagnosis on initial evaluation. Alternatively, a more thorough documentation when using an AST could have aided in identifying more symptomatic and severe asthma.

We did not observe any clinically significant differences between the type of template used and PFTs (on initial, follow-up, or a change between encounters). Regarding clinical outcomes, only an association between the use of an AST and higher rate of systemic steroid orders within 12 months persisted when adjusting for asthma severity. This difference may be explained by possible confounding factors our study did not account for such as the level of asthma control, medication adherence, and the frequency of follow-up encounters, which we hypothesize could have been over-represented in the structured template group. In addition, using a structured template may have helped clinicians identify more uncontrolled asthma symptoms potentially leading to an increase in systemic steroid prescriptions. Although we did not find differences between hospitalizations and emergency encounters between the 2 template groups, the lack of difference may be clinically valuable considering that the higher proportion of severe asthmatics in the AST group had similar outcomes to those with milder asthma that were more prevalent in the nonstructured template group. As expected, moderate-to-severe asthma was associated with higher rates of emergency visits, asthma outpatient encounters, systemic steroid, and albuterol orders, compared with milder asthma.

The implementation of standardized patient asthma questionnaires may help improve documentation. In our practice, the Asthma Therapy Assessment Questionnaire (ATAQ) is provided routinely for asthma visits; however, patients do not always complete it, and its elements are electronically included in the ASTs but not in the NSTs. In this study, we focused on documentation obtained by physicians and did not account for the ATAQ elements; choosing to do so would have likely favored ASTs alone. In a subset analysis, we found that having the ATAQ associated with an encounter did not influence asthma documentation in both the AST and NST groups (Table E8, available in this article's Online Repository at www.jaci-inpractice.org).

The use of technology is promising in helping identify relevant disease-specific history items at a large scale, irrespective of the use of a structured template.[13,18] Recent studies have used natural language processing (NLP) for data mining, identifying congruence when compared with a manual chart review;[13] however, in the presence of high variability in documentation descriptions, this approach may be limited. Although NLP and the use of artificial intelligence can help use the EHR data to evaluate quality of care, provide feedback to physicians or health care workers, and for research retrospectively, their use helping

guide standardized documentation in a prospective manner is limited; thus the use and implementation of structured data entry systems remain valuable tools.

In our group, we did not identify any disparities in asthma history documentation or any severity of asthma ICD-10 code by ethnicity or language preference. Furthermore, we did not identify differences in asthma severity based on Hispanic ethnicity or Spanish language preference. This may be reflective of the specific location of our health system, the large volume of patients with diverse backgrounds our practice has been treating for several years, and access to interpreting resources. However, in settings where less resources are available or where the volume of patients from ethnic and linguistic minorities is small, disparities in asthma documentation may exist and the use of a structured template may help with asthma history consistency and assessment.

Finally, the development and implementation of a disease-specific structured template must take into consideration the target users' input and feedback, as both information overload or excessive data entry can lead to physician stress and burnout.[19] In addition, system-wide factors play an important role into physician EHR-related burden,[20] considering the specific amount of entry points each clinical note must have for administrative purposes, which may be a particular issue impacting EHR use by physicians in the United States when compared with other countries.[21]

Despite our encouraging findings, our study had several limitations. First, the encounters reviewed were exclusively those that occurred in a single academic subspecialty group and thus may not be generalizable to primary care groups or other subspecialty groups. Studies looking at the use of similar ASTs in primary care and other subspecialties are needed. Second, only the ASTs that had fewer than 10 items in the computerized counts underwent a manual chart review; thus, most ASTs did not go through this process, which likely resulted in underestimation of their history completeness. Third, manual chart reviews were performed by a single physician researcher; thus, selection bias is possible. Fourth, some clinical outcomes were not able to be reviewed such as access to claims data of medication pickup or refill history. Fifth, we analyzed only the first follow-up visit but did not access if documentation consistency still occurred in subsequent visits. Sixth, clinical outcomes cannot be directly attributable to the use of a specific template because outcomes may be dependent on a more complex assessment of clinical status that may not be reflected in documentation. Furthermore, we could not account for clinical outcomes that may have occurred outside our health care system. This issue highlights the importance of documentation of clinical outcomes in encounter notes. Seventh, the decision to use an AST versus an NST may not be by chance; physicians who prefer documenting more history items in their usual practice may also be more inclined to using a structured template. Finally, the "completeness percentage" approach may miss identifying items that may not be documented in a consistent manner even when completeness is high. Despite these limitations, the magnitude of our reported findings suggests that they did not significantly influence our results.

CONCLUSIONS

In conclusion, the use of an AST was associated with increased guideline-based asthma documentation consistently in initial and follow-up encounters among different providers. Adequate documentation can potentially improve clinical outcomes by aiding accurate diagnosis, assessment of control, and treatment in children with asthma. At a larger scale, using disease-specific templates can serve as a powerful data recording tool for both clinical and epidemiological research, standardizing the history taking process during direct patient encounters that can be later used in a systematic manner for retrospective and prospective studies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations used

AST	Asthma-structured template
ATAQ	Asthma Therapy Assessment Questionnaire
EHR	Electronic health records
ICD-10	International Classification of Diseases, Tenth Revision
NAEPP EPR-3	National Asthma Education and Prevention Program Expert Panel Report 3
NLP	Natural language processing
NST	Nonstructured template
PFT	Pulmonary function testing
RCHSD	Rady Children’s Hospital of San Diego

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What is already known about this topic?

Guideline-based asthma care relies on thorough and systematic history taking for diagnosis and management, yet asthma documentation remains variable despite access to electronic health records (EHR) and the time invested in them by health care professionals.

What does this article add to our knowledge?

When using an asthma-specific structured template, asthma documentation of key clinical variables is consistently increased in initial and follow-up encounters among different physicians.

How does this study impact current management guidelines?

Using an asthma-specific structured template in the EHR can improve guideline-based documentation, which may lead to better clinical care and can be leveraged as a research tool.

Boxplots of structured template use and asthma history completeness in initial and follow up encounters.

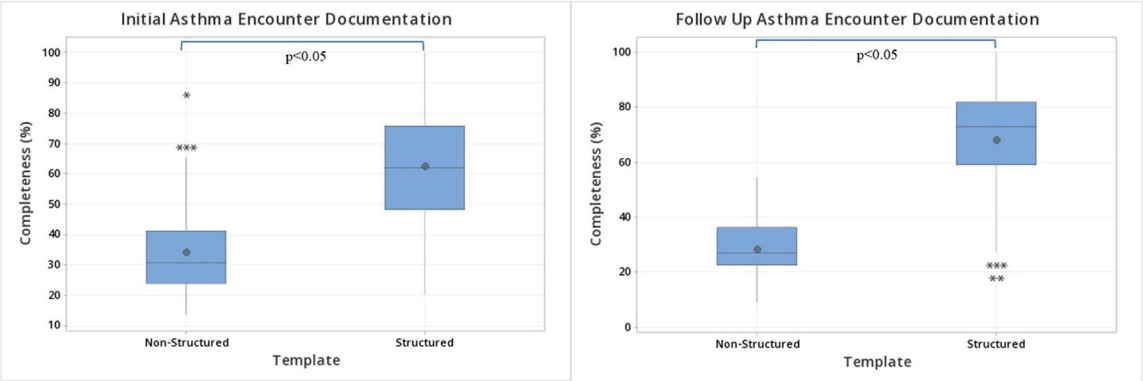

FIGURE 1.

Boxplots of structured template use and asthma history completeness in initial and follow-up encounters.

TABLE I.

Subject demographic characteristics of included encounters

Demographic characteristics	Study subjects (n = 546)	Initial encounters		Follow-up encounters	
		Nonstructured template (n = 96)	Asthma structured template (n = 450)	Nonstructured template (n = 70)	Asthma structured template (n = 476)
Age	8.0 (5.0)	7.4 (5.4)	8.2 (4.8)	7.9 (5.0)	7.7 (5.0)
Male sex	318 (58.2)	56 (58.3)	262 (58.2)	39 (55.7)	279 (58.6)
Ethnicity					
Hispanics	274 (50.2)	48 (50.5)	226 (50.2)	39 (55.7)	235 (49.4)
non-Hispanic					
White	154 (28.2)	31 (32.3)	123 (27.3)	16 (22.9)	138 (29.0)
Black or African American	42 (7.7)	8 (8.3)	34 (7.6)	6 (8.6)	36 (7.6)
Asian and Pacific Islander	30 (5.5)	2 (2.1)	28 (6.2)	3 (4.3)	27 (5.7)
Other	38 (7.0)	4 (4.2)	34 (7.6)	4 (5.7)	34 (7.1)
Declined answer	8 (1.5)	3 (3.1)	5 (1.1)	2 (2.9)	6 (1.3)

Values are presented as mean (standard deviation) for normally distributed continuous variables and n (%) for binary variables. No statistical differences were observed between type of template used and the variables listed.

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TABLE II.

Asthma documentation included in asthma encounters

	Initial encounter		Follow-up encounter	
	Nonstructured template (n = 96)	**Asthma structured template (n = 450)**	**Nonstructured template (n = 70)**	**Asthma structured template (n = 476)**
Asthma items included	10.0 (4.0)	18.2 (5.0) **	6.3 (2.0)	15.0 (3.9) **
Asthma history completeness (%)	34.5 (13.7)	62.6 (17.1) **	28.4 (9.1)	68.1 (17.7) **
Structured template in initial encounter	–	–	12 (17.1)	438 (92.0) **
Pharmacological interventions				
Systemic steroids	43 (44.3)	315 (7) **	21 (30)	397 (83.2) **
Antibiotics	22 (22.7)	229 (50.9) **	4 (5.7)	373 (78.2) **
Response to steroids/antibiotics	28 (28.9)	201 (44.7) **	3 (4.3)	224 (47.0) **
Severity of exacerbations				
ED visits	35 (36.1)	295 (65.6) **	20 (28.6)	362 (75.9) **
Hospitalizations	52 (53.6)	302 (67.1) *	16 (22.9)	366 (76.7) **
PICU history	14 (14.4)	298 (66.2) **	2 (2.9)	341 (71.5) **
Severe infection	27 (27.9)	254 (56.4) **	–	–
Quality of life				
Interference with activities	40 (41.2)	328 (72.9) **	10 (14.3)	356 (74.6) **
Days missed of school	1 (1.0)	70 (15.6) **	2 (2.9)	110 (23.1)
Exertional symptoms	41 (42.3)	345 (76.7) **	35 (50)	396 (83.0) **
Symptom progression	46 (47.4)	221 (49.1)	36 (51.4) *	187 (39.2)
Asthma contributors				
Triggers	23 (23.7)	411 (91.3) **	26 (37.1)	414 (86.8) **
Symptoms by season	34 (35.1)	174 (38.7)	8 (11.4)	131 (27.5) **
Environmental exposures	56 (57.7)	274 (60.9)	16 (22.9)	196 (41.1) **
History of pneumonia	13 (13.4)	299 (66.4) **	–	–
Recurrent otitis or sinusitis	15 (15.5)	302 (67.1) **	–	–
History of snoring	47 (48.5)	283 (62.9) **	38 (54.3)	198 (41.5)

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	Initial encounter		Follow-up encounter	
	Nonstructured template (n = 96)	**Asthma structured template (n = 450)**	**Nonstructured template (n = 70)**	**Asthma structured template (n = 476)**
Age first suspected asthma	53 (54.6)	212 (47.1)	–	–
Allergy testing	23 (23.7)	245 (54.4)**	–	–
Chest X-ray	97 (100)	450 (100)	–	–
Asthma symptom control				
Symptoms today	27 (27.8)	315 (70)**	8 (11.4)	381 (79.9)**
Cough frequency	32 (33.0)	407 (90.4)**	33 (47.1)	442 (92.7)**
Wheezing frequency	22 (22.68)	354 (78.67)**	26 (37.14)	414 (86.79)**
Shortness of breath frequency	27 (27.8)	307 (68.2)**	14 (20)	384 (80.5)**
Bronchodilator frequency	37 (38.1)	338 (75.1)**	37 (52.9)	385 (80.7)**
Duration of symptoms	11 (11.3)	179 (39.8)**	–	–
Asthma management assessment				
Medication adherence	20 (20.6)	339 (75.3)**	29 (41.4)	422 (88.5)**
Spacer use frequency	24 (24.7)	344 (76.4)**	2 (2.9)	392 (82.2)**
Treatments tried	65 (67.0)	353 (78.4)*	54 (77.1)**	276 (57.9)

Values are presented as n (%) for binary variables and mean (standard deviation) for normally distributed continuous variables.

ED, Emergency department; *PICU*, pediatric intensive care unit.

* $P < .05$ and

** $P < .01$ for pairwise comparisons between nonstructured and structured templates.

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TABLE III.

Linear regression of asthma history completeness percentage and structured template use

	Initial encounter				Follow-up encounter			
	Unadjusted		Adjusted for severity		Unadjusted		Adjusted for severity	
Predictor variable	β (standard error)	*P* value	β (standard error)	*P* value	β (standard error)	*P* value	β (standard error)	*P* value
Asthma structured template	28.2 (1.9)	<.01	27.9 (2.0)	<.01	39.7 (2.2)	<.01	39.8 (2.3)	<.01
Moderate-to-severe asthma	–	–	1.2 (1.6)	.47	–	–	0.7 (1.6)	.65

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TABLE IV.

Encounter templates and asthma severity documented in International Classification of Diseases, Tenth Revision (ICD-10) codes

	Initial encounter		Follow-up encounter	
ICD-10 codes in EHR	**Nonstructured template (n = 93)**	**Asthma structured template (n = 437)**	**Nonstructured template (n = 67)**	**Asthma structured template (n = 465)**
Any asthma severity	85 (91.4)	427 (97.7) **	66 (98.5)	453 (97.4)
Unspecified: J45.90	8 (8.6) **	10 (2.3)	1 (1.5)	12 (2.6)
Mild intermittent: J45.2	18 (19.4) **	43 (9.9)	19 (28.4) **	56 (12.0)
Mild persistent: J45.3	59 (63.4) **	206 (47.1)	39 (58.2)	221 (47.5)
Moderate persistent: J45.4	8 (8.6)	155 (35.5) **	7 (10.5)	149 (32.0) **
Severe persistent: J45.5	0 (0)	23 (5.3) *	1 (1.5)	27 (5.8)
Grouping severity	n = 85	n = 427	n = 66	n = 453
Mild intermittent and persist	77 (90.6) **	249 (58.3)	58 (87.9) **	277 (61.2)
Moderate and severe	8 (9.4)	178 (41.7) **	8 (12.1)	176 (38.9) **
Other	n = 3	n = 13	n = 3	n = 11
Exercise induced: J45.99	3 (3.1)	9 (2.0)	3 (4.3)	9 (1.9)
Cough variant: J45.991	0 (0)	4 (0.9)	0 (0)	2 (0.4)

Values are presented as n (%) for binary variables.

* $P < .05$ and

** $P < .01$ for pairwise comparisons between nonstructured and structured templates.

TABLE V.

Rate ratios of clinical outcomes and structured template use with and without adjusting for moderate-to-severe asthma estimated using Poisson regression models

		Unadjusted model	Model adjusted for asthma severity
Outcome	**Predictor variable**	**Rate ratio (95% CI)**	**Rate ratio (95% CI)**
Hospitalizations	Asthma structured template	1.4 (0.9, 2.1)	1.3 (0.8, 1.9)
	Moderate-severe asthma	–	1.3 (0.9, 1.7)
Emergency encounters	Asthma structured template	1.5 (0.9, 2.7)	1.1 (0.6, 2.0)
	Moderate-severe asthma	–	1.8 (1.2, 2.6) *
Pulmonology follow-up	Asthma structured template	1.1 (0.9, 1.3)	1.2 (0.9, 1.4)
	Moderate-severe asthma	–	0.9 (0.8, 1.1)
Asthma outpatient encounters	Structured template	1.2 (1.1, 1.4) *	1.2 (0.9, 1.3)
	Moderate-severe asthma	–	1.3 (1.1, 1.4) *
Systemic steroid orders	Asthma structured template	2.4 (1.6, 3.4) *	1.8 (1.2, 2.7) *
	Moderate-severe asthma	–	1.8 (1.4, 2.2) *
Albuterol orders	Asthma structured template	1.4 (1.2, 1.9) *	1.2 (0.9, 1.5)
	Moderate-severe asthma	–	1.4 (1.2, 1.6) *

CI, Confidence interval.

* $P < .05$ for the Poisson regression model.

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TABLE VI.

Encounter templates, ethnicity, and language preference

	Initial encounter		Follow-up encounter	
	Nonstructured template (n = 96)	**Asthma structured template (n = 450)**	**Nonstructured template (n = 70)**	**Asthma structured template (n = 476**
Hispanic ethnicity *	48 (50.5)	225 (50.2)	39 (55.7)	234 (49.5)
Spanish preferred † language	10 (10.4)	68 (15.1)	8 (11.4)	70 (14.7)
Non-English ‡ preferred language	11 (11.5)	77 (17.1)	8 (11.4)	80 (16.8)

Values are presented as n (%) for binary variables and mean (standard deviation) for normally distributed continuous variables. Pairwise comparisons did not show significant differences between nonstructured and structured templates.

* Three encounters were missing ethnicity data (2 had nonstructured templates and 1 had a structured template).

† Compared with non-Spanish preferred language.

‡ Compared with English preferred language.

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