

Can interactive parental education impact health care utilization in pediatric asthma: A study in rural Texas

Journal of International Medical Research

2018, Vol. 46(8) 3172–3182

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DOI: 10.1177/0300060518773621

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Abstract

Objective: It is well known that parent/patient education helps to reduce the burden of asthma in urban areas, but data are scarce for rural areas. This study explored the impact of asthma education in Ector County, a rural part of Health Services Region 9 in Texas, which has one of the highest prevalence rates of asthma in the state.

Methods: This prospective study investigated an interactive asthma education intervention in pediatric patients aged 2–18 years and their caregivers. Change in parental/caregiver knowledge about their child's asthma along with frequency of missed school days, emergency department (ED) visits and hospital admissions was obtained via telephone surveys before and after the educational intervention was delivered.

Results: The study enrolled 102 pediatric patients and their parents/caregivers. Asthma education was associated with significantly fewer school absences, ED visits and hospitalizations. Parents/caregivers reported feeling better educated, knowing what triggers an asthma exacerbation, identifying the signs of a severe asthma attack in their child, feeling confident about managing asthma and feeling that the asthma was under control.

Conclusion: Asthma education of caregivers and children was associated with better symptom management and fewer acute exacerbations, pointing to the relevance and importance of asthma education among pediatric patients in rural areas.

Keywords

Asthma, health care utilization, parental education, rural setting

Date received: 9 January 2018; accepted: 6 April 2018

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Introduction

Asthma is a chronic, inflammatory reversible respiratory condition that in 2015 alone affected 6 188 000 children.¹ Of these children, 219 died directly due to complications from the disease.¹ In 2013, asthma was the primary diagnosis for 2.0 million emergency room visits.² Children with asthma missed 13.8 million school days in total in 2013.³ These absences have been shown to have many adverse effects on children, including a decrease in academic performance as well as mental and social hindrances.⁴ These personal costs are accompanied by tremendous financial costs. The mean yearly cost of care for a single child with asthma was \$1309 in 2013.⁵ Prior research has shown the benefit of asthma education in children as it relates to symptom self-management and overall knowledge about the disease.⁶ Objectively, educational interventions have further been proven to reduce emergency room visits and school absences.⁷

However, it must be noted that chronic childhood diseases take a toll on parents/caregivers as well. To this effect, multiple studies have reported that the stress of symptom management has an effect on parents/caregivers of affected children.^{7,8} Thus, other interventions centered around education in disease management for both patients and parents/caregivers have been described, with varying rates of success.⁹ The present study seeks to further describe the effects of co-education of both affected child and parent, with particular focus on parental involvement, in a newly established and federally-funded program at the Texas Tech Health Sciences Center in Odessa, Texas, USA, aptly named 'Asthma Management Program at Tech (APT)'. The overall success of such educational programs has not been well described in rural settings at the time of this study.

In this current study, the authors hypothesized that education targeted at

both affected rural children in Ector County and their parents/caregivers would lead to better parental/caregiver knowledge about common asthma triggers, awareness of preventative measures, and confidence in appropriate medication management for symptom exacerbations, eventually resulting in reduced school absenteeism and fewer emergency room visits and hospitalizations over time.

Patients and methods

Study population

This prospective study enrolled consecutive patients between 2 and 18 years of age with a physician-labelled diagnosis of asthma between September 2016 and June 2017. All patients were enrolled in an 'Asthma Registry' within the primary care pediatric clinic at Texas Tech University Health Sciences Center, Odessa, TX, USA, which contained the demographic data of the patient and their respective caregiver/parent. The exclusion criteria included a history of prematurity with severe respiratory distress, a history of bronchopulmonary dysplasia, or congenital respiratory anomalies such as cystic fibrosis. An asthma survey questionnaire (Figure 1) was prepared with the help of the Clinical Research Institute of Texas Tech University Health Sciences Center and consisted of 10 easy-to-answer questions about symptom management and exacerbations. Trained research nurses contacted the patients registered in the asthma education program via telephone calls and a minimum of three attempts were made to reach each patient. Questions on the asthma survey questionnaire were asked and their answers were recorded (Figure 1). The severity of the patients' asthma was classified as intermittent or persistent as per guidelines found in the Expert Panel Report 3 by the National Asthma Education and Prevention Program.¹⁰

Parental/care giver asthma education questionnaire:

Study ID:

Date:

This is a questionnaire to assess the care-giver/parental knowledge of asthma control. Answer the following questions 1-10 with Yes or No answers. From questions 4 through 6 please specify the number. **This information is only used for data collection and there are no good or bad answers.** The following questionnaire is given to primary caregiver (can be mother or father), who answers for both the parents.

	No	Yes
1 Did you as a parent receive any asthma education with your child?	<input type="checkbox"/>	<input type="checkbox"/>
2 Do you know what triggers your child's asthma exacerbation?	<input type="checkbox"/>	<input type="checkbox"/>
3 Can you identify the signs of severe asthma attack in your child?	<input type="checkbox"/>	<input type="checkbox"/>
4 Has your child been to emergency department in past 6 months due to asthma?	<input type="checkbox"/>	<input type="checkbox"/>
If yes, how many times? ___ times		
5 Was your child hospitalized in the last 6 months for asthma?	<input type="checkbox"/>	<input type="checkbox"/>
If yes, how many times? ___ times		
6 Did your child miss school in past 6 months due to asthma?	<input type="checkbox"/>	<input type="checkbox"/>
If yes, how many times? ___ times		
7 Do you feel confident about managing your child's asthma?	<input type="checkbox"/>	<input type="checkbox"/>
8 Do you understand your child's asthma action plan*?	<input type="checkbox"/>	<input type="checkbox"/>
9 Do you know your child's best number on peak flow meter^?	<input type="checkbox"/>	<input type="checkbox"/>
10 Is your child's asthma under control?	<input type="checkbox"/>	<input type="checkbox"/>

Figure 1. Parental/caregiver asthma education questionnaire. *Asthma action plan – written plan that the caregiver designs in conjunction with the physician to help control their child's asthma symptoms. ^Peak flow meter – handheld meter used to measure peak expiratory flow for asthma patients.

Patients aged 0–4 years who reported symptoms ≤ 2 days/week, had no nighttime awakenings, used short acting beta agonist ≤ 2 days/week, had no effect of symptoms on normal activity, and had ≤ 1 exacerbation requiring oral corticosteroids per year were considered to have intermittent asthma; whereas those who reported symptoms > 2 days/week, were woken at night by

symptoms $\geq 1x/month$, used short acting beta agonist > 2 days/week, had minor or greater effect of symptoms on normal activity, and had ≥ 2 exacerbations requiring oral corticosteroids in 6 months or ≥ 4 wheezing episodes per year lasting > 1 day were considered to have persistent asthma.

The criteria were identical for those aged 5–11 years, with the added exception of

those with intermittent asthma having forced expiratory volume in 1 s (FEV1) >80%, FEV1/forced vital capacity (FVC) >85%, and ≤ 2 nighttime awakenings per month and those with persistent asthma having FEV1 $\leq 80\%$, FEV1/FVC $\leq 80\%$, ≥ 3 nighttime awakenings per month, and ≥ 2 exacerbations per year requiring oral corticosteroids.

For those ≥ 12 years, the criteria were again identical to the criteria for those aged 5–11 years, with the exceptions of intermittent asthma being classified as FEV1 >80% with normal FEV1/FVC, and persistent asthma classified as FEV1 $\leq 80\%$ with FEV1/FVC ranging from normal to reduced by $\geq 5\%$.

The study was approved by the Texas Tech University Health Sciences Center Institutional Review Board (approval registration no. L16-141). Over the telephone, parents/caregivers were given a brief introduction to the study and then asked the questions shown in Figure 1 after their verbal consent was obtained.

Asthma educational intervention

Asthma education was conducted in different sections, involving the patient and/or the caregiver, namely: (i) introduction (patient and caregiver); (ii) education (patient and caregiver); (iii) demonstration component (patient); and (iv) follow-up session(s) (both caregiver alone and patient and caregiver together). In the educational component, each patient and caregiver were taught about asthma pathophysiology, common triggers for asthma exacerbation, signs of asthma attack/exacerbation, need for adequate asthma control, and an asthma action plan. In the next section, an asthma educator first demonstrated to each patient the appropriate technique for using a metered dose inhaler (MDI) based on the Centers for Disease Control and Prevention (CDC) guidelines.¹¹ The patient's technique

was scored on the 10 steps and successful demonstration of steps 2–8 was considered adequate and the patient was changed to MDI instead of a nebulizer medication. The efficiency of the patient's effort was checked with a pulmonary airflow meter using a Philips Respironics Personal Best In-Check Dial™ (Philips Respironics, Murrysville, PA, USA). After proper demonstration, the patient was scheduled for an ambulatory follow-up determined by the physician (ranging between 2 weeks to 6 months). Each patient in the program was scheduled for an initial spirometry to confirm the diagnosis, and repeat testing was based on the physician's discretion. Each patient was given an appropriate asthma pouch that included a peak flow meter, individualized asthma action plan (with triggers), school nurse order, list of medications, a local smoking cessation resource, and information for free smoking cessation classes for parents.

Each parent was surveyed before and after enrollment in the program via a telephone call to a preferred contact number on the following: asthma education, school days missed, emergency room visits and hospital admissions. Telephone calls were made by the research nurses who were qualified and trained to conduct research studies and were a part of the Clinical Research Institute at Texas Tech University Health Sciences Center. The research nurses explained to the parents/caregivers that the questionnaire was to assess their knowledge of asthma control. The survey mostly consisted of questions with yes or no answers, with questions 4–6 in particular needing a specific number (Figure 1). Contact with every patient was attempted three times before a failed response was documented. Patients received no compensation for either participation or completion.

The caregivers' responses on hospital admissions and emergency room visits were compared with the records from the

two major hospitals within the county, Medical Center Hospital and Odessa Regional Medical Center, using International Statistical Code for Diseases (ICD-9) for asthma 493.00 and in case of discrepancies the documented information from the hospital records was used. The results were documented along with demographic data including age, sex, race, age of diagnosis of asthma, and severity of asthma.

Statistical analyses

All statistical analyses were performed using Stata statistical software release 13.1 (StataCorp, College Station, TX, USA). All data were summarized as *n* of patients (%). Frequencies before and after education were compared using χ^2 -test or Fisher's exact test as appropriate. Questions about number of emergency department (ED) visits, hospitalizations, and school missing times were compared using Wilcoxon matched-pairs signed-ranks test. A *P*-value < 0.05 was considered statistically significant.

Results

Out of the 275 families registered, 102 families agreed to be surveyed. With regards to severity of asthma, 38 of 100 patients (38.0%) were classified as having intermittent asthma and 62 of 100 patients (62.0%) were classified as having persistent asthma (Table 1). Asthma severity of two participants was unable to be classified per study criteria. Seven of 102 patients (6.9%) were Hispanic, 72 (70.6%) were white, eight (7.8%) were black, and 15 (14.7%) were classified as other (Table 2).

The survey showed similar representation by all age groups in the study population (Table 3). In terms of age distribution, 30 of 102 patients (29.4%) were 3–7 years old (age group 1), 34 of 102 patients

Table 1. Frequency of intermittent and persistent asthma in the study population.

Asthma severity	<i>n</i>	%
Intermittent	38	38.0
Persistent	62	62.0
Total	100 ^a	100.0

Data presented as *n* of patients (%).

^aAsthma severity of two participants was unable to be classified according to study criteria.

Table 2. Racial distribution of the study population.

Race	<i>n</i>	%
Hispanic	7	6.9
White	72	70.6
Black	8	7.8
Other	15	14.7
Total	102	100.0

Data presented as *n* of patients (%).

Table 3. Age distribution of the study population.

Age group	<i>n</i>	%
1: 3–7 years	30	29.4
2: 8–11 years	34	33.3
3: ≥ 12 years	38	37.3
Total	102	100.0

Data presented as *n* of patients (%).

(33.3%) were 8–11 years old (age group 2), and 38 of 102 patients (37.3%) were ≥12 years old (age group 3). There was a statistically significant difference in the severity of asthma amongst the three age groups (Table 4): 17.2% (5/29), 42.4% (14/33), and 50.0% (19/38), in age groups 1, 2 and 3, respectively, had intermittent asthma, while 82.8% (24/29), 57.6% (19/33), and 50.0% (19/38), respectively, had persistent asthma ($\chi^2 = 7.9009$, *P* < 0.019). In terms of sex distribution, 62 of 102 patients (60.8%) were male and 40 of 102 patients (39.2%) were female (Table 5).

Table 4. Summary of asthma severity by age group in the study population.

		Age group			
		1	2	3	Total
Asthma severity					
Intermittent	<i>n</i>	5	14	19	38
	%	17.2	42.4	50.0	38.0
Persistent	<i>n</i>	24	19	19	62
	%	82.8	57.6	50.0	62.0
$\chi^2 = 7.9009$	Total <i>n</i>	29	33	38	100 ^b
$P < 0.019^a$	Total %	100.0	100.0	100.0	100.0

Data presented as *n* of patients (%).

^aGroups compared using χ^2 -test.

^bAsthma severity of two participants was unable to be classified according to study criteria.

Table 5. Sex distribution of the study population.

Sex	<i>n</i>	%
Male	62	60.8
Female	40	39.2
Total	102	100.0

Data presented as *n* of patients (%).

Although there were more male patients with asthma than female patients, there was no significant difference in the severity between the sexes (Table 6). As described above, the severity of two participants' disease was unable to be classified per study criteria.

There were statistically significant increases in the frequency of parents/caregivers who underwent the educational program who reported receiving education ($\chi^2 = 109.86, P < 0.001$), knowing what triggers an asthma exacerbation ($\chi^2 = 37.03, P < 0.001$), identifying the signs of severe asthma attack in their child ($\chi^2 = 47.12, P < 0.001$), feeling confident about managing asthma ($\chi^2 = 75.38, P < 0.001$), understanding their child's asthma action plan ($\chi^2 = 78.67, P < 0.001$), knowing their child's best number on peak flow meter ($\chi^2 = 55.66, P < 0.001$) and feeling that the

Table 6. Summary of asthma severity by sex in the study population.

Asthma severity		Male	Female	Total
Intermittent	<i>n</i>	25	13	38
	%	41.0	33.3	38.0
Persistent	<i>n</i>	36	26	62
	%	59.0	66.7	62.0
$\chi^2 = 0.5910$	Total <i>n</i>	61	39	100 ^b
NS ^a	Total %	100.0	100.0	100.0

Data presented as *n* of patients (%).

^aNS, no significant between-group difference ($P \geq 0.05$); groups compared using χ^2 -test.

^bAsthma severity of two participants was unable to be classified according to study criteria.

asthma was under control ($\chi^2 = 70.24, P < 0.001$) (Table 7).

At the same time, the number of times their child was evaluated in the ED ($\chi^2 = 25.58, P < 0.001$), hospitalized ($\chi^2 = 6.20, P = 0.014$) or absent from school was significantly reduced ($\chi^2 = 15.56, P < 0.001$) (Table 7) after the educational intervention was delivered. Before the educational intervention, the range of frequency among those who had to visit the ED for 41 of 102 patients (40.2%) was 1–20 visits, while after the intervention only 10 of 102 (9.8%) reported having been to the ED. The number of hospitalizations reduced from 14 out of 102 (13.7%) to four out of 102 (3.9%) and their range reduced from 1–12 visits to three parents reporting a single visit (one patient declined to give numerical details). Similarly, the number of children that had full attendance at school during the past 6 months increased from 56 of 98 patients (57.1%) to 83 of 101 patients (82.2%) and the range of school missing times was also reduced.

Discussion

Pediatric asthma is a common disease with a number of potential social consequences,

Table 7. Summary of parental control of asthma questionnaire before and after the educational intervention.

Question	Before educational intervention n = 102	After educational intervention n = 102	Statistical significance ^a
Did you as a parent receive any asthma education with your child (yes)?	21 (20.6)	95 (93.1)	$P < 0.001$
Do you know what triggers your child's asthma exacerbation (yes)?	54 (52.9)	93 (91.2)	$P < 0.001$
Can you identify the signs of severe asthma attack in your child (yes)?	57 (55.9)	97 (95.1)	$P < 0.001$
Has your child been to emergency department in past 6–12 months due to asthma (yes)?	41 (40.2) ^b	10 (9.8) ^b	$P < 0.001$
If yes, how often? (number of emergency department visits)	n = 100	n = 101	$P < 0.001$
0	60 (60.0)	92 (91.1)	
1	18 (18.0)	9 (8.9)	
2	10 (10.0)	0 (0.0)	
3 or more	12 (12.0)	0 (0.0)	
Was your child hospitalized in the last 6 months for asthma (yes)?	14 (13.7) ^b	4 (3.9) ^b	$P = 0.014$
If yes, how often? (number of hospitalizations)	n = 101	n = 101	$P < 0.001$
0	88 (87.1)	98 (97.0)	
1	8 (7.9)	3 (3.0)	
2	3 (3.0)	0 (0.0)	
3 or more	2 (2.0)	0 (0.0)	
Did your child miss school in past 6 months due to asthma (yes)?	44 (43.1) ^c	19 (18.6) ^b	$P < 0.001$
If yes, how often? (one absence counted for each instance of missing school, regardless of length of absence)	n = 98	n = 101	$P < 0.001$
0	56 (57.1)	83 (82.2)	
1	4 (4.1)	6 (5.9)	
2	15 (15.3)	6 (5.9)	
3	7 (7.1)	1 (1.0)	
4	6 (6.1)	1 (1.0)	
5	3 (3.1)	1 (1.0)	
6	1 (1.0)	0 (0.0)	
7	0 (0.0)	1 (1.0)	
8	2 (2.0)	2 (2.0)	
10	2 (2.0)	0 (0.0)	
20	2 (2.0)	0 (0.0)	
Asthma management questions	n = 100	n = 102	
Do you feel confident about managing your child's asthma (yes)?	39 (39.0)	98 (96.1)	$P < 0.001$
Do you understand your child's asthma action plan (yes)?	33 (33.0)	95 (93.1)	$P < 0.001$
Do you know your child's best number on peak flow meter (yes)?	26 (26.0)	80 (78.4)	$P < 0.001$
Is your child's asthma under control (yes)?	40 (40.0)	97 (95.1)	$P < 0.001$

Data presented as n of parents/caregivers (%).

^aGroups compared using χ^2 -test.

^bOne participant declined to provide a numerical value and only answered yes/no.

^cTwo participants declined to provide a numerical value and only answered yes/no.

including missed school days and stress on patients and families from ED visits and hospitalizations.¹² Asthma is known to be one of the leading causes of school absenteeism,¹³ with 13.8 million school days missed in 2013,¹⁴ and is one of the most common causes of ED visits in the US.¹⁵ Several studies have been conducted illustrating the effectiveness of asthma education programs in curtailing these costs.^{16,17} One systematic literature review concluded that educating the patient and/or the caregivers about the proper management of asthma shows statistically significant reductions in missed school days and ED visits.¹⁸ Other studies conducted within the last 5 years using different methods have shown similar results.^{19,20} One study conducted in an inpatient hospital setting demonstrated that solely providing education to the patient resulted in similar benefits with respect to hospitalizations and ED visits.¹⁹

In this present study, most of the parents/caregivers of asthmatic children reported increased knowledge in managing their children's asthma symptoms, triggers, and signs. They further endorsed fewer hospitalizations/ED visits and decreased school absenteeism associated with this education. Past studies have shown that asthma education for both children and their caregivers can result in increased disease knowledge and reduced acute interventions.²¹ One study in particular educated children and caregivers using information from the National Asthma Education and Prevention program and found that such education was associated with decreased trips to urgent care and decreased use of rescue medications.²² However, the majority of previous studies conducted in the field have assessed the impact of asthma education in large urban centers or hospitals.²³⁻²⁵ The effect of these interventions in rural areas has been less well investigated.

In 2013, the prevalence of asthma in Health Services Region (HSR) 9, which

includes Ector county, was 9.1%.²⁶ According to the Texas Department of Health Services, in 2012, per every 10 000 children, HSR-9 had 11 more asthma related hospitalizations compared with the other HSRs in the state.²⁷ This current study focused on childhood asthma in Ector County specifically due to the comparatively high prevalence of asthma in this area. The current study has shown that comprehensive asthma education has the potential to have far-reaching benefits in Ector County's estimated 5000 school children who suffer from asthma, accounting for 20% of the Ector County Independent School District's population. Improving pediatric patients' ability to manage their asthma is especially crucial in Ector County. Per the Ector County Independent School District Nursing In-Charge, asthma was the primary cause for school absences and two mortalities in the 2014–2015 academic year.

At the conclusion of this current study, implementation of this unique educational program had resulted in parents/caregivers not only reporting better education about what triggers an asthma exacerbation and identifying signs of an asthma attack, but also being more confident in managing their child's asthma. These conclusions are in accordance with what previous literature has shown and are encouraging because the results found in urban areas appear to have been successfully applied to a novel rural location.²⁸ Asthma education continues to be associated with better long-term outcomes and better management of the disease.²⁸ With more widespread educational opportunities, asthma exacerbations can continue to be mitigated gradually to result in improved school attendance and less acute healthcare use in the future.

This present study had several limitations. First, out of the 275 families of pediatric asthma patients that were registered to receive education in APT, only 102 families

were successfully surveyed after the conclusion of the educational intervention. Fewer patients lost to follow-up could help elucidate stronger associations in future studies, as well as a larger population sample. Secondly, patients were not stratified according to disease severity prior to involvement, and it remains to be concluded if educational intervention is limited in effectiveness by the severity of the patient's symptoms. Thirdly, as the data were collected via surveys, there is a possibility of reporting bias in the collected statistics, notably for the outcome variables of confidence in symptom management and identification of exacerbations and triggers.

Further research could explore the effectiveness of asthma education programs, particularly as related to the different sexes, age groups, and socioeconomic status. These data could help target asthma education to the groups with the least well-controlled disease. Given the association with reduction in hospitalizations and ED visits, financial ramifications for local healthcare can be better examined and quantified to gain more insight on the full financial effect of asthma education programs. Overall, by pinpointing which groups could benefit from further education and taking into account the possible financial and social advantages of the implementation of asthma education, the results of this study underscore the relevance, efficacy, and economic potential of its use in rural West Texas.

In conclusion, pediatric asthma, due to its high prevalence in Health Services Region 9 in Texas, poses a significant burden on healthcare systems in the area and is one of the leading causes of school absences in the county. In this current study, patient and caregiver directed interactive education was associated with statistically significant improvements in asthma symptom control and reductions in healthcare utilization. As this is the first study

of its kind in Ector County, further investigation of the secondary financial and systemic effects of asthma education in the region are suitable for future research.

Acknowledgment

The authors acknowledge the support of the Clinical Research Institute at the Texas Tech University Health Sciences Center for the development of this manuscript.

Declaration of conflicting interests

The authors declare that there are no conflicts of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. Centers for Disease Control and Prevention. 2015 National Health Interview Survey (NHIS) Data: Current Asthma Population Estimates – in thousands, <https://www.cdc.gov/asthma/nhis/2015/table3-1.htm> (2015, accessed 25 Oct 2017).
2. Centers for Disease Control and Prevention. National Hospital Ambulatory Medical Care Survey: 2014 Emergency Department Summary Tables, https://www.cdc.gov/nchs/data/nhamcs/web_tables/2014_ed_web_tables.pdf (2014, accessed 22 Sept 2017).
3. United States Environmental Protection Agency. Asthma Facts, <https://www.epa.gov/asthma/2017-asthma-fact-sheet> (2013, accessed 15 Oct 2017).
4. Moonie S, Sterling DA, Figgs LW, et al. The relationship between school absence, academic performance, and asthma status. *J Sch Health* 2008; 78: 140–148.
5. United States Center for Disease Control. Asthma's Impact on the Nation, https://www.cdc.gov/asthma/impacts_nation/asthmafactsheet.pdf (2016, accessed on 18 Oct 2018).
6. Evans D, Clark NM, Feldman CH, et al. A school health education program for

- children with asthma aged 8–11 years. *Health Educ Q* 1987; 14: 267–279.
7. Halterman JS, Yoos HL, Conn KM, et al. The impact of childhood asthma on parental quality of life. *J Asthma* 2004; 41: 645–653.
 8. Juniper EF, Guyatt GH, Feeny DH, et al. Measuring quality of life in the parents of children with asthma. *Qual Life Res* 1996; 5: 27–34.
 9. Butz A, Pham L, Lewis L, et al. Rural children with asthma: impact of a parent and child asthma education program. *J Asthma* 2005; 42: 813–821.
 10. National Asthma Education and Prevention Program. Expert Panel Report 3 (EPR-3): Guidelines for the Diagnosis and Management of Asthma-Summary Report 2007. *J Allergy Clin Immunol* 2007; 120 [5 Suppl]: S94–S138.
 11. Centers for Disease Control and Prevention. Know how to use your asthma inhaler, https://www.cdc.gov/asthma/inhaler_video/default.htm (2018, accessed 24 October 2017).
 12. Moonie SA, Sterling DA, Figs L, et al. Asthma status and severity affects missed school days. *J Sch Health* 2006; 76: 18–24.
 13. Meng YY, Babey SH and Wolstein J. Asthma-related school absenteeism and school concentration of low-income students in California. *Prev Chronic Dis* 2012; 9: E98.
 14. Centers for Disease Control and Prevention. Asthma-related Missed School Days among Children aged 5–17 Years, https://www.cdc.gov/asthma/asthma_stats/missing_days.htm (2015, accessed 15 Oct 2018).
 15. US Department of Health and Human Services. Twenty leading primary diagnosis groups for emergency department visits, by patient age and sex: United States, https://www.cdc.gov/nchs/data/nhamcs/web_tables/2015_ed_web_tables.pdf (2014, accessed on 19 Oct 2018).
 16. Liu C and Feekery C. Can asthma education improve clinical outcomes? An evaluation of a pediatric asthma education program. *J Asthma* 2001; 38: 269–278.
 17. Woods ER, Bhaumik U, Sommer SJ, et al. Community asthma initiative to improve health outcomes and reduce disparities among children with asthma. *MMWR Suppl* 2016; 65: 11–20.
 18. Ahmad E and Grimes DE. The effects of self-management education for school-age children on asthma morbidity: a systematic review. *J Sch Nurs* 2011; 27: 282–292.
 19. Garvey NJ, Stukel TA, Guan J, et al. The association of asthma education centre characteristics on hospitalizations and emergency department visits in Ontario: a population-based study. *BMC Health Serv Res* 2014; 14: 561.
 20. Boulet LP, Boulay ME, Gauthier G, et al. Benefits of an asthma education program provided at primary care sites on asthma outcomes. *Respir Med* 2015; 109: 991–1000.
 21. Coffman JM, Cabana MD, Halpin HA, et al. Effects of asthma education on children's use of acute care services: a meta-analysis. *Pediatrics* 2008; 121: 575–586.
 22. Krishna S, Francisco BD, Balas EA, et al. Internet-enabled interactive multimedia asthma education program: a randomized trial. *Pediatrics* 2003; 111: 503–510.
 23. Walter H, Sadeque-Iqbal F, Ulysse R, et al. The effectiveness of school-based family asthma educational programs on the quality of life and number of asthma exacerbations of children aged five to 18 years diagnosed with asthma: a systematic review protocol. *JBIR Database System Rev Implement Rep* 2015; 13: 69–81.
 24. Raun LH, Ensor KB, Campos LA, et al. Factors affecting ambulance utilization for asthma attack treatment: understanding where to target interventions. *Public Health* 2015; 129: 501–508.
 25. Kuo CY, Pan RH, Chan CK, et al. Application of a time-stratified case-cross-over design to explore the effects of air pollution and season on childhood asthma hospitalization in cities of differing urban patterns: big data analytics of government open data. *Int J Environ Res Public Health* 2018; 15: E647.
 26. Texas Department of State Health Services. Texas Asthma Burden Report 2014, <https://www.dshs.texas.gov/chronic/pdf/astbur.pdf> (2014, accessed 20 Oct 2018).

27. Texas Department of Health and Human Services. 2012 Child Asthma Fact Sheet—Texas, http://wayback.archive-it.org/414/20180306084823/http://www.dshs.texas.gov/asthma/pdf/Fact-Sheets/2012-Texas-Fact-Sheet_Child-Asthma_12-10-14_Final.doc (2014, accessed on 01 Oct 2018).
28. Al-Muhsen S, Horanieh N, Dulgom S, et al. Poor asthma education and medication compliance are associated with increased emergency department visits by asthmatic children. *Ann Thorac Med* 2015; 10: 123–131.