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Research paper

Changes in asthma self-management knowledge in inner city adolescents following developmentally sensitive self-management training

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ABSTRACT

Objective: To evaluate efficacy of a developmentally sensitive curriculum for improving asthma self-management knowledge, attitude, and self-efficacy in adolescents.
Methods: Fourty-two inner-city adolescents (ages 16–20) participated in a 12 hour asthma self-management training program. Self-management knowledge, attitude toward asthma, and asthma-related self-efficacy were measured using short-answer tests before and after training. T-Tests were used to evaluate impact and effect sizes were calculated.
Results: Mean pretest knowledge was 21.37/46 points; mean posttest was 36.33/46 points. Change from pre- to posttest was highly significant ($t = 10.34$; $p < 0.0001$), with a large effect size ($d = 1.68$). Females improved more than males (18.66 ± 8.58 vs. 12.29 ± 8.13, $p = 0.039$). Greatest effects were seen in awareness of long-term consequences of uncontrolled asthma ($d = 2.04$), ability to recognize symptoms of life-threatening asthma ($d = 1.61$), correctly monitor symptoms ($d = 1.49$), and tell if asthma was uncontrolled ($d = 1.39$). Asthma self-efficacy also improved significantly ($p = 0.017$), particularly confidence in ability to correctly manage asthma, however improvements in attitude did not achieve statistical significance.
Conclusion: Developmentally appropriate training is effective in increasing critical self-management knowledge and self-efficacy in inner city adolescents, particularly females.
Practice implications: Providers should screen carefully for symptoms and educate using developmentally appropriate training materials on ways to correctly monitor and manage symptom.
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1. Introduction

Asthma self-management is a major determinant of asthma control and has been identified as a key area for intervention by the Expert Panel Report 3 (EPR-3) and Asthma Outcomes Workshop [1–3]. Even at its most basic level, self-management is a complex process, requiring that individuals first recognize symptoms, know how to manage symptoms, and then actually engage in specific behaviors to prevent, monitor, manage acute symptoms, and communicate about asthma needs effectively with a variety of people [4]. This can be challenging for patients of any age, and more so for younger ages [5]. Prior data indicate that adolescents and young adults in particular often do not manage their asthma properly [1,6,7] and have subsequently poorer asthma control than younger children who are often more closely supervised by parents [8,9].

Many factors contribute towards patterns of chronically suboptimal self-management. Adolescents often do not recognize symptoms of asthma and may intentionally or unintentionally normalize over time, thus becoming progressively less aware of usual and recurring symptoms [7,10,11]. Lack of knowledge or misperceptions may lead them to ignore symptoms or delay taking medications based on beliefs that "toughing it out" can strengthen the lungs, or that using rescue medication is addictive [12–14]. Beliefs such as these affect subsequent self-management decisions of when and how to treat, which in turn affects asthma control.

Given that asthma outcomes are heavily driven by self-management behaviors, interventions targeting self-management are urgently needed. Yet, the majority of programs for inner-city adolescents have focused on adherence [15–18],modification of social and environmental factors [19,20] or addressing healthcare access [21–23]. Fewer efforts have been directed towards reducing asthma morbidity by promoting adequate asthma knowledge and

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self-management [15,24–26]. These studies demonstrated small to moderate post-intervention increases in asthma knowledge, but few described theoretical grounding or systematic approaches to program development [5,15]. There is evidence that theory-based interventions may be more effective than interventions developed without explicit theoretical grounding, particularly when combined with developmentally appropriate teaching strategies [5,27,28]. Thus, based on our prior research and existing literature [4,7,10,29–32], we designed a theoretically grounded, developmentally sensitive, and comprehensive educational self-management training curriculum (*Let's Talk About Asthma!*) for adolescents [33,34]. The curriculum was developed with the understanding that (a) programs targeting adolescents unique developmental needs have greater efficacy, and (b) programs emphasizing problem solving skill and self-management training have been shown more effective than education alone [35,36].

The specific aim of this study was to evaluate the efficacy of the training curriculum for improving asthma knowledge and self-management problem solving skills in inner city adolescents (aged 16–20 years) who received 12 hours of intensive self-management training using the new curriculum. We hypothesized that following training adolescents would demonstrate significant improvement in asthma knowledge and self-management problem solving skills.

2. Study methods

2.1. Curriculum development: Let's talk about asthma!

Let's Talk About Asthma! is a theoretically derived, guideline-based [2] educational curriculum, written at sixth grade (11–12 year old) reading level. It provides in-depth asthma education and self-management training using a humorous, cartoon-style presentation format. The curriculum was developed through a three-step process [33]. First, we conducted a concept analysis and developed an operational definition of adolescent asthma self-management to identify core content [4]. The resulting four domains of self-management—prevention, monitoring, acute symptom management, and communication—served as the conceptual framework for the curriculum, and subsequent topic areas. Next, we conducted a qualitative study to explore adolescents' perceptions of asthma self-management and rationales underlying behaviors [10]. A total of 42 in-depth qualitative interviews were conducted with adolescents and their parents. Knowledge gained from these interviews was used to identify common ways of thinking and develop targeted educational strategies. Lastly, after developing preliminary manuals, we iteratively revised materials based on qualitative feedback from four adolescent-reviewers.

The final curriculum contained four interactive learning modules (30 to 45 min each), including: (1) pathology and prevention of asthma; (2) monitoring of asthma symptoms; (3) management of asthma symptoms; and (4) communication and psychosocial issues [33]. Details of training strategies are published in the *Let's Talk About Asthma! Instructor's Guide* [34]. Briefly, each session included interactive case studies that emphasized problem solving skills and application of learned content to specific asthma situations. [37]. Training techniques focused on problem-based-learning and teach-back methodology (in which the student learns and then teaches key content back to the instructor and peers), to increase comprehension and retention of information [38,39]. Self-management skills (e.g. inhaler techniques, use of peak flow meters and spacers, decision making during simulated asthma attacks, assessments of asthma control, management of acute symptoms) were first modeled by the trainer then practiced by peer leaders until fluency was achieved.

2.2. Study design overview

This study was based on a subset of adolescents who participated in a larger multi-site clinical trial, Peer-led Asthma Self-Management Program for Adolescents (PLASMA), as "peer leaders." Description of full study methodology is published elsewhere [29]. The Institutional Review Board of the affiliated University reviewed and approved the study. Informed consent was obtained from parents and adolescents. Demographic and asthma related information was collected at time of enrollment. A total of 42 peer leaders underwent a 12 hour asthma self-management training session using the curriculum described above. Content was delivered over two to three days, generally but not always consecutively. Peer leaders received training and underwent formal written assessment of asthma knowledge and self-management skills prior to and immediately following training.

2.3. Setting and sample

Participants were recruited to serve as PLASMA peer leaders from three U.S. cities: Memphis, TN; Baltimore, MD; and Buffalo, NY. Peer leaders were recommended by school nurses, teachers, or healthcare providers, and were purposefully sampled for having well-managed asthma and leadership experience or potential. Fourteen peer leaders were needed for each site, thus target sample size was 42.

Eligibility criteria for peer leaders were: (1) age between 16 and 20 years; (2) written nomination from school teachers/nurses or healthcare providers for candidates' exemplary asthma self-management, leadership, and emotional intelligence; (3) physician-diagnosed asthma that has required health service use (preventive or acute) within 12 months prior to recruitment; (4) persistent asthma as defined by National Heart Lung & Blood Institute (NHLBI) guidelines [2]; (5) no other chronic conditions requiring daily medication (e.g., diabetes, cancer, arthritis, etc.) and no severe mental illness (e.g., bipolar disorder, schizophrenia) or behavioral issues (e.g., criminal history) reported by parents or guardians; (6) primary residence located in the participating inner cities; and (7) ability to understand spoken and written English.

2.4. Training implementation

Peer leader training was delivered over 2–3 days (12 hours total) using the curriculum described above [33]. Peer leader training occurred 1 week prior to delivery of the main PLASMA intervention, with a 40 min review session prior to the main camp. Peer leader training sessions were conducted in small group format (5–14 adolescents per group) and utilized diverse adult trainers to enhance generalizability. Trainers (n = 3) included: (1) a certified asthma educator, (2) a pediatric nurse practitioner/researcher, and (3) an actively practicing family nurse practitioner. Two of the trainers were co-developers of the curriculum, and jointly provided the third trainer approximately 6 hours of training prior to program delivery. Each adult trainer conducted training sessions using the *Let's Talk About Asthma!* standardized manual [34], which delineated specific content and strategies for delivering interactive didactic sessions, group discussions, hands-on demonstrations, and role-play. Training was delivered in 4 sessions: (1) pathology and prevention of asthma; (2) monitoring of asthma symptoms; (3) management of asthma symptoms; and (4) communication and psychosocial issues

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2.5. Instruments and data collection

2.5.1. Written assessment tool

Participants completed a written test developed for the study preceding and immediately following training. The assessment tool included 13 open-ended questions evaluating asthma knowledge, problem solving skills, and application of self-management knowledge to specific scenarios. Individual items ranged from 2 to 6 points each based on item difficulty, with a maximum of 46 total points. Pre- and posttests were independently scored by two raters (AG; JM) using a structured grading rubric (SA, HR) with criteria for assigning points (Supplemental Data 1).

2.5.2. Asthma control

Asthma control was measured using EPR-3 criteria, which defines uncontrolled asthma as self-reported (1) daytime symptoms more than twice a week; (2) waking up due to asthma 1–3 times a week; (3) rescue inhaler use more than twice a week; or (4) some activity limitations [2]. Very poorly controlled asthma is defined as (1) symptoms throughout the day; (2) waking up due to asthma more than four times a week; (3) rescue inhaler use several times a day; or (4) extremely limited activity.

2.5.3. Attitude toward asthma scale

This 13-item scale measures children's attitudes toward their asthma on a 5-point Likert-type scale [40], with good internal consistency in this sample (Cronbach $\alpha = 0.86$). Possible mean scores range 1 to 5 with higher scores representing a more positive attitude towards asthma. Participants completed the scale at enrollment and immediately following training.

2.5.4. Asthma self-efficacy

This 14-item scale [41] measures a child's confidence in their asthma self-management skills, correct use of medication, ability to prevent an asthma attack, control symptoms, and decide which medication to use, and has evidence of good internal consistency (Cronbach $\alpha = 0.83$) in this sample. Possible total scores range 14 to 70 (1 to 5 points per item), with higher scores representing greater self-efficacy. This scale was administered at enrollment and immediately after training.

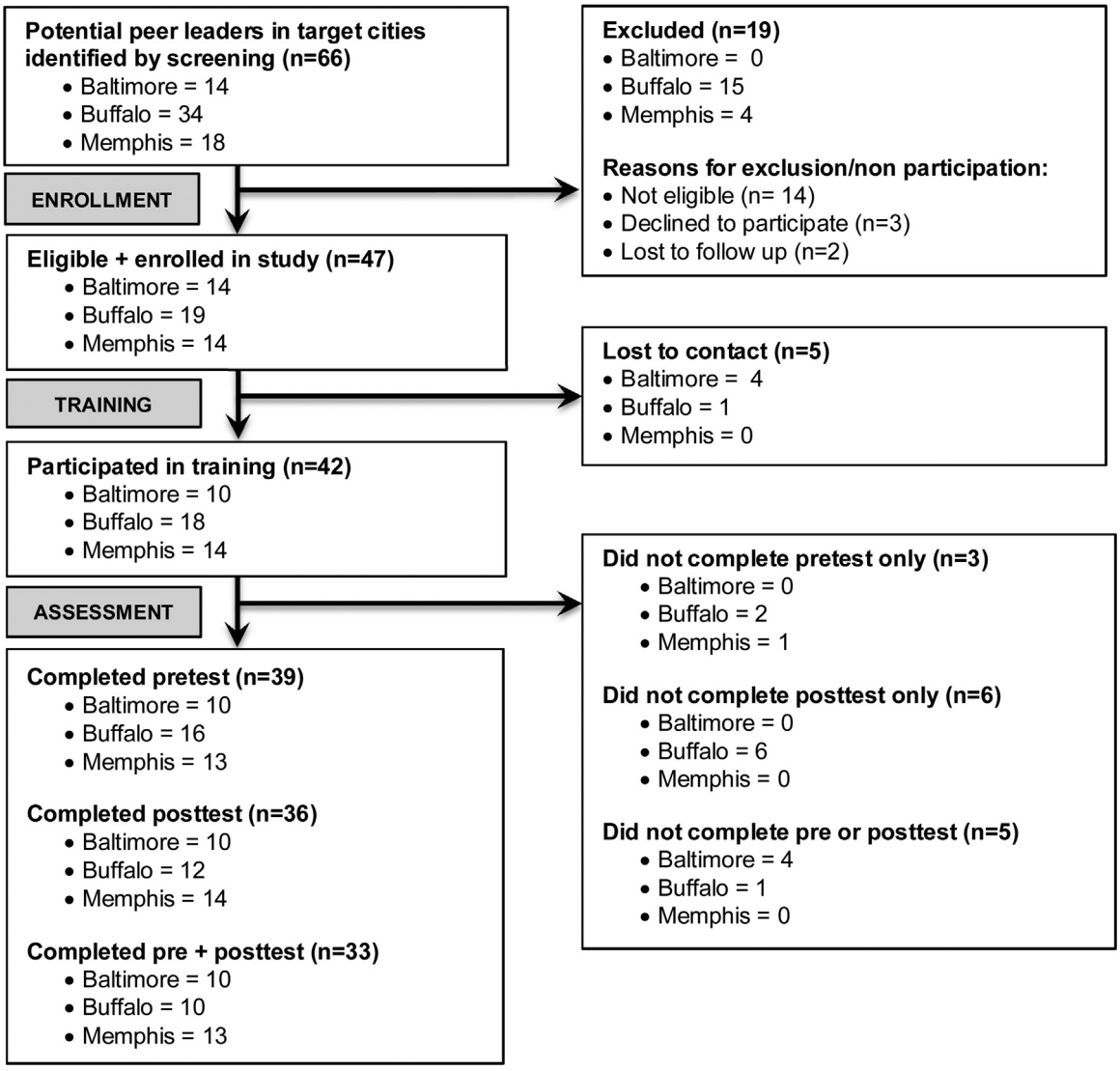


Fig. 1. Recruiting and eligibility screening flowchart.

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2.5.5. Demographic and asthma related variables

Demographic variables included adolescent age, sex, race/ethnicity, asthma medications, insurance type, and household income.

2.6. Data analysis

Due to the nature of the data (continuous with a range of 0–46 possible points) interrater reliability for pretest and posttest scores was assessed using Pearson's r. Cases with considerable differences in item scores between two raters were identified via scatterplot. Substantial discrepancies were reviewed in conjunction with the grading rubric and independently rescored one time, which successfully resolved differences. Change scores between pre and posttest were calculated to examine the extent of change, and paired *t*-tests were used to assess significance (n = 33). Overall mean test scores were calculated using all pre (n = 39) and post tests (n = 36). The mean score was also calculated for each item, and paired *t*-tests used to assess degree and significance of changes in individual mean item scores. Effect sizes (Cohen's d) were calculated using mean pre and post test scores for total and individual items. Independent *t*-tests were used to compare those who completed and those who did not complete the program in regard to demographic and asthma related factors. ANOVA was performed to compare study variables among the three sites. Independent *t*-tests or ANOVA were conducted to examine differences in mean change scores by sex, age, insurance type, asthma control, and site. Differences by race were not assessed due to the largely homogenous sample (predominantly African American). Analyses were conducted using SPSS v.24.

3. Results

In total, 66 adolescents were screened: 47 were eligible and enrolled in the study, and 42 initiated training. Five adolescents did not show up for training for unknown reasons with contact being lost after enrollment. Of the 42 who initiated training, 39 completed pre-testing, 36 completed post-testing, and 33 completed both assessments. Nine participants did not show up on the final day of training and did not complete the posttest. One peer leader enrolled late and did not receive the pretest, and pretest data were collected but lost for two others at the Buffalo site. Fig. 1 displays a complete recruitment and screening diagram, with details on dropout and non-completion. Non-completion rates differed by site (p = 0.012) with highest training non-completion in Buffalo (9/19), compared to Memphis (1/14) or Baltimore (4/14). Female gender was also marginally significant (p = 0.065) for non-completion. No other significant differences in demographics, asthma related variables, attitude, or self-efficacy were noted between those who completed training and those who did not.

3.1. Demographics and asthma related information

Demographics and asthma related information are presented in Table 1. The mean age of peer leaders was 17.23 years (±1.31; range 16–20). Of the 47 participants, 68% were less than 18 years old, and 66% were female, and 80.9% were Black. Overall, 91.5% of participants had persistent asthma; 91% were taking some form of long-term controller medication (inhaled steroids, leukotriene), and 70.2% had uncontrolled asthma by EPR-3 criteria.

3.2. Outcomes: knowledge and self-management problem solving skills, self-efficacy, and attitude towards asthma

Interrater reliability for scoring tests between two independent raters was high for both pretest (r = 0.923;) and posttest (r = 0.964).

Mean pre and posttest scores (average of two raters) for total and individual items are displayed in Table 2, along with effect sizes. The mean peer leader pretest score (n = 39) was 21.37/46 possible points, and mean posttest score (n = 36) was 36.33/46 points. Paired *t*-tests of those who completed both baseline and post training assessments (n = 33) showed a highly significant mean change from pre- to posttest (t = 10.34; $p < 0.0001$), with a large effect size (d = 1.68). In evaluating pre and post score differences for individual items, the greatest effect sizes were found in peer leaders' awareness of long-term consequences of uncontrolled asthma (d = 2.04), ability to recognize symptoms of life-threatening asthma (d = 1.61), correctly monitor symptoms (d = 1.49), and tell if asthma was uncontrolled (d = 1.39). Participants demonstrated good understanding of triggers and managing triggers on pretest, leaving little room for improvement on posttest. Sample responses, presented in Table 3, provide qualitative evidence of the marked improvement pre- to posttest.

No significant differences in mean pretest or change scores (difference from pre to posttest) were found by level of asthma control, age (16–17 vs. 18–20 year olds), or household income. While mean pretest scores were higher for those with private versus public insurance (23.00 ± 5.61 vs. 19.72 ± 10.56; t = 1.11; p = 0.002), there was no significant difference in mean pre/post change scores. There were significant differences in mean change

Table 1
Demographics and Asthma Related Information (N = 47).

	% (*N*)		% (*N*)
Sex		**Asthma control (EPR-3)**	
Female	66 (31)	Well-controlled	29.8 (14)
Race		Not well-controlled	59.6 (28)
Black	80.9 (38)	Very poorly controlled	10.6 (5)
White	19.1 (9)	**Taking long-term controller medication**	
Ethnicity		Yes	91.3 (42)
Hispanic/Latino	2.1 (1)		
Not Hispanic/Latino	97.1 (46)	**Controller medication**	
Household income		ICS	43.5 (20)
<30,000	38.3 (18)	ICS + LABA	10.9 (5)
30,000 to 70,000	34.0 (16)	ICS + Leukotriene	19.5 (9)
>70,000	21.3 (10)	ICS + Oral steroid	4.3 (2)
Not reported	6.4 (3)	ICS + Leukotriene + Oral steroid	4.3 (2)
Insurance Type		Leukotriene	8.7 (4)
Public	51.1 (24)	Oral steroid	2.1 (1)
Private	42.6 (20)		

Notes: ICS = Inhaled corticosteroid; LABA = Long acting beta-agonist.

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Table 2
Comparison of mean item and total test scores, pre and post intervention.

Item	Possible Points	Pretest Mean RS(SD)N = 39	Posttest Mean RS(SD)N = 36	Mean Change Paired Samples RS(SD)N = 33	P-value Paired Samples N = 33	Effect Size (Cohen's d)
1. What is asthma and how does it affect your breathing?	3	1.90 (0.829)	2.53 (0.885)	0.68 (0.975)	**0.000**	**0.735**
2. What kinds of things trigger asthma symptoms?	3	2.95 (0.251)	3.00 (0.000)	0.06 (0.273)	0.211	0.282
3. Choose two or three . . . discuss the ways to handle these triggers.	2	1.68 (0.532)	1.76 (0.591)	0.15 (0.679)	0.209	0.142
4. What are the symptoms of asthma?	4	2.33 (1.402)	3.46 (0.996)	1.12 (1.635)	**0.000**	**0.929**
5. What are some symptoms of life-threatening asthma?	6	1.59 (1.929)	4.39 (1.536)	2.76 (2.180)	**0.000**	**1.606**
6. What are the ways you can keep track of the asthma symptoms?	4	1.22 (1.081)	2.89 (1.166)	1.53 (1.581)	**0.000**	**1.485**
7. What are the two categories of asthma medications? Provide the name of medications (at least one) for each category.	4	1.83 (1.515)	3.15 (1.075)	1.33 (1.373)	**0.000**	**1.005**
8. What are the things that you would look for to see whether your asthma is controlled or not?	6	1.15 (1.329)	3.39 (1.825)	2.45 (1.769)	**0.000**	**1.390**
9. Why is it important to treat asthma long-term?	6	1.91 (1.163)	4.89 (1.703)	3.21 (1.904)	**0.000**	**2.044**
Problem based learning questions:						
10. Is Keiron's asthma controlled? How do you know?	2	1.49 (0.847)	1.93 (0.212)	0.54 (0.922)	**0.002**	**0.713**
11. Is he taking the right medication? Why or why not?	2	1.42 (0.839)	1.83 (0.507)	0.52 (0.939)	**0.004**	**0.591**
12. What would you recommend for Keiron, and why?	2	1.00 (0.803)	1.67 (0.431)	0.71 (0.992)	**0.000**	**1.040**
13. What would you want to teach him?	2	0.90 (0.771)	1.72 (0.404)	0.88 (0.927)	**0.000**	**1.332**
TOTAL	**46**	**21.37** (8.512)	**36.33** (8.060)	**15.95** (8.861)	**0.000**	**1.684**

Notes: Scores are reported as raw scores (RS) for each item with standard deviation (SD).

scores by sex ($t = -2.155$; $p = 0.039$) and site ($F = 6.750$; $p = 0.004$). Greater improvement in knowledge was found in females (18.66 ± 8.58) than males (12.29 ± 8.13), and in Baltimore (20.95 ± 10.70) and Memphis (17.54 ± 5.33) compared to in Buffalo (8.90 ± 6.34).

As with knowledge, self-efficacy improved significantly from pre to post training (mean 60.14 vs. 62.74, $t = 2.51$, $p = 0.017$, $df = 34$), with moderate total effect size ($d = 0.36$). Pre- and post-intervention self-efficacy scores are presented in Table 4, along with effect sizes. Greatest improvements were seen in self-efficacy to know which medications to take during an asthma attack ($d = 0.55$), when to seek emergency care ($d = 0.54$), confidence in ability to prevent a serious breathing problem ($d = 0.42$) and stay calm during exacerbations ($d = 0.40$). Again, significant differences were noted by site ($f = 7.482$, $p = 0.002$). Greatest improvements were seen in Buffalo (6.82 ± 6.31), which had lower baseline self-efficacy (57.56 ± 8.22), compared to Memphis (baseline 60.00 ± 6.96; mean change 2.57 ± 3.83) or Baltimore cohorts (baseline 63.07 ± 6.65; mean change -2.00 ± 5.60). No significant differences were found by other variables including sex, age and insurance type. Attitude towards asthma also improved with a moderate effect size ($d = 0.35$), but did not achieve statistical significance (mean score 3.65 vs. 3.89, $t = 1.71$, $p = 0.98$, $df = 32$).

4. Discussion and conclusion

4.1. Discussion

This study provides preliminary evidence about the impact of our theoretically-derived asthma self-management training curriculum for increasing asthma self-management knowledge and self-efficacy in adolescents. Notably, effect sizes for improvements in knowledge were approximately double that of prior self-management interventions in similar populations [32,42]. This may be due to the combination of evidence-based teaching strategies and age appropriate content and format [28,43]. These results, in conjunction with prior literature, suggest that use of content specifically tailored to adolescents' unique developmental needs and cognitive capacity might be effective in improving asthma self-management potential [5,32,44].

It is important to note that improvement in knowledge was also reflected in greater post-intervention self-efficacy, with greatest improvement seen in those with lowest baseline scores. Although lack of knowledge and health literacy consistently correlates with poor outcomes, improving knowledge alone does not necessarily improve outcomes, unless associated with improvements in other key factors, such as attitude or self-efficacy [45–47]. Thus, evidence of correspondingly greater self-efficacy (i.e. perceived ability to handle an asthma attack, use medication correctly, control symptoms, and self-manage effectively) supports the relevance of the marked changes in knowledge following this intervention.

Unlike self-efficacy, improvements in attitude towards asthma did not achieve statistical significance, despite having a moderate effect size. This could be attributable to a variety of possible causes. First, baseline attitude was already fairly high in our sample, leaving less room for improvement. This is likely a result of the highly selective peer leader recruitment process, which was necessary to ensure peer leaders' qualification to teach and mentor other teens in the study. Second, the smaller peer-leader sample size may have limited ability to detect change in attitude. Third, attitude may take greater time to change than other outcomes [48]. Lastly, because the intervention was heavily oriented toward achieving fluency in critical self-management skills, it may have affected knowledge and self-efficacy more than attitude. Further research is warranted to examine the impact of this intervention on attitude over time, as well as to assess if improvements in knowledge and self-efficacy are associated with meaningful improvements in clinical outcomes (e.g. asthma control, quality of life, healthcare utilization).

Like other adolescent studies, we found that older and younger peer leaders had poor baseline knowledge of asthma [49,50]. Prior research has shown that asthma knowledge, self-management, and control do not typically improve during transition to young adulthood [10,51]. Often, older adolescents have poorer outcomes than younger adolescents, which may be a result of premature withdrawal of parental supervision [6,52,53]. This suggests that adolescents and young adults may actually need increased monitoring and education by clinicians and school nurses as parental support declines.

We found that both male and female adolescents showed marked improvement in asthma self-management knowledge, however, improvement was more pronounced in females. Prior research has demonstrated gender-based differences in asthma knowledge and educational exposure [54,55]. This is the first study

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Table 3
Qualitative comparison of asthma self-management knowledge pre and post intervention for statistically significant items.

Significant Items	Sex, Age	Pretest responses	Posttest responses
What are the symptoms of asthma?	M 18	• (No response)	• Coughing • Wheezing • Chest pain/tightness • Tiredness
What are symptoms of life-threatening asthma?	M 17	• Stopped breathing	• Gasping for air • Blue fingers • Can't finish full sentences
	M 17	• Trouble breathing • Coughing a lot • Lightheadedness due to lack of oxygen	• Being unable to speak • Using your chest muscles to breath
What are ways you can keep track of asthma symptoms?	F 19	• (No response)	• Making a symptom diary • Peak flow meter
What are the two categories of asthma medications?	F 17	• (No response)	• Rescue inhaler and traditional control inhaler. A rescue works within 5–15 min, but a control begins working after a few days.
	M 16	• Breathing treatment • Inhaler	• Rescue (Albuterol) • Control (Singulair)
Why is it important to treat your asthma long term? Explain what would happen in the future if you don't treat your asthma now.	F 17	• You could suffer complications due to your asthma.	• It can cause scarring and stiffness [of the lungs]. You could get COPD and be put on an oxygen tank.
	M 17	• When your asthma is controlled you have fewer things to worry about. Not treating it could lead to having it get worse in the future.	• Being controlled prevents lung damage and you can do things you wouldn't otherwise be able to do.
	M 15	• (No response)	• It is important to treat asthma long term so you can prevent scarring of the lung. If you didn't treat your asthma several years later you could have very serious breathing problems that could cause death.
What are the things that you would look for to see whether your asthma is controlled or not?	F 17	• Chest tightness • If I'm wheezing or not • How quickly you get tired or out of breath	• How often your asthma has limited you • Your peak flow level • How often you have taken your rescue inhaler • How often you have had symptoms during the night • How many symptoms have you had
	M 16	• Amount of times a person feels they can't control their asthma	• Are you uncontrolled 3+ days a week
	F 19	• How the child responds during physical activity	• How often are your symptoms • How often are you waking up at night • How many times you use the rescue inhaler • Peak flow meter • How limited you are in physical activity

demonstrating differences in learning following an asthma self-management intervention. This suggests that males and females may not benefit equally from the same intervention, and that tailoring to each gender may be beneficial. Further research is warranted to explore how differences in gender may affect the efficacy of educational interventions and underlying mechanisms.

Although peer leaders from all participating sites improved significantly, the Memphis and Baltimore participants demonstrated greater improvement in knowledge than their Buffalo counterparts, while the Buffalo cohort had by far the greatest improvement in self-efficacy. Several factors may have contributed to site differences. First, while actual content delivery was the same, variations in trainer delivery style (e.g. personality, teaching style, speech patterns) may have affected participants' interest in and engagement with the trainer [56]. Second, the significantly greater impact on knowledge seen in the Baltimore and Memphis cohorts might be attributable to higher baseline self-efficacy, which could conceivably impact learning. A third possibility is that the varying time intervals between sessions may have affected internalization and retention of information [57]. In Baltimore and Memphis, training was delivered on two consecutive days, whereas in Buffalo training was delivered 1 week apart. Fourth, intervention efficacy may be the result of racial differences [28,58,59]. Buffalo was the only site that included white peer leaders, whereas all peer leaders from Baltimore and Memphis self-identified as Black. Because the materials were targeted towards inner-city minority adolescents and utilized racially appropriate illustrations, case studies, and names, it is possible that they were more effective for minority adolescents. Self-management programs emphasizing culturally appropriate content have been similarly effective in improving self-management in African American adults with asthma [60] and in management of other chronic diseases such as heart disease and diabetes [36,43]. In this study, the number of non-minority adolescents who completed pre and post-testing (n = 5) was too small to reasonably quantify racial variations in outcomes. Further research is needed

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Table 4
Comparison of mean pre and post intervention self-efficacy score.

Asthma Self-efficacy Scale Individual Items	Possible Points	Pretest Mean (SD) N = 44	Posttest Mean (SD) N = 35	Mean Change Paired Samples (SD) N = 35	P-value Paired Samples N = 35	Effect Size (Cohen's d)
1. How sure are you that you can have inhalers with you the next time you have a serious breathing problem?	5	4.66 (0.838)	4.49 (0.887)	-0.171	0.070	0.197
2. How sure are you that you can use your inhaler (or medicine) correctly?	5	4.80 (0.473)	4.83 (0.453)	0.029	0.530	0.065
3. How sure are you that you can prevent a serious breathing problem?	5	4.09 (1.011)	4.46 (0.741)	0.371	0.002	0.417
4. How sure are you that you can get to your next doctors appointment?	5	4.63 (0.690)	4.49 (0.742)	-0.143	0.000	0.20
5. How sure are you that you can slow yourself down to prevent a serious breathing problem?	5	4.56 (0.660)	4.57 (0.739)	0.059	0.015	0.014
6. How sure are you that you can avoid things you are allergic to?	5	4.00 (1.101)	4.32 (0.993)	0.324	0.025	0.305
7. How sure are you that you can learn the skills you need to control your asthma?	5	4.89 (0.404)	4.74 (0.657)	-0.143	0.538	0.275
8. If someone near you was smoking, how sure are you that you could ask them to stop?	5	3.74 (1.483)	4.06 (1.110)	0.382	0.001	0.244
9. How sure are you that you can control a serious breathing problem yourself rather than go to the emergency room?	5	3.74 (1.120)	3.77 (1.262)	0.029	0.285	0.025
10. How sure are you that you can keep your asthma from getting worse if you start wheezing or coughing?	5	4.14 (0.772)	4.40 (0.847)	0.257	0.007	0.321
11. How sure are you that you can stay calm during a serious breathing problem?	5	4.26 (1.010)	4.60 (0.651)	0.343	0.004	0.400
12. How sure are you that you know which medications to use during a serious breathing problem?	5	4.26 (1.120)	4.74 (0.505)	0.486	0.054	0.553
13. How sure are you that you can tell when a serious breathing problem can be controlled at home?	5	4.34 (0.802)	4.49 (0.818)	0.143	0.000	0.185
14. How sure are you that you know when you should go to the emergency room during a serious breathing problem?	5	4.40 (0.946)	4.80 (0.473)	0.400	0.289	0.535
TOTAL	70	60.15 (7.735)	62.74 (6.576)	2.600	0.017	0.361

Notes: SD = Standard Deviation.

to assess how race, geographic, time-interval, and trainer differences may affect the efficacy of the training curriculum.

Several limitations are worth mentioning. First, training sessions and assessments were all conducted during a brief time period. Therefore, it is unknown whether improvements in knowledge and self-efficacy persisted beyond the immediate intervention period or whether improvements will translate into meaningful changes in other asthma outcomes (e.g. asthma control and quality of life). Prior educational interventions in this population have demonstrated mostly short-term impact [24–26,61]. Thus, further research on duration of impact and association with clinical asthma outcomes is needed. Second, both curriculum and training were in English, and targeted English-speaking adolescents only. Efficacy for other languages and cultures is unknown and warrants further research. Third, of those who participated in training (n = 42) approximately 21% (n = 9) did not complete both pre and posttest evaluations. Data from all partial-completers was included in calculation of group mean pre- and posttest scores, as shown in Table 2, but was necessarily excluded from paired *t*-tests. These rates of non-completion may limit generalizability of findings. However, as no significant baseline differences between non-, partial-, and full-completers in demographic and asthma-related factors, it is unlikely that the internal or external validity of the study was seriously compromised. Fourth, we used a single-group pre-posttest design, with no control group for peer-leaders as it was not considered advisable to have untrained peer-leaders delivering the intervention to other teens. Because of this, we were unable to evaluate the extent of impact peer-leader training had on subsequent intervention delivery. Also, while peer-leader training included hands on practice teaching, summative evaluation was written and not performance-based, thus reflecting knowledge of content rather than ability to deliver content. Lastly, participants were purposefully selected to be peer leaders based on adult nomination attesting to potential or proven leadership ability, and/or exemplary asthma management. Therefore, the marked improvements resulting from training might reflect participants' exceptional learning capacity and motivation rather than the curriculum's effectiveness. Further research is needed to evaluate the efficacy of this curriculum in a more representative sample of adolescents with asthma.

Despite limitations, it is worth noting that even in this highly selective subset of adolescents, baseline asthma control and knowledge of asthma was poor. Following training, participants showed substantial improvements in self-management knowledge and problem solving skills, as well as self-efficacy. Our results suggest that even among adolescents with presumably better asthma management, additional training is advisable, and that the *Let's Talk About Asthma!* curriculum may be an effective resource for content delivery. Further research is needed to determine if integration of the *Let's Talk About Asthma!* training modules into school-based asthma management programs produces similar improvements, and association with other key asthma outcomes [24,62,63]

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4.2. Practice implications

In this study, peer leaders were nominated by clinicians or teachers for better than usual asthma control and self-management. Despite this, 70% had uncontrolled asthma. While assessment of control was not a primary objective of the study, this finding reinforces prior evidence that most adolescents with asthma are not well-controlled [9], and underscores the importance of careful screening in this population.

In general, participants had good awareness of asthma triggers and trigger management at baseline. However, most had very limited ability to recognize life-threatening symptoms, were unable to tell if asthma was uncontrolled, and were unaware of long-term consequences associated with uncontrolled asthma. These findings may help explain why adolescents so often have poor self-management [6,30]. It is difficult to improve control in patients who are unaware of what control should look like. Furthermore, if patients do not understand the personal future benefits of maintaining control despite present inconvenience, they may prioritize other immediate needs (e.g. fitting in, not missing out on activities) as being more important [10]. Lastly, the higher risk of morbidity found in this age group [64,65] may be due in part to inability to differentiate between life-threatening and non-life-threatening symptoms. As displayed in participant quotes (Table 3), seeking help once one has “stopped breathing” is much too late. This dangerous lack of awareness suggests an urgent need for clinicians to educate adolescents in these key areas.

4.3. Conclusion

Developmentally appropriate training incorporating interactive problem solving, hands-on self-management training, and role-play, might be highly effective in increasing critical asthma self-management knowledge and self-efficacy, and might contribute to long-term improvement in asthma outcomes.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.pec.2017.10.016.

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