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Behavioral Interventions to Improve Asthma Outcomes for Adolescents: A Systematic Review

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Abstract

Background—Factors at multiple ecological levels, including the child, family, home, medical care, and community, impact adolescent asthma outcomes.

Objective—This systematic review characterizes behavioral interventions at the child, family, home, medical system, and community level to improve asthma management among adolescents.

Methods—A systematic search of PubMed, SCOPUS, OVID, PsycINFO, CINAHL, and reference review databases was conducted from January 1, 2000 through August 10, 2014. Articles were included if the title or abstract included asthma AND intervention AND (Education OR self-management OR behavioral OR technology OR trigger reduction); and the mean/median age of participants was between eleven and sixteen years. We compared populations, intervention characteristics, study designs, outcomes, settings, and intervention levels across studies to evaluate behavioral interventions to improve asthma management for adolescents.

Results—Of 1230 articles identified and reviewed, 24 articles (21 unique studies) met inclusion criteria. Promising approaches to improving adherence to daily controller medications include: objective monitoring of inhaled corticosteroid adherence with allergist/immunologist feedback on medication taking behavior and school nurse directly observed therapy. Efficacy at increasing asthma self-management skills was demonstrated using group interactive learning in the school

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setting. This systematic review is not a meta-analysis, thus limiting its quantitative assessment of studies. Publication bias may also limit our findings.

Conclusions—Novel strategies to objectively increase controller medication adherence for adolescents include allergist/immunologist feedback and school nurse directly observed therapy. Schools, the most common setting across studies in this review, provide the opportunity for group interactive learning to improve asthma knowledge and self-management skills.

Keywords

Asthma; Childhood asthma; outcome assessment (health care); adolescents; schools

Introduction

Asthma is among the most common chronic illnesses of childhood in the United States,^{1,2} with a prevalence of 9.5%.³ Asthma is the third leading cause of hospitalization among children.⁴ Adolescents are at particularly high risk for poor asthma outcomes, with asthma death rates twice as high for 11–17 year olds than 0–10 year olds.^{2,5}

Adolescence offers a unique window of opportunity to deliver behavioral interventions to improve long-term asthma outcomes. Despite the challenges of complacency, uncertainty, and sense of invincibility,⁶ opportunities exist. Lifelong patterns of health behaviors and key self-management skills are established during this important developmental period.^{7–10} Success in changing habits during adolescence can carry through over the adult lifetime.

Research is clear that factors at multiple ecological levels impact asthma outcomes in adolescents.^{11,12} National guidelines and task forces have identified recommendations at multiple levels for improving pediatric asthma management.^{13–14} These four levels include the: child and family (e.g. asthma knowledge, self management behaviors, family support, and psychosocial factors such as depression); home (e.g. exposure to allergens and irritants); medical care (e.g. practitioner's adherence to national asthma guidelines); and community (e.g. school programs to support asthma self-management).¹³ Due to the focus on adolescents (rather than young children), in this manuscript we separate child and family into two separate levels. The goal of this systematic review was to identify and evaluate behavioral interventions targeting adolescents. Those interventions demonstrating efficacy may be considered for use in clinical practice as well as potential inclusion in future multilevel effectiveness studies.

Methods

Initial Search

We completed a systematic review of the literature in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reference standards.^{15,16} The search was completed using the following electronic databases: PubMed Medline, Ovid Medline, Scopus, PsycINFO and CINAHL (Figure 1). The electronic search included titles and abstracts limited to articles focusing on humans, published in the English language and the following date range: January 1, 2000 through August 10, 2014. We

combined the terms asthma and intervention with either: education, self-management, behavioral, trigger reduction, or technology in order to identify behavioral interventional studies in adolescents with asthma. We did not originally limit to age in order to make sure studies were not missed that may cross age ranges or included multiple age groups; however, we only reviewed articles whose population included a mean or median age between eleven and sixteen.

To ensure we did not miss any intervention studies from this time period, we pulled several review articles of asthma interventions in this age group and reviewed their references. We additionally reviewed references of the included studies. We did not include unpublished data and abstracts.

The inclusion criteria were a teenage population with asthma (mean or median age between eleven and sixteen) and behavioral intervention studies. We included all types of intervention studies completed in all health care settings, community and at home as well as interventions focusing on health care providers who have a direct impact on asthma management in our target population. Both national and international studies were included.

Article Selection

Title and abstract review was completed by a minimum of two of the following authors: AAP, SER, RNM, VV, and GSM. We excluded articles if they were not asthma focused, performed on a population other than our target age group, or not a behavioral intervention study (Figure 2). If this information was not obvious from the title or abstract review, we reviewed the full article. At least two authors (SB, CDC, RNM and VV) independently reviewed each of the remaining articles. The final inclusions were then further reviewed and finalized by the first and last two authors (GSM, EBL and LHP) to ensure all criteria were adequately met.

Grouping of Intervention Studies

Several studies yielded multiple publications (Figure 3). All articles ($n = 24$) were included, but each intervention ($n = 21$) was only counted once (Figure 4).^{12,17–39} For each article, the sample size, patient population, intervention, control, outcomes/results, timeframe, setting, and intervention level were summarized. Intervention level was determined to be either single or multi-level; levels included the child, family, home, medical system and community (Table 1). If specified, outcomes were reported as primary and secondary. All outcomes and results are listed as positive or negative.

Results

Twenty-four articles,^{12,17–39} describing 21 unique studies, were included. Of these studies, eleven were single-level (child only), and ten were multi-level: child and family ($n = 6$); child and medical system ($n = 2$); and child and community ($n = 2$). None of the studies included a home level intervention.

Intervention Level and Results

Child—Nine of the eleven child-level only interventions studies had positive outcomes.^{22–31,33,34} Seven of the nine focused on low-income minority African American and/or Hispanic adolescents in the United States^{22–29,34} one^{30–31} included a diverse national teen sample, and one was a study of British³³ adolescents (participant race/ethnicity/socioeconomic characteristics not provided). Alone or in combination with other intervention components, studies featured group^{27,29,30–31,38–39} (n=5) or individual^{22–23,24,33} (n=3) asthma education and self-management skills training, and another two included individual asthma education.^{25–26,34} All of the positive studies adhered to their country's national asthma guidelines^{14,40} by providing self-management skills training and/or education on one or more of the following topics: basic facts about asthma, environmental triggers and trigger reduction measures, roles of medications, medication inhaler technique, use of peak flow monitoring, how to handle worsening asthma, self-monitoring, and use of a written asthma action plan. Six targeted the child in the school (n = 4),^{25–27,29,33} day camp (n = 1),^{30–31} or school plus home (n = 1)²⁴ setting. One study provided directly observed therapy for asthma medications at school and motivational interviewing based asthma education and self-management skills training in the home.²⁴ Four leveraged technology as the primary agent for intervention delivery, featuring: information and decision support through a telemedicine interactive voice response system,^{22–23} web-based tailored asthma education sessions,^{25–26} celebrity asthma messages between music tracks on an mp3 player,²⁸ and tailored text messages on a mobile phone promoting medication adherence.³⁴

Positive outcomes included: knowledge;^{28–29,33} quality of life;^{24–25,30,34} proper use of medications;^{25,29,33} symptoms;^{22,24–27} medication adherence;²⁴ asthma control;^{22–23} lung function;²² and health care utilization.^{25,27,30} None of these positive outcomes were demonstrated using an objective measurement (e.g. spirometry to measure lung function, verification of emergency department visits by review of medical records, or electronic monitoring of medication adherence). Most studies (n=7) employed a control group.^{22–26,28–31,33–34} Three studies were limited by small sample sizes (range 26–30 participants)^{24,28,34} and five were limited by short follow up periods (3 months).^{22–23,27,29,34,39}

The two negative studies demonstrated improvement in both the treatment and control group outcomes, but no statistical difference in these pre-post treatment outcome improvements between groups.^{38–39} Both employed group asthma education/self-management skills training within the school setting, and targeted low-income minority adolescents.^{38–39} One study also included asthma coping skills training sessions.³⁸ These studies failed to show improvements in any of the following outcomes: knowledge;^{38–39} quality of life;³⁸ symptoms;³⁸ asthma self-management behaviors;^{38–39} lung function;³⁸ and health care utilization.³⁸ One study used an objective outcome assessment (spirometry for assessment of lung function).³⁸ Both used a control group^{38–39} and had sample sizes 50 teens (n= 136 and n=86).^{38–39} One had a 12 month follow up and the other only 10 weeks.^{38–39}

Child and Family

The five multilevel interventions addressing both the child and family had positive outcomes.^{12,18,21,32,37} Four^{12,18,32,37} targeted low-income African American and Hispanic adolescents and caregivers and utilized group (n=2)^{18,37} or individual (n=2)^{12,32} asthma education and self-management training to address core topics outlined in the EPR3 asthma guidelines.¹⁴ One study featured asthma education and self-management skills training alone;³⁷ while the second, third and fourth studies also integrated problem solving,¹⁸ motivational interviewing,³² and multi-systemic therapy-healthcare.¹² Two studies delivered the intervention to the child and caregiver simultaneously.^{12,32} The other two studies delivered intervention components to the child and caregiver separately: different group training sessions for the teens and their caregivers;¹⁸ and the adolescents received group education and self-management training and caregivers received asthma newsletters to foster discussion with their child about asthma.³⁷ One child and family level study focused on the NHLBI EPR3 asthma guideline¹⁴ recommendation of improving adherence to daily inhaled corticosteroids.²¹ This study targeted rural adolescents and caregivers and featured a psychologist-delivered parent and youth teamwork intervention focusing on shared responsibility and addressing conflicts for adherence.²¹ Studies chose school (n = 2),^{18,37} home (n = 2),^{12,32} and asthma specialty clinic (n= 1)²¹ settings. Positive outcomes included subjective and objective measurements: self-efficacy and responsibility;³⁷ parental conflict with adolescent;²¹ quality of life;¹² asthma functional impairment;²¹ medication adherence;^{12,18,21} symptoms;^{18,32} and lung function.^{12,21} Two studies used an objective outcome measure; both included spirometry to assess lung function.^{12,21} and one utilized electronic medication monitors to measure adherence to inhaled corticosteroids.²¹ Four studies utilized a control group.^{12,18,21,37} One of the studies included a small sample size (24 teens)¹⁸ and a short follow-up (2 months).^{18 18.}

Child and Medical System

The two multilevel interventions targeting the child and medical system were conducted by the same group of investigators.^{19,20} Both were positive studies, focused on poor urban African American and Hispanic adolescents and conducted in the school setting.^{19,20} The intervention had several components: group sessions promoting asthma education and self-management skills outlined in the asthma guidelines;¹⁴ individual coaching sessions promoting goal setting, problem solving, and communication skills with their health care provider; and academic detailing for the adolescents' primary care provider (e.g. asthma specialist made in-person or telephone presentations to primary care providers about guideline¹⁴ based changes in therapy).^{19,20}

Positive outcomes included: asthma self-management;²⁰ quality of life;²⁰ symptoms²⁰ and proactive use of preventive health care services.¹⁹ Neither study used objective measurement of asthma outcomes. In contrast to the first study,¹⁹ the second had a large sample size (n=345), robust follow up period (12 months), and a control group.²⁰

Child and Community

Both multilevel interventions targeting the adolescent and the community were conducted outside the United States (Jordan and Australia).^{17,35} The two studies were positive,

conducted in the school setting, employed no treatment control group schools as the comparator arm, and utilized peer-led group asthma education and self-management skills training.^{17,34} The Jordanian study (n = 261) delivered these peer-led sessions to the adolescents and school community and had a 3-month follow-up period,¹⁷ while the Australian study (n = 133) utilized peer-led education/training for the teens and separate asthma education workshops for the school staff and followed the participants for 9 months.³⁴ Neither study reported following asthma guideline based interventions. Positive outcomes included: knowledge,¹⁷ quality of life^{17,35} and asthma attacks at school.³⁵ No outcomes were measured objectively.

Child, Family, and Medical System

One multilevel study targeted the adolescent, parent, and medical system.³⁶ In this pilot study, inhaled corticosteroid use was electronically monitored and bi-monthly feedback on medication taking behavior was provided to the adolescent and parent by an allergist/immunologist.³⁶

Following treatment, feedback was stopped and the effects of objective adherence monitoring alone were observed for an additional 4–5 weeks.³⁶ Although this study lacked a control group and the sample size was small (n = 5), it demonstrated a trend for improvement in subjective (e.g. proper medication technique and parental report of asthma functional severity) and objective outcomes including electronic medication monitoring of inhaled corticosteroid use.³⁶ Results were variable regarding objective measurement of improvements in lung function using spirometry.³⁶

Discussion

National guidelines and task forces have identified behavior change recommendations at the child, family, home, medical care, and community levels to improve adolescent asthma management.^{13,14} This systematic review sought to evaluate published behavioral intervention studies to identify approaches demonstrating efficacy at these five levels for potential inclusion in future multi-level effectiveness studies and clinical practice. Nineteen^{12,17–37} of the twenty-one^{12,17–39} published studies yielded positive results. In total, eleven targeted the child only;^{21–31,33–34,38–39} five, two, two, and one studies targeted child and family,^{12,18,21,32,36–37} child and medical system,^{19,20} child and community,^{17,35} and child, family, and medical system, respectively; none targeted the home. Few studies included objective measurement of objective outcomes, (n=5),^{12,21,24,36,38} and less than half included rigorous attention control groups (i.e. a group that receives a treatment that provides an equal amount of time and attention as the treatment group but is thought not to have a specific effect upon the subjects)⁴¹ (n=9),^{12,21–23,25–26,30–31,33–34,37–38} or had follow up periods > 3 months (n=9).^{12,20–21,25–26,30–31,33–35,38}

Although the title/abstract review included a study describing home level interventions (e.g. eliminating/reducing exposure to allergens and irritants) targeting parents of children with asthma,⁴² none specifically addressed adolescents. The lack of home level interventions targeting the adolescent may be due to their lack of autonomy and financial resources to implement these types of changes. Perhaps the positive single and multi-level behavioral

interventions identified in this systematic review directed at increasing asthma knowledge and improving self-management behaviors that address trigger reduction^{12,18–19,21,24–27,29,31,37–39} may empower the adolescent to make changes that are currently within their control (e.g. removing stuffed animals from the bed) and make additional changes (e.g. carpet removal, cockroach and rodent extermination, and enforcing a no-smoking policy in the home) once they establish their own household.

Of the sixteen positive US based studies, fourteen focused on low-income African American and Hispanic adolescents (13 targeted this demographic, and 1 study included a diverse teen population)^{12,18–32,34,37–39} and two targeted rural teens.^{21,36} These population sub-groups are at particularly high risk of poor asthma outcomes.^{1–5,431–5} While the total number of intervention studies addressing asthma in adolescents is low, it is encouraging to see that investigators are focusing on interventions for the most vulnerable teens.

Allergist/immunologist objective monitoring of inhaled corticosteroid use and provision of adherence feedback to adolescents and parents showed promise in a pilot study.³⁶ Objective monitoring of inhaled corticosteroid use with asthma specialist feedback has also successfully increased adherence in other studies with adults⁴⁴ and younger children and their parents.⁴⁵ This approach offers advantages in that it could be integrated in a time and cost effective fashion into clinical practice. As many of the newer controller medications for asthma now have integrated dose counters, this approach could be implemented without adding additional cost and burden of purchasing electronic medication monitors.

The most common intervention setting was the school (n = 12 studies).^{17–20,24–27,29,33,35,37–39} As teens, on average, spend approximately 8 to 12 hours per day, 180 days per year in school, this appears to be a prime setting to access and engage them in behavioral asthma interventions.⁴⁶ However, due to variation in state, district, and individual school level policies and resources, schools across the United States have tremendous variability in their ability to promote health. On a national level, only 36% of schools have a full-time school nurse.⁴⁷ Without adequate nursing staff, under-resourced schools may not be able to deliver interventions that have proven efficacious in other schools. The positive results demonstrated by group interactive learning with other adolescents experiencing asthma self-management challenges^{17–20,27,29,35,37} and nurse-delivered directly observed therapy for asthma controller medications²⁴ in the school setting provides a clear directive to tackle these policy and resource limitations.

A limitation of this study is the lack of quantitative analysis across studies. Although we did not perform a meta-analysis, we carefully followed the PRISMA guidelines for systematic reviews.^{15,16} This systematic review also benefits from multidisciplinary expertise, with both asthma content experts (allergists/immunologists) and behavioral intervention scientists (behavioral psychologists) identifying, evaluating, and analyzing the studies.

In summary, a variety of multi-level behavioral interventions for adolescents with asthma demonstrate promise and warrant further testing in rigorous controlled trials with larger sample sizes (e.g. n = 100), longer durations of follow up (e.g. = 12 months), and robust attention control groups. Objective monitoring of inhaled corticosteroid use coupled with

allergist/immunologist feedback³⁶ may be readily incorporated into clinical practice to improve adherence and deserves future investigation. Schools were by far the most common venue for adolescent asthma behavioral interventions. Group interactive learning^{17–20,27,29,35,37} to promote asthma education and self-management and nurse delivered directly observed therapy for controller medications²⁴ to increase adherence both leverage unique features of this setting, and these interventions also merit additional study in behavioral controlled trials.

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Abbreviations

PICOTS Population, Intervention, Control, Outcomes, Timeframe, Setting

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Highlights Box

What is already known about this topic?

Factors at multiple ecological levels, including child, family, home, medical system, and community impact asthma outcomes in adolescents.

What does this article bring to our knowledge?

School-based group interactive learning and directly observed therapy have demonstrated efficacy at improving asthma self-management skills and inhaled corticosteroid adherence among adolescents, respectively. Allergists/immunologists may promote increased adherence by objective monitoring of inhaled corticosteroid use combined with feedback on medication taking behavior. How does this study impact management guidelines? This study offers support of new approaches for the delivery of asthma guideline recommendations for asthma self-management and adherence to inhaled corticosteroid medications among adolescents.

PubMed Search Strategy:

*(Asthma[Title/Abstract]) AND
(Intervention[Title/Abstract]) AND
(Education[Title/Abstract]) OR (Self-
management[Title/Abstract]) OR
(Behavioral[Title/Abstract]) OR
(Trigger Reduction[Title/Abstract])
OR (Technology[Title/Abstract])*

Limited to literature published from
January 1, 2000 through August 10,
2014, English Language and
Humans.

Figure 1. Search Strategy Text Box

This figure describes the search strategy implemented to execute this systematic review.

Figure 2. Consort Diagram

This diagram illustrates article inclusion and exclusion criteria for this systematic review.

Figure 3. Study Intervention Level Flow Diagram

This diagram illustrates the distribution of studies across the intervention levels.

Figure 4. Specific Intervention Level Chart
This chart groups the studies according to the specific intervention levels: child only, child and family, child and medical system, child and community, and child, family, and medical system.

Table 1

PICOTS

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Al-Sheyab 2012 ^{17, ii}	261, Range 13– 15 y.o.	Peer led group asthma education and self-management t skills training (number of sessions not specified) to teens and school community.	No-treatment control schools	Pediatric Asthma Quality of Life Questionnaire (PAQLQ): Improved (p=0.02–0.03) Asthma Knowledge Consumer Questionnaire (CQ): Improved (p=0.03) Self-Efficacy subscale of the Nicotine Dependence Scale: Improved (p=0.03)	3 months	School	Child; Community
Bruzzese 2008 ^{18, ii}	24, Range 11– 13 y.o. Mean age (SD) = 12.9 (0.81).	6 group asthma education/ self-management/problem solving sessions for the teens. 5 asthma education/ parent training sessions for caregivers.	No-treatment control group	Asthma symptom prevention: Improved (p<0.05) Caregiver report of child responsibility for own medications: Improved (p<0.05) Asthma symptom severity: Improved (p<0.01) Parent-Adolescent Relationship Questionnaire: Variable (p<0.05 and >0.05) Asthma attack management: No change (p>0.05)	2 months	School	Child; Family
Bruzzese 2011 ^{19, ii}	30, Range 14– 16 y.o. Mean age (SD) = 15.9 (0.98).	3 educational/self-management group sessions; 5 individual coaching sessions promoting goal setting and problem solving; communication skills coaching at visit to PCP.	No-treatment control group	Receiving a provider diagnosis of asthma: Improved (p<0.001) Receiving a prescription for asthma	8 weeks	School	Child; Medical System

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Bruzzese 2011 ^{20, ii}	345, Range 14– 16 y.o. Mean age (SD) = 15.10(0.86).	3 group sessions and 5 individual coaching sessions for teen on asthma education/s elf-management/problem solving. Asthma academic detailing for the adolescent's primary care provider.	Waitlist control	medication from provider: Improved (p<0.01) medication from provider: Improved (p<0.01) medication from provider: Improved (p<0.01) Asthma self-management (prevention steps) ‡: Improved (p=0.0001–0.04) Asthma self-management (self-efficacy) ‡: Improved (p=0.0001–0.003) Nighttime awakenings in prior two weeks [‡] : Improved (p=0.001) Pediatric Asthma Quality of Life Questionnaire (PAQLQ) [‡] : Improved (p=0.0045) Asthma self-management (management steps) [‡] : No change (p=0.24–0.96) Symptom days in prior two weeks [‡] : No change (p=0.12) Asthma Medical Management: Improved (p=0.006) Self-reported school absences: Improved (p=0.004) Days with activity limitations: Improved (p=0.003) Urgent health care use: Improved (p=0.0001–0.0042)	12 months	School	Child; Medical System

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Duncan 2012 ^{21, iii}	48, Range 9–15 y.o. Mean age (SD)= 11.1 (1.9)	4 individual parent and youth teamwork intervention (TI) sessions focusing on shared responsibility and addressing conflicts for asthma management delivered by a psychologist	Attention Control : 4 parent and youth Asthma Education (AE) Sessions OR Standard Care (SC): Usual Care	Objectively measured inhaled corticosteroid medication adherence at 20 weeks, TI vs. AE and SC: Improved ($p < 0.001$, $p < 0.001$) Adolescent report of conflict with caregiver at 20 weeks, TI vs. AE and SC : No improvement ($p = 0.11$ and $p=0.26$) Parental rating of conflict with adolescent at 20 weeks, TI vs. AE and SC: $p = 0.45$ and $p=0.04$ Asthma symptom severity and functional impairment at 20 weeks, TI vs. AE and SC: Improved ($p = 0.01$ and $p=0.005$) Spirometric measure of FEF _{25–75} at 20 weeks, TI vs. AE and SC: Variable ($p = 0.09$ and $p=0.05$)	8 week intervention ; 20 week primary outcome assessment	Asthma specialty clinics	Child: Family
Guendelman 2002 ^{22, ii} , Guendelman 2004 ^{23, ii}	134, Range 8–16 y.o. Mean age = 12.	Information and decision support through telemedicine interactive voice response system. 3 individual nurse asthma education/self-management training sessions.	Paper asthma diary and 3 individual nurse asthma education/self-management training sessions.	(2002 Publication) Activity limitation [†] : Improved ($p=0.03$) Peak flow readings ever in the red or yellow zone: Improved ($p=0.01$) Perceived asthma symptoms: No change ($p=0.23–0.83$)	12 weeks	Primary care clinic; Home; Technology (Health Buddy)	Child

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Joseph 2007 ²⁵ , ii; Joseph 2013 ²⁶ , ii	(2007 Publication) 314, Range 14– 16 y.o. Mean age (SD) = 15.3 (1.0). (2013 Publication) 422, Mean age = 15.6 y.o.	4 individual web-based tailored asthma education sessions and health care referral coordinator.	4 session s with access to generic asthma education websites.	Rescue medicine use days over past 2 weeks: Variable (p<0.05 and >0.05) Rescue medicine use days over past 2 weeks: Variable (p<0.05 and >0.05) Rescue medicine use days over past 2 weeks: Variable (p<0.05 and >0.05) Exhaled nitric oxide: Variable (p<0.05 and >0.05) Confidence to take ICS: Variable (p<0.05 and >0.05) Importance to take ICS: Variable (p<0.05 and >0.05) Pediatric Asthma Caregiver Quality of Life Questionnaire (PACQLQ): No change (p>0.05)	days over past 2 weeks: Variable (p<0.05 and >0.05) days over past 2 weeks: Variable (p<0.05 and >0.05) days over past 2 weeks: Variable (p<0.05 and >0.05) days over past 2 weeks: Variable (p<0.05 and >0.05)	School ; Technology (Computer)	Child
				(2007 Publication) Number of symptom days over past 2 weeks [†] ; Improved (p=0.003) Days of restricted activity over past 2 weeks: Improved (p=0.02) Nights of symptoms over past 2 weeks: Improved (p=0.009) School days missed over past 30 days: Improved (p=0.006) Hospitalizations over past 12 months: Improved (p=0.01) Carrying rescue inhaler on person: Improved	12 months		

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
				(p=0.01) Days had to change plans: No change (p=0.17) ED visits over past 12 months: No change (p=0.08) (p=0.01) Days had to change plans: No change (p=0.17) ED visits over past 12 months: No change (p=0.08) (p=0.01) Days had to change plans: No change (p=0.17) ED visits over past 12 months: No change (p=0.08) (p=0.01) Days had to change plans: No change (p=0.17) ED visits over past 12 months: No change (p=0.08) (p=0.01) Days had to change plans: No change (p=0.17) ED visits over past 12 months: No change (p=0.08) (p=0.01) Days had to change plans: No change (p=0.17) ED visits over past 12 months: No change (p=0.08) (p=0.01) Days had to change plans: No change (p=0.17) ED visits over past 12 months: No change (p=0.08) Controller medicine adherence: No change (p=0.09) Smoking cessation/reduction: No change (p=0.89) Pediatric Asthma Quality of Life Questionnaire (PAQLQ): No change (p=0.07–0.38) (2013 Publication) Number of symptom days: Improved (p=0.013–0.019) Nights of symptoms: No change (p=0.210–0.82) Days of restricted activity: No change (p=0.14) ED visits and hospitalizations: No change (p=0.47–0.95)			
Magzamen 2008 ²⁷ ;	845, Range 11–15 y.o.	Group nurse-led asthma education/self-management skills training.	No control group	Nights of sleep disruptions: Improved (p=0.0001–0.006) Activity limitations: Improved (p=0.0001–0.015) Emergency room visits: Improved (p<0.05) Missed days of school: Variable (p=0.0103–0.4387)	3 months	School	Child

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Mosnaim 2008 ^{28,ii}	28, Range 10–18 y.o.	Celebrity Asthma Messages	General Health Messages	Daytime symptoms Variable (p<0.05 and >0.05) Daytime symptoms Variable (p<0.05 and >0.05) Daytime symptoms Variable (p<0.05 and >0.05) MD visits for asthma symptoms: Variable (p<0.05 and >0.05) Controller medication use while healthy: No change (p>0.05)	Variable (p<0.05 and >0.05) Variable (p<0.05 and >0.05) Variable (p<0.05 and >0.05)		
Mosnaim 2011 ^{29,ii}	192 (subgroup), Range 12–15 y.o. Median age = 13.	Group asthma education/self-management skills training.	Wait-list control	ZAP Asthma Knowledge Instrument: Improved (p=0.02–0.05) FAN Asthma Knowledge Questionnaire: Improved (p<0.0001–0.011) FAN Spacer Competency Checklist: Improved (p<0.0001)	14 weeks	Technology (mp3 player)	Child
Naar-King 2014 ^{12,ii}	170, Range 12–16 y.o. Mean age = 13.	Individual asthma education/self-management/empowerment through MST-HC (Multi-systemic therapy-healthcare). Mean number of MST session 27 (range 4–62)	FS (In-home Family Support)	Family Asthma Management System Scale: Improved (p=0.03) Child Response to Symptoms and Exacerbations Scale: Improved (p=0.04) Daily Phone Diary for medication adherence: Improved (p=0.03) Lung function (FEV1): Improved (p<0.05)	7 months	Home	Child; Family
Rhee 2011 ^{30,ii} ; Rhee 2012 ^{31,ii}	112. Range 13–17 y.o. Mean age = 14.	Group peer-led asthma education/self-management training plus follow-up phone calls.	Health care provider led asthma education/self-management training.	(2011 Publication) Child Attitude Toward Illness	9 months	Day Camp	Child

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Riekert 2011 ^{32, i}	37, Range 10–15 y.o. Mean age (SD) = 12.5 (1.6).	Individual motivational interviewing based asthma education/self-management training/adherence promotion/goal setting and problem solving.	No control group	Scale ⁷ : Improved (p=0.001–0.02) : Improved (p=0.00) –0.02) Pediatric Asthma Quality of Life Questionnaire (PAQLQ) ⁷ : Improved (p=0.002–0.03) Lung function (FEV1): No change (p=0.06) (2012 Publication) Number of acute PCP visits: Variable (p=0.01– 0.61) Days of hospitalization: No change (p=0.29–0.49) Number of ED visits: No change (p=0.16–0.62) Number of specialist visits: No change (p=0.63–0.87) Number of routine PCP visits: No change (p=0.11– 0.43) Number of school clinic visits: No change (p=0.09–0.29)	3 months	Home	Child; Family

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Salisbury 2002 ²³ , ⁱⁱ	455, Range 12–14 y.o. Median age = 13.	Individual asthma education/self-management training.	Practice care	Asthma follow-up appointments [†] ; Improved (p<0.001–0.006) Pediatric Asthma Quality of Life Questionnaire (PAQLQ) [‡] ; No change (p=0.63) Asthma symptoms [‡] ; No change (p=0.42) Asthma knowledge;	6 months	School	Child
				change: Improved (p<0.05) change: Improved (p<0.05) Caregiver reported symptom-free days: Improved (p<0.05) Caregiver reported symptom-free nights: No change (p>0.10) Adolescent reported symptom free days and nights: No change (p>0.10) Caregiver reported adherence: No change (p>0.10) Adolescent reported adherence: No change (p>0.10) Caregiver and adolescent reported responsibility for treatment: No change (p>0.05) Child Asthma Self Efficacy Scale (CASES): No change (p>0.05)			

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Seid 2012 ^{34, ii}	26, Range 12–18 y.o. Mean age (SD) = 15.1 (1.67)	2 brief individual in-person sessions approximately 1-week apart delivering asthma education/motivational interviewing/problem solving skills training to promote adherence. Cell phone with tailored text messages promoting adherence for 1 month.	2 asthma education sessions and cell phone without tailored text messaging.	Improved (p=0.001) Improved (p=0.001) Attitudes towards asthma: Improved (p=0.007) Inhaler medication technique: Improved (p<0.001–0.04) ICS adherence: No change (p=0.60) Asthma-related school absences: No change (p=0.78) Peak flow measurement: No change (p=0.36) Health care utilization: No change (p-value not given, but stated insignificant)	3 months	Specialty Clinic; Technology (Mobile Phone)	Child

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Shah 2001 ^{35, ii}	133 (subgroup). Mean age = 15.5 y.o.	Group peer-led asthma education. Asthma education workshops for school staff.	No-treatment control schools	Survey: No change (p>0.05) Survey: No change (p>0.05) Reduced asthma symptom days in past 2 weeks: No change (p>0.05) Pediatric Asthma Quality of Life Questionnaire (PAQLQ) ⁷ : Improved (p=0.01) Missed school days: Improved (p<0.05) Asthma attacks at school: Improved (p<0.05) Lung function (FEV1): No change (p>0.05)	9 months	School	Child; Community
Spaulding 2011 ^{36, i}	5, Range 11–14 y.o. Mean age (SD) = 12.4 (1.52).	Phase I: electronic objective monitoring of inhaled corticosteroid medication adherence plus 4 pediatric allergist led adherence feedback sessions with adolescent and parent Phase II: electronic objective monitoring of inhaled corticosteroid medication adherence alone	No control group	<i>i</i> Objectively measured inhaled corticosteroid medication adherence: 4 of 5 participants demonstrated improvements at the end of Phase I and Phase II. Proper medication technique: 5 participants demonstrated improvements at the end of Phase I that were maintained at the end of Phase II. Spirometric measure of FEF _{25–75} : Variable Parental Report of Asthma Functional Severity: 5 participants demonstrated a decrease at the end of Phase I, which was	Variable: duration of electronic monitoring plus feedback ranged from 27–50 days; electronic monitoring alone ranged from 30–36 days	Asthma specialty clinic	Child; Family; Medical System

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Terpstra 2012 ^{37, ii}	58, Range 11–14 y.o. Mean age = 12.	6 weekly group asthma education/self-management training sessions for the teen. 6 newsletters sent to adult (identified by adolescent) and teen over the next 6 weeks to foster discussion about asthma.	6 weekly group asthma education/self-management training sessions for the teen.	Self-efficacy for asthma scale: Improved (p<0.05) Asthma Responsibility Questionnaire: Improved (p<0.01) Holden's Outcomes Expectations Scale: No change (p>0.05)	12 weeks	School	Child; Family
Velsor-Friedrich 2012 ^{38, ii}	137, Range 13–19 y.o. Mean age = 15.	5 asthma coping skills training sessions, 5 group asthma education/self-management sessions, and 1 clinic visit with nurse practitioner.	5 asthma education/self-management sessions, and 1 clinic visit with nurse practitioner.	Asthma self-care: No change (p>0.05) Pediatric Asthma Quality of Life Questionnaire (PAQLQ): No change (p>0.05) Knowledge about asthma: No change (p>0.05) Asthma self-efficacy: No change (p>0.05) Coping frequency: No change (p>0.05) Spirometry: No change (p>0.05) Mean peak expiratory flow rate (PEFR): No change (p>0.05) Symptom days: No change (p>0.05) Asthma related doctor/emergency room visits and hospitalizations: No change (p>0.05) Asthma diary symptoms: No change (p>0.05)	12 months	School (and School Based Clinic)	Child

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention Level
Zografos 2010 ^{39, iii}	86. Mean age (SD) = 13 y.o. (1.25).	Group asthma education/ self-management skills training.	Waitlist control	<p>School absences: No change (p>0.05) School absences: No change (p>0.05) School absences: No change (p>0.05)</p> <p>Asthma Knowledge Questionnaire: Improved (p=0.000) Child Asthma Self-Efficacy Questionnaire: Improved (p=0.008) Intention to perform asthma self-management behaviors alone and with peers: Variable (p=0.000–0.117) Report of actual asthma self-management behaviors: Variable (p=0.003–0.945) Report of self-consciousness of performing asthma management behaviors in front of peers: No change (p=0.726)</p>	10 weeks	School	Child

[†] Named as primary outcome.

Ranges of p-values reflect either differences in outcomes between distinct cohorts receiving identical interventions or variations in subscores within larger measurement assessments.

If reported by authors, mean/median age and SD included.

ⁱ Sample size too small to report p values.

ⁱⁱ For studies using no control group, the p-values are for the change from baseline comparison. 24,27,32

ⁱⁱⁱ For studies using a no-treatment control group, 17,18,19,35 waitlist control group, 20,29 or a control group 12, 22,23,25,26,28,30,31,33,34,37,38 the p-values are for comparison with the no-treatment control group, waitlist control group, or control group, respectively.

^{iv} One study using a waitlist control group³⁹ indicated p-values for the change from baseline comparison.