

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



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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 add 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 and/or immunologists may promote increased adherence by objective monitoring of inhaled corticosteroid use combined with feedback on medication-taking behavior.

How does this study impact current 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.

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 and/or median age of participants was between 11 and 16 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 and/or 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 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 and/or 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. © 2015 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2016;4:130-41)

Key words: Asthma; Childhood asthma; Outcome assessment (health care); Adolescents; Schools

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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 4 levels include the child and family (eg, asthma knowledge, self-management behaviors, family support, and psychosocial factors such as depression), home (eg, exposure to allergens and irritants), medical care (eg, practitioner's adherence to national asthma guidelines), and community (eg, school programs to support asthma self-management).¹⁵ Because of the focus on adolescents (rather than young children), in this article, we separate child and family into 2 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 to identify behavioral interventional studies in adolescents with asthma. We did not originally limit to age to make sure that 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 11 and 16.

To ensure that 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 11 and 16) 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 2 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

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

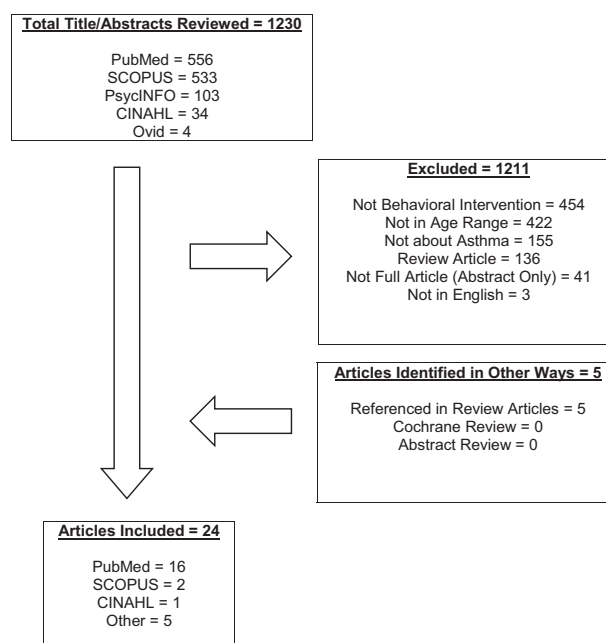
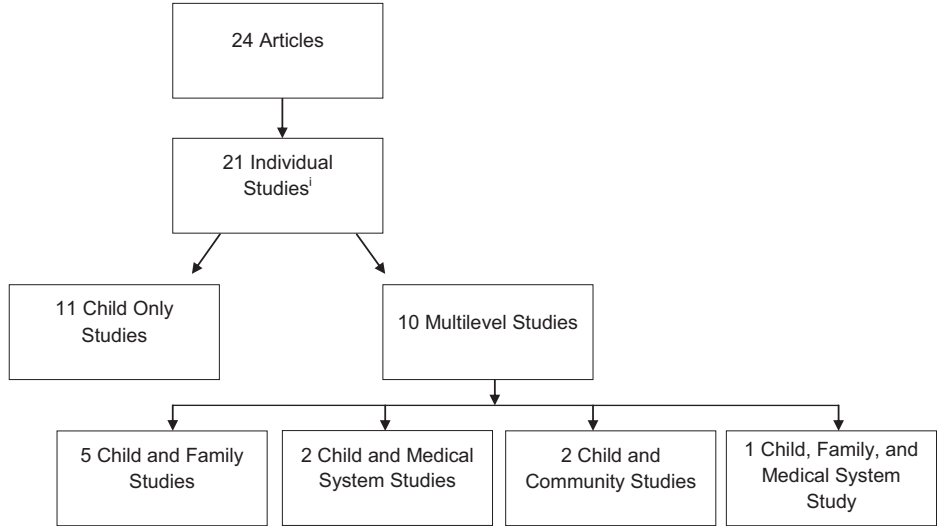


FIGURE 2. Consort diagram. The diagram illustrates article inclusion and exclusion criteria for this systematic review.

intervention study (Figure 2). If this information was not obvious from the title or abstract review, we reviewed the full article. At least 2 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 2 authors (GSM, EBL, and LHP) to ensure that all criteria were adequately met.

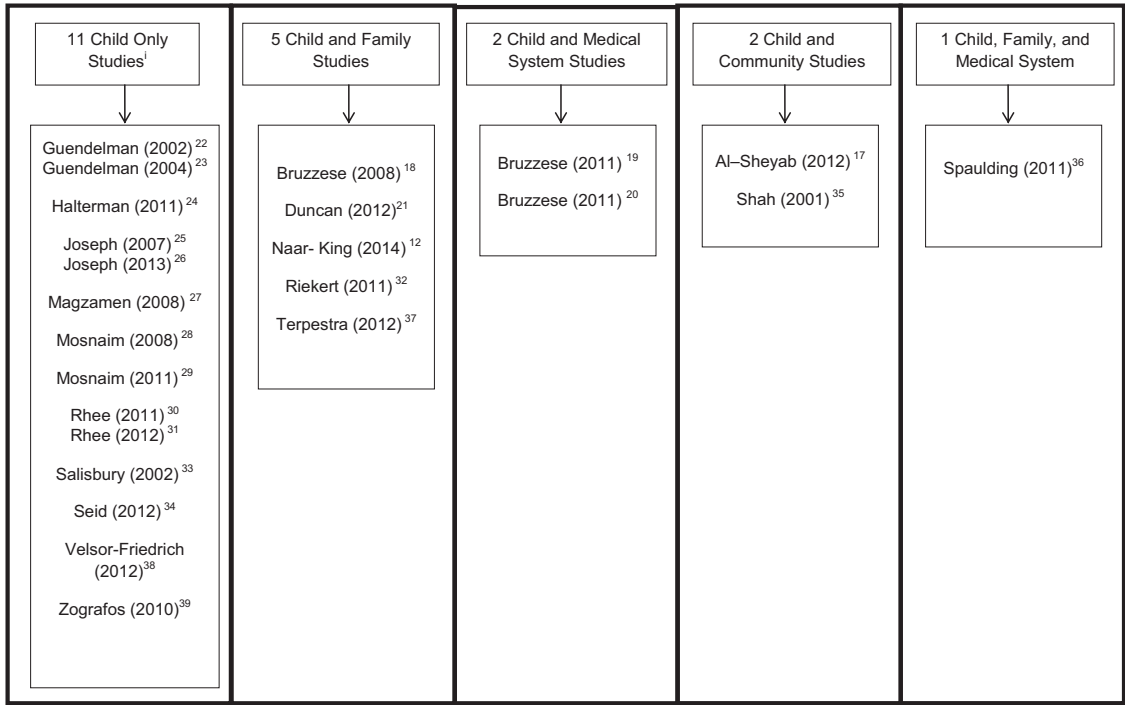
Grouping of intervention studies

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 and/or results, timeframe, setting, and intervention level were summarized. Intervention level was determined to be either single or multilevel;



i. Discrepancies between number of articles and number of studies are due to several authors publishing more than one article on the same study (e.g. Guendelman^{22,23}, Joseph^{25,26}, and Rhee^{30,31}).

FIGURE 3. Study intervention level flow diagram. The diagram illustrates the distribution of studies across the intervention levels.



i. The following pairs of articles describe the same study: Guendelman²² and Guendelman²³; Joseph²⁵ and Joseph²⁶; and Rhee³⁰ and Rhee.³¹ This accounts for the difference between number of studies (n=11) and number of articles (n=14).

FIGURE 4. Specific intervention level chart. The 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.

levels included the child, family, home, medical system, and community (Table I). 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, 11 were single-level (child only) and 10 were multilevel: child and family (n = 6), child and

TABLE I. Population, Intervention, Control, Outcomes, Timeframe, Setting (PICOTS)

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention level
Al-Sheyab et al ^{17,†}	261, Range 13-15 y.o.	Peer-led group asthma education and self-management skills training (number of sessions not specified) to teens and school community	No-treatment control schools	Pediatric Asthma Quality of Life Questionnaire (PAQLQ): improved ($P = .02-.03$) Asthma Knowledge Consumer Questionnaire: improved ($P = .03$) Self-Efficacy subscale of the Nicotine Dependence Scale: improved ($P = .03$)	3 mo	School	Child; community
Bruzzese et al ^{18,‡}	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 ($P < .05$) Caregiver report of child responsibility for own medications: improved ($P < .05$) Asthma symptom severity: improved ($P < .01$) Parent-Adolescent Relationship Questionnaire: variable ($P < .05$ and $> .05$) Asthma attack management: no change ($P > .05$)	2 mo	School	Child; family
Bruzzese et al ^{19,‡}	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 ($P < .001$) Receiving a prescription for asthma medication from provider: improved ($P < .01$)	8 wk	School	Child; medical system
Bruzzese et al ^{20,‡}	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/self-management/problem-solving; asthma academic detailing for the adolescent's primary care provider	Waitlist control	Asthma self-management (prevention steps)*: improved ($P = .0001-.04$) Asthma self-management (self-efficacy)*: improved ($P = .0001-.003$) Nighttime awakenings in prior 2 wk*: improved ($P = .001$) PAQLQ*: improved ($P = .0045$) Asthma self-management (management steps)*: no change ($P = .24-.96$) Symptom days in prior 2 wk*: no change ($P = .12$) Asthma medical management: improved ($P = .006$) Self-reported school absences: improved ($P = .004$) Days with activity limitations: improved ($P = .003$) Urgent health care use: improved ($P = .0001-.0042$)	12 mo	School	Child; medical system
Duncan et al ^{21,§}	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	Attention control: 4 parent and youth asthma education (AE) sessions OR	Objectively measured inhaled corticosteroid medication adherence at 20 wk, TI vs AE and SC: improved ($P < .001$, $P < .001$) Adolescent report of conflict with caregiver at 20 wk, TI vs AE and SC: no improvement ($P = .11$ and $P = .26$)	8 wk intervention; 20 wk primary outcome assessment	Asthma specialty clinics	Child; family

(continued)

TABLE I. (Continued)

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention level
		conflicts for asthma management delivered by a psychologist	Standard care (SC): usual care	Parental rating of conflict with adolescent at 20 wk, TI vs AE and SC: $P = .45$ and $P = .04$ Asthma symptom severity and functional impairment at 20 wk, TI vs AE and SC: improved ($P = .01$ and $P = .005$) Spirometric measure of FEF ₂₅₋₇₅ at 20 wk, TI vs AE and SC: variable ($P = .09$ and $P = .05$)			
Guendelman et al ^{22,†} ; Guendelman et al ^{23,†}	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 ($P = .03$) Peak flow readings ever in the red or yellow zone: improved ($P = .01$) Perceived asthma symptoms: no change ($P = .23-.83$) School absences in prior 6 wk: no change ($P = .41$) Use of health care services: no change ($P = .05$ to $.96$) (2004 Publication) Asthma control problems at 6 wk: improved ($P = .03$) Asthma control problems at 12 wk: no change ($P = .07$) Asthma hospitalizations: no change ($P > .05$)	12 wk	Primary care clinic; home; technology (health buddy)	Child
Halterman et al ^{24,†}	30, Range 12-15 y.o. Mean age (SD) = 13.6 (1.1)	3 individual motivational interviewing-based asthma education/self-management sessions; direct observed therapy for medication-taking behavior for 6- 8 wk	No control group	Symptom-free days over past 2 wk*: improved ($P < .05$) "Slow down" or "stop" days over past 2 wk: improved ($P < .05$) PAQLQ: improved ($P < .05$) Motivation to take ICS: improved ($P < .05$) Asthma Readiness to Change Questionnaire: improved ($P < .05$) Reduced symptoms days over past 2 wk: variable ($P < .05$ and $> .05$) Rescue medicine use days over past 2 wk: variable ($P < .05$ and $> .05$) Exhaled nitric oxide: variable ($P < .05$ and $> .05$) Confidence to take ICS: variable ($P < .05$ and $> .05$) Importance to take ICS: variable ($P < .05$ and $> .05$) Pediatric Asthma Caregiver Quality of Life Questionnaire (PACQLQ): no change ($P > .05$)	7 mo	School; home	Child
Joseph et al ^{25,†} ; Joseph et al ^{26,†}	(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 sessions with access to generic asthma education websites	(2007 Publication) Number of symptom days over past 2 wk*: improved ($P = .003$) Days of restricted activity over past 2 wk: improved ($P = .02$) Nights of symptoms over past 2 wk: improved ($P = .009$) School days missed over past 30 d: improved ($P = .006$) Hospitalizations over past 12 mo: improved ($P = .01$) Carrying rescue inhaler on person: improved ($P = .01$)	12 mo	School; technology (computer)	Child

				Days had to change plans: no change ($P = .17$) Emergency department (ED) visits over past 12 mo: no change ($P = .08$) Controller medicine adherence: no change ($P = .09$) Smoking cessation/reduction: no change ($P = .89$) PAQLQ: no change ($P = .07$ -.38) (2013 Publication) Number of symptom days: improved ($P = .013$ -.019) Nights of symptoms: no change ($P = .210$ -.82) Days of restricted activity: no change ($P = .14$) ED visits and hospitalizations: no change ($P = .47$ -.95)			
Magzamen et al ^{27,†}	845, Range 11-15 y.o.	Group nurse-led asthma education/self-management skills training	No control group	Nights of sleep disruptions: improved ($P = .0001$ -.006) Activity limitations: improved ($P = .0001$ -.015) ED visits: improved ($P < .05$) Missed days of school: variable ($P = .0103$ -.4387) Daytime symptoms: variable ($P < .05$ and $> .05$) MD visits for asthma symptoms: variable ($P < .05$ and $> .05$) Controller medication use while healthy: no change ($P > .05$)	3 mo	School	Child
Mosnaim et al ^{28,†}	28, Range 10-18 y.o.	Celebrity asthma messages	General health messages	ZAP Asthma Knowledge Instrument: improved ($P = .02$ -.05)	14 wk	Technology (mp3 player)	Child
Mosnaim et al ^{29,†}	192 (subgroup), Range 12-15 y.o. Median age = 13	Group asthma education/self-management skills training	Waitlist control	Fight Asthma Now (FAN) Asthma Knowledge Questionnaire: improved ($P < .0001$ -.011) FAN Spacer Competency Checklist: improved ($P < .0001$)	4 d	School	Child
Naar-King et al ^{12,†}	170, Range 12-16 y.o. Mean age = 13	Individual asthma education/self-management/empowerment through MST-HC (multisystemic therapy health care); mean number of MST sessions 27 (range 4-62)	FS (in-home family support)	Family Asthma Management System Scale: improved ($P = .03$) Child Response to Symptoms and Exacerbations Scale: improved ($P = .04$) Daily phone diary for medication adherence: improved ($P = .03$) Lung function (FEV1): improved ($P < .05$)	7 mo	Home	Child; family
Rhee et al ^{30,†} ; Rhee et al ^{31,†}	112. Range 13-17 y.o. Mean age = 14	Group peer-led asthma education/self-management training	Health care provider-led asthma	(2011 Publication) Child Attitude Toward Illness Scale*: improved ($P = .001$ -.02)	9 mo	Day camp	Child

(continued)

TABLE I. (Continued)

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention level
		plus follow-up phone calls	education/self-management training	PAQLQ*: improved ($P = .002-.03$) Lung function (FEV1): no change ($P = .06$) 2012 Publication) Number of acute PCP visits: variable ($P = .01-.61$) Days of hospitalization: no change ($P = .29-.49$) Number of ED visits: no change ($P = .16-.62$) Number of specialist visits: no change ($P = .63-.87$) Number of routine PCP visits: no change ($P = .11-.43$) Number of school clinic visits: no change ($P = .09-.29$)			
Riekert et al ^{32,†}	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	PAQLQ: improved ($P < .05$) PACQLQ: improved ($P < .05$) Adolescent reported medication motivation and willingness to change: improved ($P < .05$) Caregiver reported symptom-free days: improved ($P < .05$) Caregiver reported symptom-free nights: no change ($P > .10$) Adolescent reported symptom-free days and nights: no change ($P > .10$) Caregiver reported adherence: no change ($P > .10$) Adolescent reported adherence: no change ($P > .10$) Caregiver and adolescent reported responsibility for treatment: no change ($P > .05$) Child Asthma Self-Efficacy Scale: no change ($P > .05$)	3 mo	Home	Child; family
Salisbury et al ^{33,‡}	455, Range 12-14 y.o. Median age = 13	Individual asthma education/self-management training	Practice care	Asthma follow-up appointments*: improved ($P < .001-.006$) PAQLQ*: no change ($P = .63$) Asthma symptoms*: no change ($P = .42$) Asthma knowledge: improved ($P = .001$) Attitudes towards asthma: improved ($P = .007$) Inhaler medication technique: improved ($P < .001-.04$) ICS adherence: no change ($P = .60$) Asthma-related school absences: no change ($P = .78$) Peak flow measurement: no change ($P = .36$) Health care utilization: no change (P value not given, but stated insignificant)	6 mo	School	Child

Seid et al ^{34,†}	26, Range 12-18 y.o. Mean age (SD) = 15.1 (1.67)	2 brief individual in-person sessions approximately 1 wk apart delivering asthma education/motivational interviewing/problem-solving skills training to promote adherence; cell phone with tailored text messages promoting adherence for 1 mo	2 asthma education sessions and cell phone without tailored text messaging	Asthma Module Asthma Symptom Scale (Asthma HRQOL-PedsQL): variable ($P < .05$ and $> .05$) Patient activation measure: no change ($P > .05$) Intention measure for adherence studies: no change ($P > .05$) Motivation to take controller medications and avoid triggers: no change ($P > .05$) Asthma Module Treatment Problem Scale (PedsQL): no change ($P > .05$) Illness Management Survey: no change ($P > .05$) Reduced asthma symptom days in past 2 wk: no change ($P > .05$)	3 mo	Specialty clinic; technology (mobile phone)	Child
Shah et al ^{35,†}	133 (subgroup) Mean age = 15.5 y.o.	Group peer-led asthma education; asthma education workshops for school staff	No-treatment control schools	PAQLQ*: improved ($P = .01$) Missed school days: improved ($P < .05$) Asthma attacks at school: improved ($P < .05$) Lung function (FEV1): no change ($P > .05$)	9 mo	School	Child; community
Spaulding et al ^{36,†}	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 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 maintained through the end of phase II	Variable: duration of electronic monitoring plus feedback ranged from 27 to 50 d; electronic monitoring alone ranged from 30 to 36 d	Asthma specialty clinic	Child; family; medical system
Terpstra et al ^{37,†}	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 wk to foster discussion about asthma	6 weekly group asthma education/self-management training sessions for the teen	Self-efficacy for asthma scale: improved ($P < .05$) Asthma Responsibility Questionnaire: improved ($P < .01$) Holden's Outcomes Expectations Scale: no change ($P > .05$)	12 wk	School	Child; family

(continued)

TABLE I. (Continued)

Reference	N, Population	Intervention	Control	Outcome/Results	Timeframe	Setting	Intervention level
Velsor-Friedrich et al ^{38,†}	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 ($P > .05$) PAQLQ: no change ($P > .05$) Knowledge about asthma: no change ($P > .05$) Asthma self-efficacy: no change ($P > .05$) Coping frequency: no change ($P > .05$) Spirometry: no change ($P > .05$) Mean peak expiratory flow rate: no change ($P > .05$) Symptom days: no change ($P > .05$) Asthma-related unscheduled doctor/ED visits and hospitalizations: no change ($P > .05$) Asthma diary symptoms: no change ($P > .05$) School absences: no change ($P > .05$)	12 mo	School (and school-based clinic)	Child
Zografos et al ^{39,§,}	86 Mean age (SD) = 13 y.o. (1.25)	Group asthma education/self-management skills training	Waitlist control	Asthma Knowledge Questionnaire: improved ($P = .000$) Child Asthma Self-Efficacy Questionnaire: improved ($P = .008$) Intention to perform asthma self-management behaviors alone and with peers: variable ($P = .000-.117$) Report of actual asthma self-management behaviors: variable ($P = .003-.945$) Report of self-consciousness of performing asthma management behaviors in front of peers: no change ($P = .726$)	10 wk	School	Child

FEF₂₅₋₇₅, Forced expiratory flow at 25% to 75% of forced vital capacity; ICS, inhaled corticosteroid; PCP, primary care provider; y.o., year olds.

*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 and/or median age, and SD included.

†Sample size too small to report P values.

‡For studies using no-control group, the P values are for the change from baseline comparison.^{24,27,32}

§For studies using a no-treatment control group,^{17-19,35} 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.

||One study using a waitlist control group³⁹ indicated P values for the change from baseline comparison.

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 11 child-level only intervention studies had positive outcomes.^{22-31,33,34} Of the 9 studies, 7 focused on low-income minority African American and/or Hispanic adolescents in the United States,^{22-29,34} 1^{30,31} included a diverse national teen sample, and 1 was a study of British³³ adolescents (participant race/ethnicity/socioeconomic characteristics not provided).

Alone or in combination with other intervention components, studies featured group^{27,29-31,38,39} (n = 5) or individual^{22-24,33} (n = 3) asthma education and self-management skills training, and another 2 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 at 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 (eg, 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 5 were limited by short follow-up periods (≤ 3 months).^{22,23,27,29,34,39}

The 2 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 and/or 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 of 50 or more 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 5 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 whereas the second, third, and fourth studies also integrated problem solving,¹⁸ motivational interviewing,³² and multisystemic therapy health care, respectively.¹² Two studies delivered the intervention to the child and caregiver simultaneously.^{12,32} The other 2 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

Child and medical system. The 2 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 (eg, asthma specialist made in-person or telephone presentations to primary care providers about guideline-based¹⁴ changes in therapy).^{19,20}

Positive outcomes included asthma self-management,²⁰ quality of life,²⁰ symptoms,²⁰ 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 2 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 whereas the Australian study (n = 133) utilized peer-led education and/or 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 bimonthly feedback on medication-taking behavior was provided to the adolescent and parent by an allergist and/or immunologist.³⁶ After 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 (eg, 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 5 levels for potential inclusion in future multilevel effectiveness studies and clinical practice. Of the 21^{12,17-39} published studies, 19^{12,17-37} yielded positive results. In total, 11 targeted the child only,^{21-31,33,34,38,39} and 5, 2, 2, and 1 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 (ie, 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 on the subjects)⁴¹ (n = 9),^{12,21-23,25,26,30,31,33,34,37,38} or had follow-up periods more than 3 months (n = 9).^{12,20,21,25,26,30,31,33-35,38}

Although the title and/or abstract review included a study describing home level interventions (eg, eliminating and/or 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 multilevel 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 (eg, removing stuffed animals from the bed) and make additional

changes (eg, carpet removal, cockroach and rodent extermination, and enforcing a no-smoking policy in the home) once they establish their own household.

Of the 16 positive US-based studies, 14 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 2 targeted rural teens.^{21,36} These population subgroups are at particularly high risk of poor asthma outcomes.^{1-5,43} Although 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 and/or 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, because of 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, underresourced 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 provide 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 and/or immunologists) and behavioral intervention scientists (behavioral psychologists) identifying, evaluating, and analyzing the studies.

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