

REVIEW

Asthma interventions in primary schools – a review

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Abstract

Objective: To explore, in depth, the literature for evidence supporting asthma interventions delivered within primary schools and to identify any “gaps” in this research area. **Methods:** A literature search using electronic search engines (i.e. Medline, PubMed, Education Resources Information Center (ERIC), International Pharmaceutical Abstracts (IPA), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Embase and Informit) and the search terms “asthma”, “asthma intervention” and “school-based asthma education program” (and derivatives of these keywords) was conducted. **Results:** Twenty-three articles met the inclusion criteria; of these eight were Randomised Controlled Trials. There was much variety in the type, content, delivery and outcome measures in these 23 studies. The most common intervention type was asthma education delivery. Most studies demonstrated improvement in clinical and humanistic markers, for example, asthma symptoms medication use (decrease in reliever medication use or decrease in the need for rescue oral steroid), inhaler use technique and spacer use competency, lung function and quality of life. Relatively few studies explored the effect of the intervention on academic outcomes. Most studies did not report on the sustainability or cost effectiveness of the intervention tested. Another drawback in the literature was the lack of details about the intervention and inconsistency in instruments selected for measuring outcomes. **Conclusion:** School-based asthma interventions regardless of their heterogeneity have positive clinical, humanistic, health economical and academic outcomes.

Keywords

Asthma, asthma education, children, elementary schools, interventions, primary schools, students

History

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Introduction

Asthma is one of the most common chronic diseases in adults and children. The prevalence of asthma particularly in children is high, making asthma one of the common chronic childhood conditions, especially in developed countries. For example, recent figures indicate that 10.4% of children aged 0–15 years in Australia have asthma [1]. In the US too, recent estimates demonstrate that 9.5% of children aged 0–17 have asthma [2,3]. The current epidemiological data however provides some relief, as it appears that asthma prevalence in developed nations is plateauing, although in absolute terms it is still very high [1,3–5]. In the developing world, whilst asthma lags behind other issues such as infectious disease, it is “fast catching up” as a key childhood problem [6–8]. Asthma is a leading cause of hospitalisations and emergency room visits in children compared to adults [9,10], as well as compared to other chronic diseases in children [11].

As in adults, the condition affects the child’s quality of life, restricts social and physical activities and disturbs sleep [12–14]. It places parents/caregivers, and in fact the whole family of the child with asthma under duress [15,16].

School consumes a good proportion of children’s life including, of course, children with asthma [17]. On the other hand, asthma affects many aspects of school life such as attendance and performance [18,19]. In Australia, latest Australian Bureau of Statistics (ABS) figures indicate that 24% of children with asthma reported missing a day of school within the last 2 weeks, compared with 16% of children without asthma [11]. Besides absenteeism, asthma affects a child’s emotions and behaviour, especially as it may put the child in fear of repeating a grade or being placed in a class for those with special conditions [20]. In addition, good asthma management may improve academic performance through improved attendance, decreased asthma symptoms and sleep disturbance; conversely, all of these factors contribute to poor attention, hyperactivity, cognitive and speech problems, as well as a poor academic outcomes [20]. Further, asthma affects school sports performance, since asthma is often triggered by exercise [21].

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School-based interventions can have a positive effect on students with chronic illness such as asthma, diabetes, severe allergies, seizures and sickle-cell anaemia [22]. In many countries, school-based asthma programs and policies have been successfully developed and implemented with an aim of helping students with asthma to better control their condition, improve their quality of life and from an academic perspective, to advance their learning. Many of these school programs and policies achieve or attempt to achieve asthma related gains through a wide variety of different interventions, i.e. by controlling the school environment and removing known asthma agents, educating school staff and implementing asthma first aid protocols/procedures for response to an emergency asthma attack [23,24].

Whilst teachers at school play a major role in implementing these policies to care for their students, especially children at pre-schools and primary school, the literature reveals that teachers' knowledge of asthma is often sub-optimal [25–30]. To address these problems, many asthma education programs for school teachers have also been developed and tested in high asthma burden countries including England, Italy and the United States [31–36]. These programs have demonstrated that education and training can improve teachers' awareness about childhood asthma and provide them with skills necessary to recognize and provide appropriate first aid for children when experiencing a worsening of symptoms during school hours. Moreover, some school asthma programs, were shown to be effective both from a clinical and economic standpoint, in reducing asthma symptoms in children [37]. Asthma education programs for pre-school and childcare centres have also indicate a potential for improved asthma outcomes [38]. In Australia, the government supported Asthma Friendly School program has been successful in providing staff training and resources for over a decade, although outcomes mapped within the project are process related only [39].

Much of this research emanates from developed countries; the foreseeable need in developing countries needs to be addressed. For example, recent needs analyses of children with asthma and their parents, conducted in India, demonstrated the lack of school-based support for the child with asthma. In this study, parents reported that if their child with asthma had symptoms at school, the school requested that the parents take the child home. Parents in this study strongly advocated that schools adopt proactive measures to facilitate opportunities for children with asthma to lead a “normal” school life, and for peers and teaching staff to be “asthma literate” [40].

The purpose of this review was to scope the literature for evidence supporting school-based interventions at primary schools. Such collated evidence can help design effective school-based strategies in countries where asthma is an emerging problem in children.

Methods

The primary aim of this review was to investigate the evidence supporting asthma interventions delivered within primary schools (or elementary schools). The nomenclature describing school levels and ages at different levels varies

globally. In some countries, primary could mean birth to age eight, in others grades such as 1–3 (ages 6–8), and in some countries, the word implies school years below high school (6–12). Thus, for the purposes of our review, we operationalise the term “primary” to include children going to school and between the ages 6–12 years. Second, the review aimed to identify any “gaps” in research in this area. A scoping review method was utilised to identify available literature and undertake a critical analysis of evidence supporting asthma related interventions in primary schools (or elementary schools). Since we expected a broad range of interventions for asthma to have been conducted in schools with a variety of disciplinary inputs, a scoping review method was thought appropriate [41,42]. We used a systematic search strategy followed by record retrieval, article selection and qualitative assessment of selected articles. The systematic search strategy involved searching seven databases for relevant articles. The search was conducted across the months of May–June 2012. Databases searched included: Medline, PubMed, Education Resources Information Center (ERIC), International Pharmaceutical Abstracts (IPA), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Embase and Informit. These databases were searched using the following terms/combinations of terms: asthma OR bronchial asthma OR asthma children OR children asthma OR childhood asthma AND asthma education OR asthma intervention OR asthma action OR asthma self-management AND school-based asthma education program OR school asthma education program OR primary school asthma education program OR elementary school asthma education program. The search terms were collectively identified by the authors as relevant descriptors, based on our familiarity with the literature. One of the authors being an experienced asthma intervention researcher and asthma educator had insight into the literature (BS). Limits that were applied included selecting studies pertaining to human subjects, those published in English language, those published between 2007 and 2012, and where the participants targeted were children in the age group between 6 and 12 years old (i.e. elementary, primary, grammar or grade school age).

This age group was selected as the age represents the average age of children in primary/elementary schools. The search was limited to the years 2007–2012, since the researchers wished to capture “recent” activity. There have been no specific or comprehensive reviews on primary school-based asthma interventions since 2006 [43,44].

The primary author (NA) independently reviewed and applied the selection criteria to all titles and abstracts obtained through the above process and after removal of duplicates between databases (duplicate removal facilitated by the EndNote bibliographic system). Detailed inclusion/exclusion criteria are outlined in Figure 1. Studies that were included for final review were those that related to *asthma interventions* of any type conducted at a primary/elementary school and targeting asthma. These intervention studies were included if they targeted students with asthma with/without their peers, parents of the students, school teachers, school personals, school nurses or combination of these groups, and were conducted by any professional/lay educator. Studies conducted outside the school, or delivered to students of

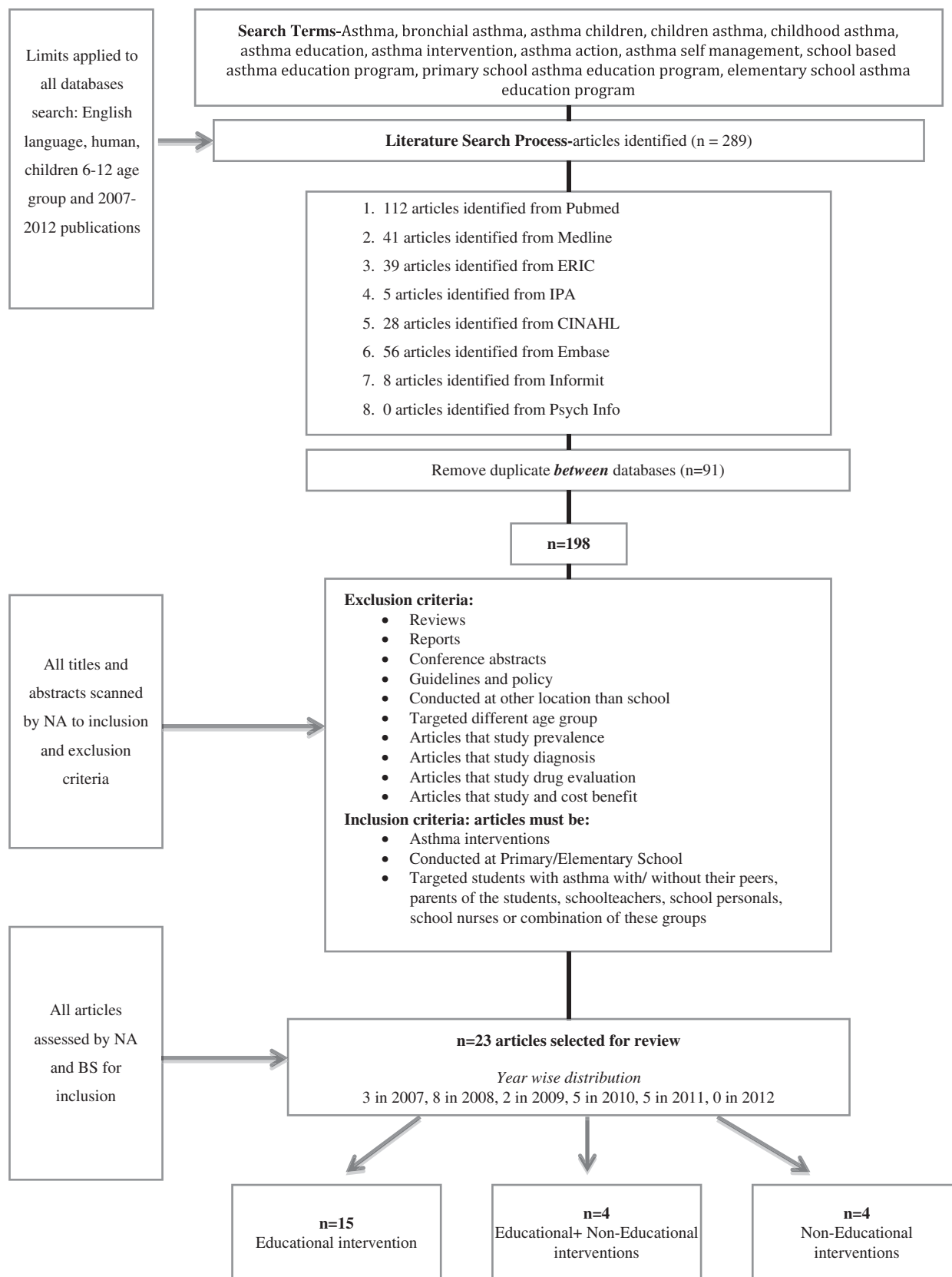


Figure 1. Results of literature search of electronic databases.

different age group were excluded. In addition, reviews, reports, conference abstracts, guidelines and policy were excluded. Articles about prevalence, diagnosis, drug evaluation, cost benefit and comparative effectiveness

studies were also excluded. The primary author (NA) screened the identified articles title and abstract for possibility of eligibility for inclusion. After an initials selection of articles to include for review was conducted, two authors

(NA and BS) independently assessed each article for inclusion (Figure 1).

Key information from selected articles was extracted and is tabulated. The data extraction process comprised the use of a coding key, against which each study was mapped. The coding key included study design, type of intervention, intervention format, curricular inclusion of intervention, time expended on intervention delivery, targeted population, type of personnel conducting the intervention and outcomes of these interventions. The extraction process was double checked by another author (PNP).

Results

Of the 198 identified studies, only 23 studies were eligible for our review after application of inclusion/exclusion criteria. Tables 1–3 represent data extracted from these studies. Of the 5 years period covered in the review exploration, 2008 appeared to be a year where a bulk of studies included in the review were published. Nearly, one-third of the studies included were RCTs; most others were quasi-experimental pre-post designs [33,35,45–50]. Most studies (16 of 23) were conducted in the United States of America [17,22,32–34,45,47–57]. Nine of the 23 studies targeted low-income communities [32,34,45,48,51,53,55–57]. Most studies were conducted in urban centres and only two studies were conducted in rural schools [17,47]. Few studies also focused on specific ethnic groups. Those included African American (USA) [55,56], Aborigines (Australia) [58] and Spanish origin Americans (Hispanics) [32,53]. In most studies (15 of 23), the school-based intervention was asthma education (Table 1) [17,33,35,36,45–48,51–55,59,60]. The format of these educational interventions varied widely, and included didactic lessons/educational sessions, workshops, structured education activities, extra-curriculum health activities, interactive digital story and story writing, educational pamphlets and booklets. In four studies, the interventions were non-educational and included direct observation of therapy (DOT), environmental tobacco smoke reduction (ETSR), case management and stress management (Table 2) [32,34,57,58]. Four studies included a mix of educational and non-education types. (Table 3) [22,49,50,56].

Only two studies reported the instrument used to identify children with asthma (the written part of the ISAAC questionnaire) [36,60]. In one study, the questionnaire was followed-up by physician diagnosis to clearly identify children with asthma [60]. As is the issue with many intervention studies reporting, some studies did not outline details of the test intervention, for example the time taken to conduct the intervention was reported only in 15 studies; and in these studies, the time taken to deliver the intervention ranged from 15 min to 3 h [17,32,34,35,45–49,51,53,54,56–58].

School children with asthma were the main target of school-based asthma intervention in a majority of studies. Other interventions targeted the *all* school children, including those without asthma. Permutations of participants in these interventions included staff alone, or staff with children with asthma. In other cases, parents with their children who had asthma, with either staff or school nurses were the target

group. In most instances (15 studies, 65%), the intervention delivery was conducted by health professionals (physicians, clinical pharmacists, health educators and nurses). In addition peers, school teachers, graduate university students, interactive media, booklets and pamphlets were also used as a means of delivering the intervention.

A host of outcome types were used as markers in these interventions studies. Upon review, the suites of outcomes were themed into clinical, humanistic, economic (health economic), academic and system related. The outcome classification we used followed the conventional ECHO (Economic (or Health Economic), clinical, humanistic outcomes) [61]. Given the research venue were schools, we also included academic outcomes in our suite. Humanistic outcomes are conceptualised differently by intervention researchers. For the purposes of this review, we operationalised this term “humanistic” to include outcomes such as: quality of life, self-regulation, self-management, self-efficacy, attitudes toward asthma, self-esteem and satisfaction [62]. In many studies, the intervention improved a variety of outcomes, which indicated that school-based asthma interventions are a valuable tool in improving asthma management. These outcomes are summarised below.

Clinical outcomes

Clinical outcomes that were included in the outcome measurement in the reviewed studies covered asthma severity [57], symptom frequency [34,35,45,49,60], activity limitation [46,49,55,60], medication use and profile [34,35,46,49,53,55,60], lung function [34,50,56,58,60], missed school/work days [34,35,49,50,53] and asthma knowledge [17,32,33,35,47,48,52,59]. In most cases, asthma symptoms or activity limitation were a key outcome measured. This outcome also appeared to be sensitive to change for example, six studies that measured the effect of the intervention on asthma symptoms and activity limitation, reported positive outcomes such as decrease in symptom or exacerbations, and decrease in activity limitation [34,35,46,49,55,60]. One study however showed no effect of the intervention on symptoms [45]. Another clinical marker included in the reviewed studies was asthma severity, where a school situated pharmacist delivered a service for children with asthma which led to a drop in severity classification as based on the NHLBI guidelines [57]. Medication use was another clinical outcome of interest. Mostly, this outcome was mapped as adherence to preventer medication, decrease in reliever medication use or decrease in the need for rescue oral steroid. Several studies found that the interventions improved medication use, i.e. there was a demonstrated decrease in the need for reliever inhaler use [34,46,49,50,60] or decrease in rescue oral steroid [53]. Fewer studies measured the impact of the intervention skills such as inhaler use technique [47,57] and spacer use competency [48]; these studies revealed improvement after intervention.

Objective markers usually confer confidence in the effect of an intervention. In our reviewed articles, four studies demonstrated an improvement in the lung function (PEFR, FEV1 and FVC) of children with asthma post-intervention [34,50,56,58]. Another clinical outcome measure

Table 1. Asthma educational interventions.

References, Country	Study design	Study population	Intervention/Control	Personnel conducting intervention	Outcomes measured	Key findings	Comments
Abdel Gawwad et al. [59], SA	Pre-test–post-test one sample experimental research	School staff (teachers, administrators, social workers) of randomly selected girl's schools compounds.	Type: educational program Format: six educational pamphlets on nature of asthma, prevention and control, medication, how to use inhalers, peak flow meter and aero-chamber, role of teacher in asthma management and role of school in asthma management + demonstration of the use of peak flow meter and correct use of inhaler. Time taken: any time	Researcher distributed pamphlets and demonstration of inhaler technique and peak flow meter by researchers	Staff's experiences with asthma and previous training, asthma related-knowledge, asthma management practices in schools, attitudes towards asthma education (all assisted by customised questionnaires).	C: intervention improved both asthma knowledge (Cohen's $d = 0.9$) and management practice (Cohen's $d = 0.33$). H: intervention improved teachers attitudes toward school role in asthma management (Cohen's $d = 0.22$).	Short follow-up period, hence outcome sustainability not clear. No control group Pamphlets have advantage of low cost, easy distribution, can be read at any time and several times (no interference with school time).
		$n = 4$ schools (297 school staff)			Outcomes reported by teachers.		
Chini et al. [36], Italy	Epidemiological study over 3 years, each year in two different schools.	Primary school teachers, personnel and parents in the urban area of Rome.	Type: educational program followed by written questionnaire (WQ) Format: structured course with information on asthma and how it affects social, physical and emotional life. Time taken: over period of 2 months.	Physicians (pediatric allergist)	Asthma Detection in children (International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire)	C: participation of school and parents in asthma screening program helped in asthma detection.	The daily time across which the intervention was conducted is not clearly reported
		$n = 6$ schools (2765 children)			Outcome reported by parents		
Chini et al. [60], Italy	Single group, with pre-/post-test	Primary school children with asthma (6–10 years old) from urban areas.	Type: educational program Format: extracurricular health activities, including cognitive techniques and age appropriate techniques to correctly perform diaphragm breathing and effective use accessory respiratory muscles. Time taken: weekly meeting	Psychologist and an opera singer.	Health related Quality of Life (HRQoL): PedsQLTM 4.0 (Paediatric Quality of Life Inventory) Asthma score: medical examination Pulmonary function (spirometry measure FEV1).	C: intervention improved total clinical asthma score (Cohen's $d = 1.4$) including nocturnal symptoms, asthma medication need and limitation of activity, but did not significantly improve lung function. H: intervention improved children HRQoL (Cohen's $d = 1.72$) and parent's perception of their child's HRQoL (Cohen's $d = 0.79$).	Extracurricular The time across which the intervention was conducted is not clearly reported.
		$n = 6$ schools (135 children)			Outcome (QoL) reported by parents and students		
Clark et al. [45], USA	RCT with 12 and 24 months follow-up	Students with asthma (10–13 years old)	<i>Intervention group</i> Type: educational programs Format: program 1: seven	Program 1: Graduate students and community leaders Program 2:	Asthma symptoms (Series of Questions), QoL [Paediatric Asthma Quality of	C: both interventions had no significant effect on asthma symptoms, and	High dropout rate due to reasons below may have led to low observed impact:
		$n = 19$ school (468)					

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Table 1. Continued

References, Country	Study design	Study population	Intervention/Control	Personnel conducting intervention	Outcomes measured	Key findings	Comments
DePue et al. [53] USA, Rhode Island	Single group with 12 months pre- and 12 months post-comparison	Children with asthma (5–11 years old) their parents and school nurses $n = 24$ schools (972 families)	Lessons, included in curriculum, with interactive problem-solving activities. Program 2:3 asthma awareness lessons with activities Time taken: both programs conducted during school hours. Program 1: 1.5 h/week, for 6 weeks Program 2: 50 min, three sessions each <i>Control group</i> Type: no education Type: educational program Format: workshop with curriculum tailored to low literacy parents in both English and Spanish languages and bi-monthly asthma support group following the workshop. Age appropriate children's workshop focusing on behavioural strategies and interactive games and activities. Nurses provided two training sessions on asthma management. Time taken: 2:30 hour at school For nurses 1 h each session.	Peers (seventh and eighth grades students)	Life Questionnaire (PAQLQ) Self-regulation and management practices (assessed by authors' scale). Students academic performance (grade reports provided by school) Outcomes reported by parents and students	overall parent asthma management practice at 12 or 24 months. H: both interventions had no significant effect on QoL at 12 or 24 months. Program 2 improved overall asthma related self-regulation significantly at 24 months. A: program 1 had a positive effect on GPA at 24 months C: intervention improved asthma outcomes as it decrease oral steroid use and school days missed due to asthma HE: intervention decreased ED visits and hospitalisations. Outcomes reported by parents.	–Economic events synchronous with the study –Study participant developmental transitions (adolescence) –Students withdrawals from schools Included in the curriculum No control group Advantage of considering ethnic groups as study was conducted in two languages, Children workshop tailored to their age, and bi-monthly asthma support group following the workshop which support sustainability of the outcomes. Personnel delivering training for nurses not reported.
Gerald et al. [54], USA	Single group with 12 months pre- and 12 months post-comparison	School children with persistent asthma (9–13 years old) and their caregivers $n = 256$ children $n = 256$ caregivers	Type: educational program (supervised asthma therapy) Format: education on asthma which involved discussion on the avoidance of asthma triggers including environmental tobacco smoke (ETS) Time taken: 20 min	Researchers	Asthma morbidity, Change in ETS exposure, experiencing an episodic poor asthma control (EPAC), ED visits and hospitalisation (Parents interview) Outcomes reported by parents.	C: intervention improved asthma management behaviours. There was a reduction in exposure to ETS Decrease in episodes of acute asthma occurred in those who had ETC exposure history. Because ETS exposure was collected via caregiver report, there may be possibility of underreporting/inaccurate reporting Caregivers did not receive any education	

Goei et al. [33], USA	Randomised pre-test/post-test group (group 1), and post-test only comparison group (group 2)	School staff (principals, administrative assistants, custodians and teachers). $n = 191$ schools (group 1:104; group 2:64)	Type: educational program Format: 4 small booklets with basic information on asthma, each tailored for the target audience.	Researcher distributed educational booklets	Asthma knowledge (knowledge quiz), behavioural intent (customised scale). Outcomes reported by school workers.	C: intervention improved participants knowledge of asthma (Cohen's $d = 0.61$) H: intervention improved participants behavioural intent (Cohen's $d = 0.36$) as it increased their perceived severity (Cohen's $d = 0.48$), perceived susceptibility (Cohen's $d = 0.28$), response efficacy (Cohen's $d = 0.45$) and self-efficacy (Cohen's $d = 0.45$). Intervention also increased the staffs' underlying motivations to attend to and respond to recommended asthma behaviours in others.	HE: in children whose ETS exposure was decreased there were fewer episodes of poor asthma control, reduced number of ED visits and hospitalisations than those who had the same or increased exposure. C: Advantage of tailoring each booklet to target audience. H: Pages of booklet designed as magazine advertisement to encourage exposure to messages. Booklet has advantage of low cost and can be read at any time as well as several times (without interfering with school time). Concern with respect to sustainability of outcomes. No control group.	on smoking cessation or ETS exposure.
Horner et al. [47], USA	RCT with 6 weeks post-intervention (12 weeks from enrolment) follow-up	Children with asthma (5–14 years old) living in rural areas. $n = 163$ children (86 students in intervention and 77 in control)	<i>Intervention group</i> Type: educational program Format: 16 educational sessions with activities curriculum included seven-step asthma self-management plan designed for rural children. Time taken: 15 min during school lunch breaks, twice or thrice a week.	18 lay health educators (LHEs)	Asthma knowledge (Asthma knowledge questionnaire), Asthma self-management (Asthma Inventory for Children, AIC), Asthma self-efficacy (Child Asthma Self-Efficacy questionnaire, MDI technique (Assessed by graduated research	C: intervention improved asthma knowledge, and MDI technique H: intervention improved asthma self-management and self-efficacy.	Short follow up period, hence outcome sustainability not clear. Included in the curriculum.	

(continued)

Table 1. Continued

References, Country	Study design	Study population	Intervention/Control	Personnel conducting intervention	Outcomes measured	Key findings	Comments
Mansour et al. [55] USA	Single group with 1-year follow-up	Teachers, school staff and SBHC nurses $n = 4$ schools	<i>Control group</i> Type: general health promotion education	Teachers and school staff: by physical education instructors Nurses: by staff at Cincinnati Children's Hospital Medical Center (CCHMC) who were experienced in the application of self-management skills in the clinical setting.	assistance, using eight-item scoring tool). Outcomes reported by students.	C: intervention improved clinical outcomes as it decreased children's activity restriction, lowered the percentage of children classified with severe asthma and students needing rescue medication. Improved prescription of controller medications and written care plan ownership. Participating children set self-management goals.	Format of teacher education not mentioned Time of day at which nurses sessions conducted not mentioned No control group
			Type: educational program Format: training on asthma self-management in one session followed by a few mini sessions. Time taken: Conducted during teacher staff meetings		Activity restriction, asthma severity controller medications prescribed, written care plan, perfect asthma care and % of students with both rescue medication with parent consent to take medication and % of children with self-management goal set (Web-based asthma registry). ED visits for asthma (CCHMC's database).	HE: intervention decreased ED visits for asthma although not statistically significant	
McGhan et al. [46], Canada	RCT with 6 and 12 months follow-up	Children with asthma (6–13 years old) $n = 34$ schools (104 students in intervention and 162 in control)	<i>Intervention group</i> Type: educational program Format: six educational sessions with activities Time taken: 45–60 min per session <i>Control group</i> Type: usual care	Four respiratory therapists and one community health nurse	QoL (PAQLQ), Activity limitation, medication use, health care utilisation, school absenteeism, self-management, behaviour/attitudes. (Custom designed questionnaire)	C: intervention improved activity at 6 and 12 months and improved medication use and management behaviour at 6 months. H: intervention improved the overall QoL score at 6 and 12 months. HE: there was a decrease in unscheduled doctor and emergency department (ED) visits (statistically significant ($p < 0.05$) at 12 months in the control group only).	The day time across which the intervention was conducted is not clearly reported.
					Outcomes reported by parents and students		

Mc Whirter [35], England	RCT with 6 months pre-intervention and 6 months post-intervention comparison	Children with asthma (7–9 years old) + School staff (school secretary, care-taker, teacher with responsibility for Personal, Social and Health Education and class teachers) $n = 24$ schools (12 schools/106 children in intervention, 11 schools/113 children in control). +149 school staff	Intervention group Type: educational program Format: Staff workshop, support for policy development, distribution of MDI and spacers for use in emergencies, interactive lesson with draw-and-write activity for children. Time taken: children lesson was 45 min Control group Type: lesson about the respiratory system and how the body defends itself against infection	Nurse	Asthma knowledge in children (draw-and-write exercise) and school staff knowledge (custom designed questionnaire), School asthma policies (questionnaire from the head teacher and interviews with staff), Asthma morbidity (attendance from the class register for the school year, GP records on prescribed medication, prevalence of wheeze obtained from parents using the asthma section of the ISAAC questionnaire) Daily well-being (novel daily diaries), QoL (Childhood Asthma Questionnaire), Perceived self-competence and Self-esteem (Harter Questionnaire). Outcomes reported by students themselves.	C: intervention improved asthma knowledge in children (Cohen's $d = 0.3$) but not in school staff. In the intervention group, there was a lower requirement for medication. Symptoms of wheeze reduced in all children with asthma. No change in school absence. H: intervention improved children's QoL and increased self-esteem in girls but not boys. S: There was a marginal improvement in the establishment of asthma policies/practices in schools within the intervention group.	Advantage of including school teachers Short follow up period, hence outcome sustainability not clear The children's lessons were consistent with the national science curriculum for pupils aged 7–9 years. The time span for staff workshop is not clearly reported.
Mosnaim et al. [48], USA	RCT With pre-/post-test	Students with asthma-Youth (8–12 years old) and teens (13–18 years old) $n = 26$ schools (275 youth and 141 teens in intervention, 69 youth and 51 teens in control)	Intervention group Type: educational program Format: four sessions curriculum on asthma education topics in age appropriate language and components addressing tobacco and social pressures unique to each age group Time taken: 45 min each session conducted in school on four consecutive school days at time with least impact on instruction as determined by the school.	Educators	Asthma knowledge (FAN Asthma Knowledge Questionnaire) Spacer competency (FAN Spacer Competency Checklist). Outcomes reported by students	C: intervention improved both asthma knowledge and spacer competency in both age groups Short follow up period, hence outcome sustainability not clear. Included in the Curriculum Children were divided according to age to groups and intervention tailored to their level.	

(continued)

Table 1. Continued

References, Country	Study design	Study population	Intervention/Control	Personnel conducting intervention	Outcomes measured	Key findings	Comments
Pike et al. [52], USA	Experimental study with comparison group and pre-test/post-test survey	Elementary school children (10–11 years old) $n = 5$ school districts (167 children in intervention, 69 in control)	Control group Type: no education Intervention group Type: educational program Format: 15-lesson curriculum incorporating the core content areas of mathematics, science, health and communication arts. Time taken: Timing of lessons was at teacher's discretion. Control group Type: no education	Teachers	Asthma knowledge (unit assessment test) in children and teacher evaluation of the program (evaluation survey) Outcomes reported by teachers	C: intervention improved asthma knowledge in children. H: teachers showed strong acceptance and indicated that intervention was age appropriate, addressed specific grade-level expectations, had actively engaged students and had increased their understanding of asthma. HE: intervention decreased hospitalisation and ED admissions H: intervention improved asthma related self-efficacy (Cohen's $d = 0.84$) and reading levels (Cohen's $d = 0.66$) No control group	School resources used to deliver intervention, school teachers and materials. Included in the curriculum Advantage of including all children with and without asthma Short follow up period, hence outcome sustainability not clear.
Robinson et al. [51], USA	Longitudinal with 6 months follow-up	Children of impoverished and medically underserved community (6–14 years old) $n = 110$ children	Type: educational program Format: educational curriculum focusing on reading accuracy, comprehension, writing and oral language skills. Asthma education provided by utilising the Open Airways Program with a camp held on a university site with different daily activities. Time taken: each Saturday from 9 to 12, 2 h for literacy training and 30 min for asthma education, for a minimum of 6 months. Asthma education provided in a 6-week module with a refresher class every 4–6 weeks. The camp was for 5 days with 4 h activities.	College students, medical students and volunteer physicians	Asthma-related self-efficacy (Drew Self-Efficacy Scale) Reading level (Gilmore Oral Reading Test), Hospitalisation and emergency room visits (patient history and medical records) Outcome (asthma self-efficacy) reported by students	HE: intervention decreased hospitalisation and ED admissions H: intervention improved asthma related self-efficacy (Cohen's $d = 0.84$) and reading levels (Cohen's $d = 0.66$) No control group	Included in the Curriculum Short follow up period, hence outcome sustainability not clear.
Wyatt et al. [17], USA	One-group pre-test/post test quasi-experimental design with 1 and 2	Children with asthma (8–11 years old) in rural public elementary schools	Type: educational program Format: Interactive digital story and story writing that delivered the curriculum.	Self-guided Internet interactive media.	Child's asthma knowledge [Asthma Information Quiz (AIQ)] Attitude about	C: intervention improved asthma knowledge (Cohen's $d = 0.75$ one week post-intervention)	Short follow up period, hence outcome sustainability not clear (this was a pilot testing).

weeks post-intervention follow-up	$n = 16$ schools (35 child)	Time taken: during school or after school hours, animated story was about 20-min.	asthma [The Child Attitude Toward Illness Scale (CATIS)].	H: intervention improved attitude toward asthma (Cohen's $d = 0.4$ one week post-intervention).	Included in the Curriculum. The program is published online; free and accessible to any school. The program is self-guided
			Outcomes reported by students		No control group

Effect sizes have not been calculated for all the studies in the table due to lack of reported statistical descriptors^a in some studies.

A: Academic outcomes, **C:** Clinical outcomes, **H:** Humanistic outcomes, **HE:** health economic outcomes, **S:** System-related outcomes.
^a Age estimated based on American School System.

used to identify intervention effect was the number of days missed from school [35,49,50,53] and work [34]; in most instances, this outcome showed an improvement, except in one case [35].

Given that a majority of the studied used “education” as an intervention, asthma knowledge was a key outcome measured, and not surprisingly in most cases it improved (Table 1) [17,32,33,35,47,48,52,59]. Knowledge gains were observed in many instances regardless of the target population. For example, knowledge improvement was observed in studies where the school child with asthma was provided an intervention [17,47,48,52]. Studies where school-staff were the sole target of the intervention demonstrated the same effect [33,59].

Mixed results were obtained for asthma knowledge when the intervention program targeted several rather than one single group. For example, in studies where the intervention was provided to a mixed group including school staff, school students and parents, asthma knowledge improved only in the parent group [32]. Interestingly, in another study, where school staff and students with asthma were provided an intervention, asthma knowledge improved in students but not in school staff [35]. An Italian study that administered the ISAAC questionnaire as a means of identifying asthma cases in school students, demonstrated that school-based screening may be an exercise that can be used as a base for other interventions such as asthma education [36].

Although behaviour may be considered as a humanistic outcome, we themed it as a clinical marker, as in most studies behaviours measured were related to clinical asthma management. For example, changes in the environment including external tobacco smoke exposure and pet contact, avoidance of triggers, controlling household triggers, use of peak flow meter and use of action plans were some of the behaviours mapped in the studies. Interventions in some cases were successful in improving asthma management practices by school staff and school nurses, or asthma management behaviour of school students with asthma [32,46,54,55,59]. In other cases, interventions were not as successful in changing asthma management behaviours of parents [45]. One study that described a stress management intervention, reported a reduction in stress and depression scores and an improvement in anxious and angry moods in children with asthma [56].

Humanistic outcomes

The quality of life (QoL) of the child with asthma was one of the main humanistic measures covered in most of the reviewed studies. Whilst in three studies, the QoL questionnaires were completed by both parents and children [45,46,60], in another three studies, QoL was completed by either parents [50] or children [35] or school nurses [22]. Six studies examined the impact of interventions on the quality of life of the student/child. Two of them showed no effect [45,50], whereas four studies showed an improvement in QoL [22,35,46,60]. Other humanistic outcomes measured in the reviewed articles included asthma related self-regulation (measured through a series of items developed by the authors) [45], and self-management (assessed with a Asthma Inventory

Table 2. Educational + non-educational interventions.

References, Country	Design	Targeted population	Intervention	Person conduct intervention	Outcomes measured	Key findings	Comments
Brooten et al. [32], USA	Quasi experimental study with pre-/post-survey	Catholic elementary school children (7–14 years old ^a) and their parents, teachers, school staff (asthma amigos) $n = 1$ school (276 children, 15 parents, teachers, school staff)	Type: educational program + activities Format: 2 educational sessions, conducted in English and Spanish for asthma amigos first session included general information of asthma, homework of interviewing family with asthmatic child. Second session about ways to educate and help others, sharing learn with community with aid of educational brochures and coupons for household products to reducing asthma triggers. Children were provided with session on asthma, triggers, prevention followed by drawing pictures and asthma fair at school. Time taken: 90 min for each amigos session and 15–20 min for children session.	Registered nurses	Asthma knowledge, household triggers risk perception, Asthma management behaviour, Misconception (Custom designed questionnaire) Outcomes reported by parents, teachers, school staff	C: intervention improved knowledge of asthma household triggers, risk perception and improved asthma management behaviour H: intervention decreased misconceptions or stigma about asthma	Outcomes of intervention on children not measured Use of school resources to deliver intervention, i.e. school nurses. Advantage of involving parents, teachers, school staff and non-children with asthma. Time of day at which education provided for children not mentioned No control group Advantage of considering ethnic groups as intervention was conducted in two languages. Children were divided according to age to groups and intervention tailored to their level. Short follow-up period, hence outcome sustainability not clear.
Eley et al. [58], Australia	One-group pre-test/post-test with 3 and 6 months follow-up.	Aboriginal children (5–8 years old) and adolescents (13–18 years old) students with asthma and their parents/guardians. $n = 9$ children, 18 adolescent, 5 adults.	Type: activities to support asthma management + asthma education Format: playing a traditional didgeridoo sounds and melodies with the art of circular breathing, singing and breathing exercises with information about asthma and its management provided by Aboriginal Medical Service Centre staff and culturally appropriate brochures, pamphlets and posters.	Aboriginal didgeridoo player and a professional vocal coach/singer aided by an Aboriginal singer.	Respiratory function (RF) (spirometry, Peak flow meter). Outcomes reported by participants.	C: intervention improved respiratory function.	No control group Short follow-up period, hence outcome sustainability not clear. Advantage of involving families in the intervention. Time of day at which education provided for children not mentioned.

Patel et al. [34], USA	Retrospective cohort 1999–2004	Children (Infancy to 18 years old), teachers and school staff $n = 40$ schools (677 children)	Time taken: 1-h lesson weekly for 26 weeks. Adult lessons at the AMS clinic and students lessons at schools. Type: medical care + educa- tional program Format: care delivered by two mobile health clinics (asthma vans) to children. Teachers and school staff provided asthma education session. Time taken: asthma vans provided care 5 days/week throughout school year and summer months, 1 h for teachers education session.	Children: paediatrician. Teachers and other school staff: the American Lung Association.	Asthma control (day–night asthma symptoms, rescue inhaler use, lung function, work days missed, ED visit and hospitalisation). Outcomes reported by paediatrician.	C: intervention decreased day–night asthma symptoms, rescue inhaler use, improved PFT and decreased parents work days missed (Cohen's $d = 0.16$). HE: intervention decreased ED visits and hospitalisation.	No control group Time at which teachers session conducted not mentioned High potential for sustain- ability as intervention did not consume school time or resources.	Advantage of considering the ethnic group in modelling.
Petrie et al. [57], USA	Single group with follow-up depending on asthma severity	Children with asthma (11–15 years old) (within underserved areas of Albuquerque). $n = 1$ school (19 children)	Type: educational + asthma management intervention. Format: single patient educa- tion and self-management intervention at school clinic (education on proper inhal- ation techniques, instruc- tions for avoiding patient- specific asthma triggers, proper usage of a peak flow meter, development of an asthma action plan and education on the roles of medications) and asthma management interventions (changing medications, consulting physicians or nurse practitioners, contact- ing parents, pharmacies and primary care providers). Time taken: initially 30 min average for education and management intervention reaching 15 min at final follow-up visit.	Clinical pharmacist	Asthma severity (NHLBI medical history ques- tionnaire). Inhaler technique. Outcomes reported by clin- ical pharmacist.	C: Pharmacist interven- tions improved inha- ler technique and reduced asthma severity	Conducted at schools that had health centres/ clinics, which may not be available in all schools. Sustainability may be an issue as the program. Was not part of school cur- riculum program. Lack of control group. Very small sample size.	

Effect sizes have not been calculated for all the studies in the table due to lack of reported statistical descriptors' in some studies.

A: Academic outcomes, **C:** Clinical outcomes, **H:** Humanistic outcomes, **HE:** health economic outcomes, **S:** System-related outcomes.
^aAge estimated based on American School System.

Table 3. Non-asthma educational interventions.

References, Country	Design	Targeted population	Intervention	Person conduct intervention	Outcomes measured	Key findings	Comments
Halterman et al. [49], USA	RCT with monthly follow-up over 1 year	Children with persistent asthma (3–10 years old) in urban school district. $n = 67$ schools (non-smoke exposed/120 usual care, 125 school-based care, smoke exposed/145 usual care, 140 school-based care + ETS program).	<i>Intervention group</i> Type: Direct observed therapy (DOT) + environmental tobacco smoke reduction program (ETS) Format: observed administration of daily preventive asthma medications with dose adjustment, and motivational counselling for caregiver and smoker at home with respect to smoke reduction and cessation. Time taken: for ETS program 20–30 min counselling 2–3 weeks after baseline with 10–15 min follow-up telephone counselling 1 and 3 months after home visit. The time of dose delivery varied by child and coincided with the routine time most convenient for the student and nurse. <i>Control group</i> Type: usual care	School nurses	Asthma exacerbations during the year, days absent from school due to asthma and rescue medication use, days and nights symptoms, activity limitation. (Telephone interview) smoke exposure (cotinine level) ED visits, acute office visits and hospitalisations (Telephone interview) Outcomes reported by parents.	C: intervention reduced asthma exacerbations during the year (Cohen's $d = 1.18$), days absent from school due to asthma (Cohen's $d = 0.29$) and rescue medication use (Cohen's $d = 0.41$). It improves symptom free days (Cohen's $d = 0.32$), nights without symptoms (Cohen's $d = 0.26$) and days without activity limitation (Cohen's $d = 0.23$). Treatment effect was independent of smoke exposure as cotinine level changes not associated with intervention outcomes. HE: intervention decreased ED visits (Cohen's $d = 0.99$), acute office visits (Cohen's $d = 0.94$) and hospitalisations (Cohen's $d = 2.83$).	Used school resources to deliver intervention, school nurses.
Gerald et al. [50], USA	RCT with 15 months follow-up	School children with persistent asthma (8–14 years old) who, needed daily controller medication and who had the ability to use dry powder inhalers/peak flow meters. $n = 36$ schools (145 children in intervention, 145 in control).	<i>Intervention group</i> Type: Directly observed therapy (DOT) Format: School-based supervised use of daily inhaled corticosteroids. Time taken: standard daily time <i>Control group</i> Type: usual care	Seven trained study personnel	Asthma control (PFM readings, rescue medication use, and school absences, ED visits or hospitalisations attributable to asthma). QoL (Juniper Paediatric Asthma Caregiver Quality of Life Questionnaire). Health care utilisation, second-hand smoke exposure and quality of life through telephone interviews with parents. Outcomes reported by parents (QoL, ED visits or hospitalisations)	C: intervention improved asthma control. H: intervention did not show change in the QoL. Randomisation occurred at student level within each school to omit differences across school systems. Inhaler use and PFM measurement taken at standard daily time to prevent diurnal variation and reported in the system (Asthma Agents system).	

Keehner et al. [22], USA	One-group pre-test/post-test with 1 year follow-up	Children with asthma, diabetes, severe allergies, anaemia (5–19 years old) who were struggling academically or having difficulty managing their illness at school. $n = 5$ school districts (114 children).	Type: case management Format: teaching and counselling, direct care, working with teachers and school personnel, working with families and making referrals, developing individualised health care plans, goals reflected health and academic outcomes, family involvement, and school/environmental support. Time taken: to be estimated by nurses.	School nurses	School staff (PFM readings, school absences). Study personal (rescue medication use). Academic outcomes (attendance and grades). QoL for children with asthma QoL (PedsQL 3.0 SF22 Asthma Module Instrument). QoL for children with diabetes (PedsQL 3.0 Type 1 Diabetes Module). Children with seizures, sickle-cell anaemia, and severe allergies (PedsQL 4.0 SF15). Outcomes reported by school nurses	Rescue medication use was monitored by a Doser device. No control group No interference with school time.
Long et al. [56], USA	Single group with 2 weeks pre- and 2 weeks post-comparison	Children with asthma (7–12 years). $n =$ trial 1 (14 children from community), trial 2 (8 children from charter school of low-income population).	Type: stress management intervention. Format: Six educational sessions with didactic training followed by relaxation exercise. Sessions were based on cognitive behavioural therapy and involved developing an asthma coping plan. Time taken: trial 1: 50 min for each session and 20 min for relaxation exercise at psychology department of a large urban university, trial 2: at school and during the school day.	Trial 1: Two senior graduate students Trial 2: senior graduate student, a master's level clinician, and an advanced research assistant. All had basic training in CBT and received at least 25 h of didactic and experiential training to conduct the intervention. Weekly supervision provided by a paediatric psychologist and social worker with Biofeedback Certification from Institute of America certification.	Lung function (FEV1) Perceived stress, depressed mood, anxiety, mood change, satisfaction (Psychosocial questionnaires: Perceived Stress Scale (PSS), Child Depression Index (CDI), The State-Trait Anxiety Inventory for Children (STAIC), Profile of Mood States (POMS), Child Behaviour Checklist (CBCL), Demographic Information Form, Satisfaction Survey). Outcomes reported by parents and children.	No control group Short follow-up period, hence outcome sustainability not clear. Advantage of including ethnic groups of African American. Consuming school time Costly, as it uses tokens in sessions and home practicing of coping that converted to financial rewards at end of program to reinforce participation. Advantage of using a multidisciplinary group for creating the manual and work book for the intervention.

Effect sizes have not been calculated for all the studies in the table due to lack of reported statistical descriptors in some studies.

A: Academic outcomes, C: Clinical outcomes, H: Humanistic outcomes, HE: health economic outcomes, S: System-related outcomes.

for Children [AIC]) [47], both of which showed improvements in these studies. Self-efficacy, as measured by scales such as Child Asthma Self-Efficacy questionnaire, Drew Self-Efficacy Scale and a customised questionnaire [33,47,51] was another humanistic marker, and in studies where this was measured the intervention appeared to enhance it. Two studies (one targeted children/students whilst the other targeted school staff) also reported that the intervention enhanced attitudes toward asthma, as measured by The Child Attitude Toward Illness Scale (CATIS) and a customised questionnaire [17,59]. Self-esteem was an outcome measured in one study, where a literacy enhancement intervention demonstrated improved student self-esteem in the target population [35]. Satisfaction is usually a component of quality control/evaluation of new programs. This appeared to be included as an outcome in few studies only, for example a stress management intervention for school children with asthma was found to be an acceptable intervention by affected families (parents and guardians of children with asthma) [56].

Health-economic outcomes

Seven studies assessed whether the intervention had an effect on the number of emergency department (ED) visits [34,46,49,51,53–55], hospitalisation and acute office or unscheduled visits to doctor office for the school child with asthma. Most of these studies demonstrated positive outcomes [34,46,49,51,53,55].

Academic outcomes

Two studies measured the effect of intervention (one educational, the other was case management) on students/children academic performance. Both showed improvement in students' grades/GPA and attendance [22,45].

System-related outcomes

Only one educational study measured the effect of intervention on establishment of asthma policies and practices in schools. This study showed improvement in the establishment of asthma policies/practices in participated schools within the intervention group [35].

Discussion

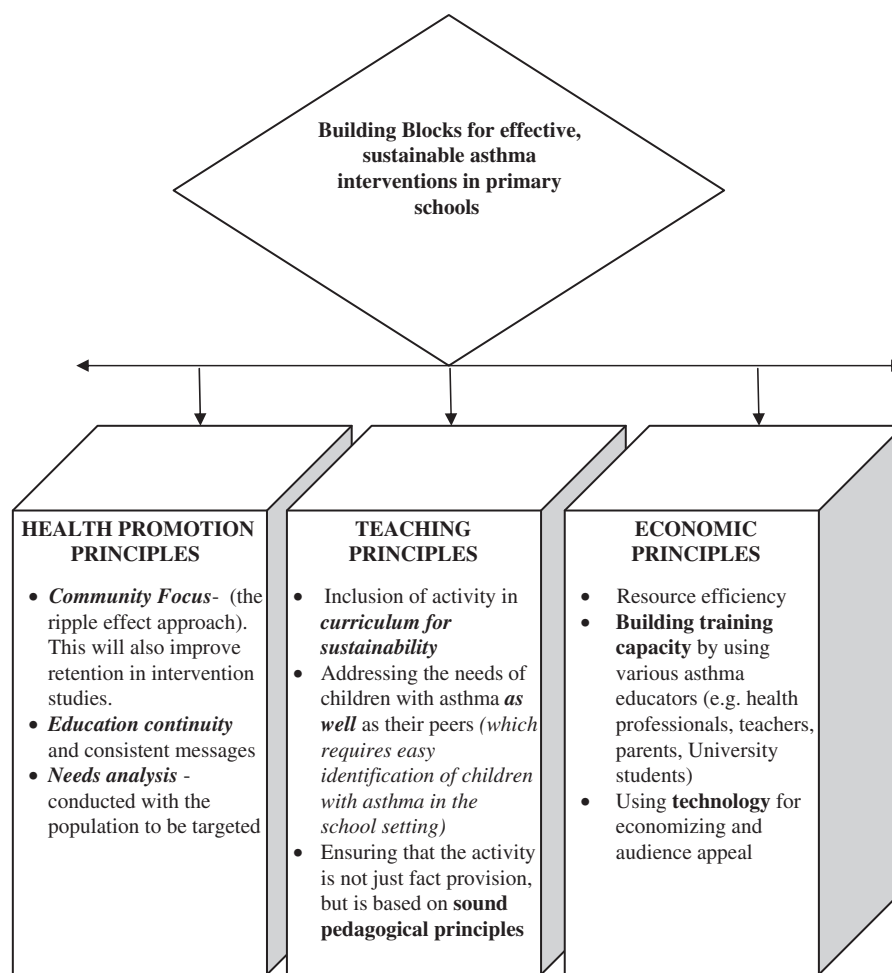
This is the first comprehensive review exploring asthma interventions delivered within the setting of primary schools (or elementary schools). The review identified recently published available literature of asthma interventions conducted within schools. The effects of these interventions on health and other outcomes in participants were mapped. Most of the intervention studies were asthma education interventions, delivered in various formats and in most cases improved knowledge, quality of life and clinical outcomes. Interventions were delivered by a variety of people including health professionals, peers and lay educators. Very few studies mapped academic outcomes. The review provides a summary of intervention types and their outcomes for asthma programs in schools for future translation and also explores gaps in this area that can be addressed by future research.

It would be pertinent to discuss some of the drawbacks in research reported in this area. A common problem in the field

of intervention research is that the published papers often lack clarity and detail about the intervention that was used. For example, in the studies reporting educational interventions, the format of the education (session plan, content, preparation and delivery time, resources required, etc.) was not fully outlined in the publication. This makes study replication and implementation difficult. Furthermore, there appears to be no standard format of the education. With so much research conducted one would expect some guidelines about the ideal format of asthma education to children of primary school age. The studies reviewed had used lessons, educational sessions, workshops, structural courses, extra-curriculum health activities, interactive digital story and story writing, educational pamphlets and booklets as asthma education formats. It is interesting to note that in this generation of younger children, there were no technology-focused programs trialed. Further, the target population in each intervention varied, as did the type of deliverers and their qualification to deliver the intervention. One issue worth pointing out here is that despite the variety, there were fewer programs targeting teachers/staff alone. Given that asthma issues will be handled by teachers in schools, once the intervention deliverers have terminated their program, it may be important to consider asthma education for teachers using programs and methods that utilize adult education methods. Given the target population included children with asthma and their peers, it is also surprising that few studies reported using validated measures to actually identify children with asthma. There are previous studies where simple instruments, such as questionnaires have been used and validated in paediatric clinics and schools, and such instruments could be easily utilised by future researchers [63]. In addition, not all interventions measured the same outcomes, and even when the same outcomes were measured, the instruments for measurement and time interval over which the outcomes were assessed was different. These issues make systematic calculation of "effect size" problematic. For the education interventions, the pedagogical principles used to design the intervention were rarely discussed. To convince Education Departments all over the world to incorporate asthma education into their health curricula, one would need robust data that showcases numerically the benefits to be had from asthma education in schools. This heterogeneity of intervention design and outcome measures should be addressed in future research in the setting so that systematic reviews and meta-analyses can support research translation.

On a more positive note, it appears that asthma intervention for primary school children is a thriving research topic, as our research articles showcased research from developing and developed nations, with a predominance of the latter. This perhaps has followed the pattern of childhood asthma prevalence, which peaked in developed countries in the last decade and has now plateaued, whereas the prevalence in the developing world is still emerging [9]. More studies on the effectiveness of asthma education in developing countries would be needed, given the shifting prevalence patterns. Further, despite the fact that even amongst developed countries asthma prevalence is usually skewed, and ethnic subgroups with low income feature heavily in asthma epidemiology [64], however only a few of the studies we reviewed focused on these populations. The same applied to

Figure 2. Components of successful school asthma interventions.



rural regional settings, where the lack of health resources and environmental risk factors complicate the management of asthma [65–67]. Future research should explore developing and implementing programs targeting ethnic subgroups, impoverished/low-income communities and at rural areas.

Interestingly our review results indicate that, different types of interventions possibly affect different aspects of asthma. A majority of studies that measured asthma symptoms showed that regardless of the intervention type (education or not) and despite the format of the educational intervention, the school-based asthma interventions could improve asthma symptoms. Although instrument measures varied, the same was seen for activity limitation, medication use, lung function, QoL, hospital admissions and level of absenteeism of asthmatic students/children. Furthermore, our results revealed that most interventions have a positive effect on asthma knowledge. This finding is consistent with a previous systematic review, which indicated that multiple types of school-based education interventions for asthma improved asthma knowledge [44]. Again, the issue is that different non-validated instruments were used for measure the asthma knowledge, which needs to be investigated in future research. Possibly there is no good validated asthma knowledge instrument designed for use in research with children of primary school age. Whilst we can conclusively argue, based on our review, that school-based asthma interventions improve symptoms of asthma and asthma knowledge, the same cannot be concluded for some skill based, behavioural

or general psychological outcomes such as inhaler use technique, child psychological status, asthma management behaviours or academic performance because only one or two studies each measured these outcomes. Future studies should focus on targeting and measuring outcomes.

The most important issue facing all types of interventions is the issue of sustainability of their outcomes. Many factors can affect outcome sustainability including: time during which the intervention was delivered (during school hours or after school hours), if intervention was included in the curriculum or not, and the resources used to deliver the intervention such as: school staff time, materials and health services. One would expect that educational interventions provided by school staff to students might be more sustainable as they rely on regular school processes. Those interventions, which require non-school personnel, would be more resource intensive to the health system. However, in most schools, school staffs have limited time and possibly no training on asthma education [68]. Some forms of interventions could be proposed to have a higher chance of sustainability from a resource use viewpoint, for example, educational pamphlets and booklets which have the advantage of low cost, can be read repeatedly and at the user's convenience. However, there were only a few interventions that used this intervention format. None of the intervention studies reported on "sustainability" of the program [69].

By looking at the effective interventions thoroughly, we can posit intervention themes that were associated with

improved outcomes. We believe that these may be useful for future researchers exploring the issue of asthma education for primary school. These are depicted in the figure below (Figure 2). Involving a wider audience, e.g. school children, parents, their teachers, can possibly have a better reach for asthma education. The “ripple effect” in the field of health promotion has long been considered an effective approach [70]. Using this community wide approach also ensures that consistent messages are provided to all stakeholders in asthma education. In their review of effective asthma programs, Clark et al. also suggest the community wide approach as a way forward [71]. Second, we suggest that asthma education programs seriously consider the issue of sustainability. For programs to be adopted on a wider scale, first program details should be described and documented in depth. There should be standard outcome measures that can be used to capture program efficacy. Various school asthma programs should be compared for effectiveness, and the best ones placed on a globally accessible site. An example of this is the Centers of Disease Control and Prevention’s Bibliography of effective asthma interventions [72]. Sustainability could also be ensured through inclusion in school curricula. Third, resource use should be considered. Resources that are present in schools should be utilised rather than externally sought. Resource use and sustainability are of course linked, and these considerations would need to be customised for each school and intervention context as “one size” does not fit all. For example, if the outcome measures are asthma control and reduced asthma morbidity, the intervention will fail if the cohort does not have access to proper medications. Resources may also depend on the external economic, social and political environment of the school. This reinforces the issue of conducting a contextual needs analysis and resource audit prior to planning a program. Finally, in this era of the virtual, not many programs utilised the Internet. If effective asthma programs can be placed in a form that can be used by any school anywhere in the world, then asthma education could be globally standardised.

Conclusion

This review demonstrated that primary school-based asthma interventions improved asthma symptoms including activity limitation, lung function, QoL, asthma knowledge, missed school days, ED visit and hospitalisation in children with asthma. This review also identified a number of research gaps that need to be focused on in future research. These issues include attention to homogeneity in intervention design and outcome measures, addressing niche populations in need and targeting outcomes, which are under-researched, e.g. academic and psychological outcomes. Further, new interventions developed should focus on resource issues and sustainability. We propose a model that collates the characteristics of successful interventions and will assist in developing and evaluating new interventions.

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References

1. Australian Centre for Asthma Monitoring 2011. Asthma in Australia 2011: with a focus chapter on chronic obstructive pulmonary disease. Asthma series no. 4. Cat. no. ACM 22. Canberra: AIHW. Available at: <http://www.aihw.gov.au/publication-detail/?id=10737420159> [last accessed 28 Apr 2013].
2. Current asthma prevalence percentage by age United States, National Health Interview Survey, 2011, National Center for Health Statistics, CDC. Available from: <http://www.cdc.gov/asthma/nhis/2011/table4-1.htm> [last accessed 10 Jan 2013].
3. Akinbami LJ, Moorman JE, Bailey C, Zahran HS, King M, Johnson CA, Liu X. Trends in asthma prevalence, health care use, and mortality in the United States, 2001–2010. NCHS Data Brief, no 94. Hyattsville, MD: National Center for Health Statistics; 2012.
4. Global Strategy for Asthma Management and Prevention, Global Initiative for Asthma (GINA). 2012. Available from: <http://www.ginasthma.org/> [last accessed 22 Apr 2013].
5. The Global Asthma Report 2011. Paris, France: The International Union Against Tuberculosis and Lung Disease, 2011.
6. Ait-Khaled N, Enarson D, Bousquet J. Chronic respiratory diseases in developing countries: the burden and strategies for prevention and management. Bull World Health Organ 2001;79:971–979.
7. Zar HJ, Levin ME. Challenges in treating pediatric asthma in developing countries. Paediatr Drugs 2012;14:353–359.
8. Al-Hajjaj MS. Bronchial asthma in developing countries: a major social and economic burden. Ann Thorac Med 2008;3:39–40.
9. Global Burden of Asthma, Global Initiative for Asthma (GINA). Available from: <http://www.ginasthma.org/> [last accessed 12 Dec 2013].
10. Akinbami L. Asthma prevalence, health care use and mortality: 2005–09. National Health Statistics Reports. Number 32. Available from: www.cdc.gov/nchs/data/nhsr/nhsr032.pdf [last accessed 12 Jan 2011].
11. Australian Institute of Health and Welfare 2005. Selected Chronic Diseases Among Australia’s Children. Bulletin no. 29. AIHW cat. no. AUS 62. Canberra: AIHW.
12. Chen H, Gould MK, Blanc PD, Miller DP, Kamath TV, Lee JH, Sullivan SD, for the TENOR Study Group. Asthma control, severity, and quality of life: quantifying the effect of uncontrolled disease. J Allergy Clin Immunol 2007;120:396–402.
13. Milton B, Whitehead M, Holland P, Hamilton V. The social and economic consequences of childhood asthma across the life-course: a systematic review. Child Care Health Dev 2004;30:711–728.
14. Fagnano M, Bayer AL, Isensee CA, Hernandez T, Halterman JS. Nocturnal asthma symptoms and poor sleep quality among urban school children with asthma. Acad Pediatr 2011;11:493–499.
15. Halterman JS, Yoos HL, Conn KM, Callahan PM, Montes G, Neely TL, Szilagyi PG. The impact of childhood asthma on parental quality of life. J Asthma 2004;41:645–653.
16. Morawska A, Stelzer J, Burgess S. Parenting asthmatic children: identification of parenting challenges. J Asthma 2008;45:465–472.
17. Wyatt TH, Hauenstein EJ. Pilot testing okay with asthma: an online asthma intervention for school-age children. J School Nurses 2008; 24:145–150.
18. U.S. Environmental Protection Agency, Indoor Environments Division. Asthma facts. 2013. 2p. Report No: EPA-402-F-04-019.
19. Basch CE. Asthma and the achievement gap among urban minority youth. J School Health 2011;81:606–613.
20. Grant R, Brito A. Chronic illness and school performance: a literature review focusing on asthma and mental health conditions. A Children’s Health Fund Monograph 2010; June.
21. Sandsund M, Thomassen M, Reinertsen RE, Steinshamn S. Exercise-induced asthma in adolescents: challenges for physical education teachers. Chronic Respir Dis 2011;8:171–179.
22. Keehner Engelke M, Guttu M, Warren MB, Swanson M. School nurse case management for children with chronic illness: health,

- academic, and quality of life outcomes. *J School Nurs* 2008;24:205–214.
23. Houston P. Asthma Wellness Keeping Children with Asthma in School and Learning. American Association of School Administrators. School Governance & Leadership. Spring 2003. Available at: www.cdc.gov/asthma/schools.html [last accessed 16 Dec 2012].
 24. School Asthma Action Plan. The Asthma Foundation of Victoria. Available at: www.asthma.org.au/Resources/SchoolsandChildrensServices.aspx [last accessed 10 May 2013].
 25. Ones U, Akcay A, Tamay Z, Guler N, Dogru M. Asthma knowledge level of primary schoolteachers in Istanbul, Turkey. *Asian Pacif J Allergy Immunol* 2006;24:9–15.
 26. Lucas T, Anderson MA, Hill PD. What level of knowledge do elementary school teachers possess concerning the care of children with asthma? A pilot study. *J Pediatr Nurs* 2012;27:523–527.
 27. Bahari MB, Nur NM, Rahman AF. A knowledge of asthma in school children: a survey among primary school teachers. *Singapore Med J* 2003;44:131–135.
 28. Getch YQ, Neuhauser-Pritchett S. Teacher characteristics and knowledge of asthma. *Public Health Nurses* 2009;26:124–133.
 29. Bruzzese JM, Unikel LH, Evans D, Bornstein L, Surrence K, Mellins RB. Asthma knowledge and asthma management behavior in urban elementary school teachers. *J Asthma* 2010;47:185–191.
 30. Rodríguez Fernández-Oliva CR, Torres Alvarez de Arcaya ML, Aguirre-Jaime A. Knowledge and attitudes of teachers on children with asthma. *Ann Pediatr (Barcelona)* 2010;72:413–419.
 31. National Asthma Education and Prevention Program. Available from: <http://www.nhlbi.nih.gov/about/naepp/> [last accessed 10 May 2013].
 32. Brooten D, Youngblut JM, Royal S, Cohn S, Lobar SL, Hernandez L. Outcomes of an asthma program: Healthy Children, Healthy Homes. *Pediatr Nurs* 2008;34:448–455.
 33. Goei R, Boyson AR, Lyon-Callo SK, Schott C, Wasilevich E, Cannarile S. An examination of EPPM predictions when threat is perceived externally: an asthma intervention with school workers. *Health Commun* 2010;25:333–344.
 34. Patel B, Sheridan P, Detjen P, Donnersberger D, Gluck E, Malamut K, Whyte S, et al. Success of a comprehensive school-based asthma intervention on clinical markers and resource utilization for inner-city children with asthma in Chicago: the Mobile C.A.R.E. Foundation's asthma management program. *J Asthma* 2007;44:113–118.
 35. McWhirter J, McCann D, Coleman H, Calvert M, Warner J. Can schools promote the health of children with asthma? *Health Educ Res* 2008;23:917–930.
 36. Chini L, Borruto M, Chianca M, Corrente S, Graziani S, Iannini R, La Rocca M, et al. Happy Air: a school-based educational program to maximize detection of asthma in children. *J Asthma* 2008;45:197–200.
 37. Noyes K, Bajorska A, Fisher S, Sauer J, Fagnano M, Halterman JS. Cost-effectiveness of the School-Based Asthma Therapy (SBAT) program. *Pediatrics* 2013;131:e709–e717.
 38. Soo YY, Saini B, Moles RJ. Can asthma education improve the treatment of acute asthma exacerbation in young children? *J Paediatr Child Health* 2013;49:353–360.
 39. Asthma friendly programs. Asthma Australia. Available from: http://www.asthmaaustralia.org.au/Asthma_Friendly.aspx [last accessed 20 Jan 2014].
 40. Grover C, Goel N, Chugh K, Gaur S, Armour C, Van Asperen PP, Moles RJ, Saini B. Medication use in Indian children with asthma – the user's perspective. *Respirology* 2013;18:807–813.
 41. Mays N, Roberts E, Popay J. Synthesising research evidence. In: Fulop N, Allen P, Clarke A, Black N, eds. *Studying the organisation and delivery of health services*. New York: Routledge; 2001:188–214.
 42. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* 2005;8:19–32.
 43. Coffman JM, Cabana MD, Yelin EH. Do school-based asthma education programs improve self-management and health outcomes? *Pediatrics* 2009;124:729–742.
 44. Ahmad E, Grimes DE. The effects of self-management education for school-age children on asthma morbidity: a systematic review. *J School Nurs* 2011;27:82–92.
 45. Clark NM, Shah S, Dodge JA, Thomas LJ, Andridge RR, Little RJ. An evaluation of asthma interventions for preteen students. *J School Health* 2010;80:80–87.
 46. McGhan SL, Wong E, Sharpe HM, Hessel PA, Mandhane P, Boechler VL, Majaesic C, Befus AD. A children's asthma education program: Roaring Adventures of Puff(RAP), improves quality of life. *Can Respir J* 2010;17:67–73.
 47. Horner SD, Fouladi RT. Improvement of rural children's asthma self management by lay health educators. *J School Health* 2008;78:506–513.
 48. Mosnaim GS, Li H, Damitz M, Sharp LK, Li Z, Talati A, Mirza F, et al. Evaluation of the Fight Asthma Now (FAN) program to improve asthma knowledge in urban youth and teenagers. *Ann Allergy Asthma Immunol* 2011;107:310–316.
 49. Halterman JS, Szilagyi PG, Fisher SG, Fagnano M, Tremblay P, Conn KM, Wang H, Borrelli B. Randomized controlled trial to improve care for urban children with asthma results of the school-based asthma therapy trial. *Arch Pediatric Adolescent Med* 2011;165:262–268.
 50. Gerald LB, McClure LA, Mangan JM, Harrington KF, Gibson L, Erwin S, Atchison J, Grad R. Increasing adherence to inhaled steroid therapy among schoolchildren: randomized, controlled trial of school-based supervised asthma therapy. *Pediatrics* 2009;123:466–474.
 51. Robinson Jr LD, Calmes DP, Bazargan M. The impact of literacy enhancement on asthma related outcomes among underserved children. *J Natl Med Assoc* 2008;100:892–896.
 52. Pike EV, Richmond CM, Hobson A, Kleiss J, Wottowa J, Sterling DA. Development and evaluation of an integrated asthma awareness curriculum for the elementary school classroom. *J Urban Health* 2011;88:61–67.
 53. DePue JD, McQuaid EL, Koinis-Mitchell D, Camillo C, Alario A, Klein RB. Providence school asthma partnership: school-based asthma program for inner-city families. *J Asthma* 2007;44:449–453.
 54. Gerald LB, Gerald JK, Gibson L, Patel K, Zhang S, McClure LA. Changes in environmental tobacco smoke exposure and asthma morbidity among urban school children. *Chest* 2009;135:911–916.
 55. Mansour ME, Rose B, Toole K, Luzader CP, Atherton HD. Pursuing perfection: an asthma quality improvement initiative in school-based health centers with community partners. *Public Health Rep* 2008;123:717–730.
 56. Long KA, Ewing LJ, Cohen S, Skoner D, Gentile D, Koehrsen J, Howe C, et al. Preliminary evidence for the feasibility of a stress management intervention for 7- to 12-year-olds with asthma. *J Asthma* 2011;48:162–170.
 57. Petrie JL, Segal AR. Clinical pharmacy services provided to asthma patients in a school-based clinic. *Am J Health Syst Pharm* 2010;67:185, 188–189.
 58. Eley R and Gorman D. Didgeridoo playing and singing to support asthma management in aboriginal Australians. *J Rural Health* 2010;26:100–104.
 59. Abdel Gawwad ES, El-Herishi S. Asthma education for school staff in Riyadh City: effectiveness of pamphlets as an educational tool. *J Egypt Public Health Assoc* 2007;1–2:147–171.
 60. Chini L, Iannini R, Chianca M, Corrente S, Graziani S, La Rocca M, Borruto M, et al. Happy air®, a successful school-based asthma educational and interventional program for primary school children. *J Asthma* 2011;48:419–426.
 61. Kozma CM, Reeder CE, Schulz RM. Economic, clinical and humanistic outcomes: a planning model for pharmacoeconomic research. *Clin Ther* 1993;15:1121–1132.
 62. Nicolucci A, Rossi MC, Pellegrini F, Lucisano G, Pintaudi B, Gentile S, Marra G, et al. Benchmarking network for clinical and humanistic outcomes in diabetes (BENCH-D). *Springerplus* 2014;3:83.
 63. Kachru R, Morphew T, Kehl S, Clement LT, Hanley-Lopez J, Kwong KY, Guterman JJ, Jones CA. Validation of a simple survey that can be used for case identification and assessment of asthma control. The Breathmobile program. *Ann Allergy Asthma Immunol* 2006;97:775–783.
 64. Centers for Disease Control. Asthma prevalence, health care use, and mortality, 2002. Hyattsville, MD: US Department of Health and Human Services, CDC, National Center for Health Statistics; 2004. Available at: <http://www.cdc.gov/nchs/>

- products/pubs/pubd/hestats/asthma/asthma.htm [last accessed 15 Feb 2006].
65. Bolin J, Gamm L. Access to quality health services in rural areas – insurance: a literature review. In: Gamm LD, Hutchison LL, Dabney BJ, Dorsey AM, eds. *Rural Healthy People 2010: a companion document to healthy people 2010*. Vol. 2. College Station, TX: A&M University Press; 2003:15–26.
 66. Gamm L, Castillo G, Pittman S. Access to quality health services in rural areas – primary care. In: Gamm LD, Hutchison LL, Dabney BJ, Dorsey AM, eds. *Rural Healthy People 2010: A Companion Document to Healthy People 2010*. Vol. 1. College Station, TX: A&M University Press; 2003:45–50.
 67. Huss K, Winkelstein M, Calabrese B, Rand C. Role of rural school nurses in asthma management. *Pediatr Drugs* 2001;3: 321–328.
 68. Bruzzese J, Evans D, Wiesemann S, Heller M, Levison M, Du Y, Fitzpatrick C, et al. Using school staff to establish a preventive network of care to improve elementary school students' control of asthma. *J School Health* 2006;76:307–312.
 69. Halterman J, Sauer J, Fagnano M, Montes G, Fisher S, Tremblay P, Tajon R, Butz A. Working toward a sustainable system of asthma care: development of the School-Based Preventive Asthma Care Technology (SB-PACT) trial. *J Asthma* 2012;49:395–400.
 70. Drummond RL, Staten LK, Sanford MR, Davidson CL, Magda Ciocazan M, Khor KN, Kaplan F. A pebble in the pond: the ripple effect of an obesity prevention intervention targeting the childcare environment. *Health Promot Pract* 2009;10:156S–167S.
 71. Clark N, Lachance L, Milanovich AF, Stoll S, Awad DF. Characteristics of successful asthma programs. *Public Health Rep* 2009;124:797–805.
 72. The Cochrane Collaboration. Cochrane database of systematic reviews. Available from: http://www.mrw.interscience.wiley.com/cochrane/cochrane_clsystrev_articles_fs.html23 [last accessed 9 June 2009].