School-based asthma education and impact on asthma morbidity: A systematic literature review

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Abbreviations: AAP – asthma action plan; DB – Downs and Black; ED – emergency department; NHLBI – National Heart, Lung, and Blood Institute; RCT – randomized controlled trial

Contributor's Statements:

Anna Volerman and Shilpa Vasishta conceptualized and designed the study, coordinated data collection, collected the data, led the data analysis and interpretation, drafted the initial manuscript, revised the manuscript, and approved the final manuscript as submitted.

Valerie Press and Monica Vela assisted with the design of data collection instruments, collected the data, participated in the data analyses and interpretation, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Margaret Dennin and Ajanta Patel collected the data, provided critical input on data analysis and interpretation, critically reviewed the manuscript, and approved the final manuscript as submitted.

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ABSTRACT

Context: School-based asthma education programs have been shown to variably impact asthma morbidity outcomes, including school attendance, emergency department (ED) visits, and hospitalizations. These mixed results have been attributed to the heterogeneity of program characteristics among educational interventions.

Objective: To systematically review the literature on school-based asthma education programs to describe and compare program characteristics and their impact on asthma morbidity.

Data Sources: Studies were drawn from five medical and educational databases: PubMed, Ovid MEDLINE, CINAHL, PsycINFO, ERIC.

Study Selection: Studies were included based on the following criteria: description of school-based asthma education program; documentation of asthma morbidity outcomes; English-language publication.

Data Extraction: Data pertaining to program characteristics (format/content) and study characteristics (design/quality) were extracted for analysis.

Results: Thirty-one studies met inclusion criteria. Studies with improved outcomes were significantly more likely to use self-report (vs. records-based) methods and to exclude school-based clinical interventions (health provider consultation and asthma action plan development). Improved outcomes were also associated with adolescent (vs. younger child) population and nonrandomized (vs. randomized) study design, though these did not reach statistical significance.

Limitations: Study power is limited by small sample size. Comparisons of program characteristics are limited to the level of detail provided in the articles. Studies had variable means of defining and measuring outcomes, precluding meta-analysis.

Conclusions: The impact of school-based asthma education can be explained not only by differences in program characteristics, but also by differences in study design and reporting methods. Future studies should describe program characteristics in detail to facilitate further analyses.

BACKGROUND

Asthma is the most common pediatric chronic condition, affecting 8.3% of children in the United States and approaching 20% in minority subgroups.[1] Nearly 60% of children with asthma have at least one exacerbation annually and at least one missed school day per year.[2] Among chronic conditions, pediatric asthma is the leading annual cause of school absences (14.4 million), emergency department (ED) visits (1.8 million), and hospitalizations (439,000) with significant downstream impacts, including school underperformance and persistent asthma morbidity in adulthood.[3]

Asthma education is associated with improved outcomes, including health status and quality of life.[4] The National Heart, Lung, and Blood Institute (NHLBI) guidelines recommend that asthma education is delivered as one of four core components of asthma care in both clinical and non-clinical settings. Asthma education that occurs in school has the potential to reach children who do not have a regular healthcare provider and are therefore most susceptible to asthma-related morbidity.[5]

Prior systematic reviews show that school-based asthma education is effective in improving knowledge, self-efficacy, and self-management behaviors among children with asthma.[6] However, findings are mixed with regard to other asthma morbidity outcomes, including school absences, ED visits, and hospitalizations.[5–7] Authors attribute these ambiguities in part to the heterogeneity that exists among educational programs.[7]

School-based asthma education delivery has been shown to vary widely in its program characteristics, including format and content. In addition, research into these programs has varied widely in quality indices, including research design.[6] No study to date has characterized these differences in detail to understand how asthma education is delivered in the schools and which program characteristics are associated with improved outcomes. Here, we review the literature on school-based asthma education programs with documented outcomes of school attendance, ED visits, and/or hospitalizations to identify program characteristics associated with improvement in these areas.

METHODS

This review was designed and carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) standards (Appendix 1).[8]

Data Sources

A database search was performed by two authors (SV, AV) with consultation from a biomedical librarian. The primary search was conducted in PubMed using Medical Subject Heading (MeSH) terms and keywords targeting topic areas of patient education, children/adolescents, schools, and asthma (Appendix 2). Parallel searches were conducted in Ovid MEDLINE, Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycINFO, and Education Resources Information Center **(**ERIC). Reference lists of related review papers were searched for relevant titles that were not retrieved in the database search.

Study Selection

Inclusion criteria were as follows: publication in English; description of school-based asthma education program; children as primary recipients of education; and documented outcomes of school attendance, ED visits, and/or hospitalizations. Studies of all research designs and publication year were included to capture the breadth of education programs in the literature.

Title and abstract review were performed by all authors listed. Each study was screened for exclusion by two independent reviewers. Where the two reviewers disagreed, the two main reviewers (SV and AV) reached consensus via abstract review. Studies whose titles or abstracts did not clearly meet exclusion criteria were included for full-text review.

Full-text review was conducted by the two main reviewers. Studies were excluded if they failed to meet the listed inclusion criteria or were review articles, repeat publications of previously-described programs, or articles where the intervention was not described.

Data extraction

A standardized data extraction tool was developed to collect information from each article (Appendix 3). Detailed information was obtained pertaining to characteristics including: study design (study type, sample size, reporting methods); study quality (described below); program format (number and length of sessions, participants, teaching personnel), and program content (pathophysiology, medications, triggers, and self-

monitoring). To ensure consistency of responses, the tool was piloted on two randomly-selected articles among four reviewers (SV, VP, MV, AV) and then edited for clarity. Data extraction was completed by all authors, with each article read and extracted by one independent reviewer. Data was confirmed through full-text review of all included articles by the first author (SV).

Quality analysis

Study quality was assessed using the previously validated Downs and Black (DB) scale.[9] This scale consists of 27 items divided into subscales for reporting (10 items), external validity (3 items), bias (7 items), confounding (6 items), and power (1 item). For this review, the power item was simplified from a 5-point score to a binary score, assigning one point for adequate power calculation and zero points for inadequate power calculation. All randomized controlled trials (RCTs) and cluster RCTs were assigned points on item 23 regarding randomization. All observational studies without comparison groups were assigned zero points for items 21-24 regarding assignment of groups and for items 5 and 25 regarding confounding variables.

The DB scale was chosen because it may be applied to a variety of study designs and allows for the comparison of randomized and non-randomized studies. Prior systematic reviews of asthma education programs have utilized the Physiotherapy Evidence Database (PEDro) scale,[10] however this scale allows for assessment of RCTs only.[6]

Comparison of programs

For each outcome of interest (school absences, ED visits, hospitalizations), studies were divided into two groups: those with improved outcomes and those without improved outcomes. The two groups were compared based on the number of programs in each group with and without select program characteristics using Fisher's exact test. The two groups were also compared on continuous variables, including study quality and sample size, using two-sample student's T-test for difference in means. Study design, study quality, sample size, and reporting method were compared between groups to assess for possible sources of cumulative bias. Sensitivity analyses were completed for randomized study design and above-mean quality score. Analyses were conducted using GraphPad Software (La Jolla, CA).

RESULTS

A title review of 4,001 articles yielded 164 articles for full-text review, which then yielded 31 articles for inclusion in the final review (Figure 1).[11–41]

Following the database searches, 1,415 articles were duplicates and removed. Among the 2,419 studies excluded through title review, 842 did not describe an intervention, 840 were not school-based, 312 were not related to asthma, 208 did not target children or adolescents, 99 did not have an educational component, 96 were not English-language, 15 could not be accessed, and 10 were review articles. The title review had strong inter-rater reliability (kappa=0.93).

Of the 133 studies excluded through full-text review, 117 did not measure outcomes of interest, 9 were primarily clinical or therapeutic interventions, 3 did not include quantitative outcomes data, 2 were review articles, 1 was a hospital-based intervention, and 1 was a repeat publication of an intervention already included in the review (Figure 1).

Data pertaining to study characteristics, program characteristics, and outcomes for each of the 31 included studies are provided in Table 1.

Study characteristics

Study design

The included studies consisted of 4 RCTs,[13,25,26,33] 16 cluster RCTs,[14–18,21,22,24,27,29–31,34,37,39,40] 4 observational studies with comparison groups,[11,23,38,41] and 7 observational studies without comparison groups.[12,19,20,28,32,35,36]

Study quality

Study quality was quantified using an adapted Downs and Black scale (Table 1, Appendix 4). Of a maximum 28 points, scores ranged from 4 to 26 points with a mean of 17.2. The RCTs had the highest ratings (range 21-26, mean 24.25), followed by cluster RCTs (range 8-24, mean 18.31), observational studies with comparison groups (range 11-19, mean 15.75), and observational studies without comparison groups (range 4-19, mean 11.3).

Based on individual item analysis, all studies scored full points for representing actual treatment settings (item 13) and adjusting for differential length of follow-up (item 17). Thirteen studies (42%) fully described their confounding variables (item 5),[13,16,17,20,25,26,29–31,33,34,40,41] while an overlapping group of 13 studies accounted for these confounders in their analyses (item 25).[13,16–18,20,21,23,25–27,33,34,41] Twelve studies (39%) described subjects lost to follow-up (item 9),[11,13,15,16,20,28,31–34,37,41] while 13 studies accounted for these losses in their analyses (item 26).[11,13,15,16,20,25,26,31–34,37,41] Four studies (13%) accomplished concealment of group assignment to participants (item 14),[25–27,29] while 5 studies accomplished concealment to study personnel (item 15).[13,25–27,33]

Study population

As defined by inclusion criteria, all studies targeted children or adolescents with asthma as their primary population. Twenty-two studies (71%) included children with a previous physician-made asthma diagnosis.[11,13,16–18,22,24–33,35–40] Eighteen studies (58%) included children with recent symptoms of asthma,[11,13,15–18,21,22,25,26,28,29,32,34,37–40] and 9 studies (29%) included children with recent asthma medication use.[13,16–18,23,25,26,29,37] Five studies (16%) did not specify inclusion criteria for their target population.[12,14,19,20,41]

Participants ranged in grade level from kindergarten to 12th grade. Twenty-two studies (71%) targeted elementary school,[11,15–24,27,29–33,35,37–39,41] 4 studies (13%) targeted high school,[13,25,26,40] and 5 studies (16%) targeted some combination of elementary, middle, and high school students.[12,14,28,34,36] Overall, 24 studies (77%) primarily targeted children

(age 12 years and under),[11,14–24,27,29–33,35–39,41] while 7 (23%) primarily targeted adolescents (age 13 years and over).[12,13,25,26,28,34,40]

Several studies also targeted additional populations. Fourteen studies (45%) involved parents.[11,12,14,16,17,20,21,24,30–32,35–37] Half of these (23%) included written or video-based materials sent home to parents,[11,12,14,17,21,24,36] while the other half (23%) invited parents to participate in school-based educational sessions.[16,20,30–32,35,37] Twelve studies (39%) included education for school staff,[11,12,17,20,22,27,29–31,33,34,37] 6 of which took the form of in-service education.[12,22,27,29,34,37] Five studies (16%) included education for local physicians.[11–13,34,37] Three studies (10%) offered education to the whole student body, including those without asthma.[17,22,29]

Studies varied widely in sample size (range 13-990, mean 315.68, SD 267.37).

Program characteristics

Program format

Twenty-eight programs (90%) were carried out longitudinally over multiple sessions.[11–13,15–19,21–28,30–41] The number of sessions ranged from 1 to 32, while session length ranged from 5 minutes to 2.5 hours. Twenty-one programs (68%) delivered group education,[12,14–18,20–24,27–32,34,35,37,38] 4 programs (13%) delivered individual education,[11,25,26,33] and 6 programs (19%) used a combination of group and individual education.[13,19,36,39–41] Thirteen programs (42%) were delivered by nurses or nurse practitioners,[12,15,19,23,27–29,31–

[33,36,40,41] 7 (23%) by health or asthma educators,[12,13,16,20,21,28,32] 3 (10%) by respiratory therapists,[12,31,36] and 2 (6%) by teachers.[18,19] Three studies (10%) described computer- or web-based programs.[11,25,26]

All programs featured education as the primary intervention. Fifteen programs (48%) offered additional interventions: 8 programs (26%) included clinical evaluation by a physician or nurse,[11,19,22,33,38–41] 4 programs (13%) included communication with the child's regular physician,[17,27,30,31] and 3 programs (10%) included referrals to physicians for children who did not have a regular provider.[13,25,26] Nine programs (29%) provided participants with asthma supplies, such as peak flow meters, spacers, and medications.[11,12,20,22,23,28,29,33,36] Four programs (13%) included policy advising for the school,[11,29–31] with one specifically focused on environmental exposures.[11]

Program content

Eleven programs (35%) delivered content using the Open Airways for Schools curriculum, which includes the four content areas recommended within the NHLBI guidelines (pathophysiology, medications, self-monitoring, and triggers).[14,17,18,21–23,27,35,38,39,41] Three programs (10%) used the Roaring Adventures of Puff curriculum[16,30,31] and 2 studies used the Puff City curriculum,[25,26] both of which are computer-based.

Among the educational content areas recommended in the NHLBI guidelines, 17 programs (55%) included all four content areas,[14–18,20–23,27,30,31,35,37–39,41] and 8 programs

(26%) included three of the four content areas.[12,19,24–26,28,40] The most commonly excluded content area was self-monitoring (n=6),[19,25,26,28,29,32] followed by medications (n=4).[12,24,29,32] Among the 24 programs incorporated education about medications, 12 programs (50%) specifically taught inhaler technique.[15,16,19,20,25,26,30,31,33,37,39,40] Among the 22 programs that taught self-monitoring, 11 programs (50%) specifically addressed the correct use of a peak flow meter.[12,15,16,20,24,30,31,33,36,37,40] In addition to the four guideline-driven content areas, 16 programs (52%) addressed exercising with asthma,[14,16–19,21–24,27,30,31,35,38,39,41] 4 programs (13%) discussed use of Asthma Action Plans (AAP),[15,16,30,31] and 2 programs (6%) focused on smoking cessation.[25,26]

Outcomes

Programs with and without improved outcomes were compared based on their program characteristics (Table 2).

School Absence

All but one of the included studies measured school absences as an outcome.[41] Thirteen of these (43%) described a statistically significant improvement,[12,14,16,18–20,25–28,34–36] while 15 studies (50%) documented no significant improvement.[11,15,21–24,29–33,37–40] Two studies (7%) showed mixed findings, where school absences were significantly decreased when assessed by self-report but not decreased when assessed by school records.[13,17]

Studies with and without improved absences were similar in quality score, sample size, and in the proportion of studies conducted in a randomized design. Studies with

improvement were significantly more likely to have collected data through self-report methods, while studies without improvement were more likely to have utilized school records (p=0.02).

Studies with improved absences more frequently targeted adolescents than those without improved absences, though this difference did not reach statistical significance (p=0.07). There was no difference in the frequency of targeting additional groups for education, including peers, parents, school staff, or physicians.

Studies with and without improved absences were similar in their frequency of teaching content related to asthma pathophysiology, medications, triggers, and self-monitoring. Studies with improvement were significantly less likely to include individualized AAP development than those without improvement (p=0.02), and also less likely to include individual consultation with a physician or nurse, though this outcome did not reach statistical significance (p=0.08).

Emergency department visits

Twenty-one of the included studies (68%) documented ED visits as an outcome. Seven of these studies (33%) described a statistically significant improvement,[12,13,16,20,27,28,35] while the remaining 14 studies (67%) demonstrated no statistically significant improvement.[14,15,18,22,25,26,30,31,33,36–39,41]

Studies with and without improvements in ED visits were similar in quality, sample size, and data collection methods. Studies with improvement were more likely to have been conducted in an observational design (4 of 7), while those without improvement were more likely to have been randomized controlled trials (11 of 14); this difference did not reach statistical significance (p=0.16).

Studies with and without improvement were similar in their frequency of targeting children, adolescents, and other groups. The two groups had similar frequencies of covering content in the four core areas and of providing supplies. Studies with improvement were significantly less likely to include AAP development and physician or nurse consultation, though these outcomes did not reach statistical significance (p=0.06 and p=0.12, respectively).

Hospitalizations

Fourteen of the included studies (45%) documented hospitalizations as an outcome. Of these studies, 8 (57%) described a statistically significant improvement[13,14,16,20,25,27,28,35] and 6 (43%) documented no statistically significant improvement.[11,15,22,26,40,41]

Studies with and without improvements in hospitalization were similar in study design, quality, sample size, and reporting method. There were no significant differences between groups in terms of target population or educational content. Programs with improved hospitalizations were significantly less likely to include AAP development (p=0.03) and physician or nurse consultation (p=0.03).

Sensitivity Analyses

Two sensitivity analyses were conducted to determine if the results would differ when limited to randomized study design or high quality score (Appendix 5).

Randomized study design

The first sensitivity analysis was limited to studies of randomized design (RCTs and cluster RCTs).

For school absences, the analysis included 7 programs with improved outcomes,[14,16,18,25–27,34] 11 programs without improved outcomes,[15,21,22,24,29–31,33,37,39,40] and 2 programs with mixed results.[13,17] As in the original analysis, AAP development was seen more frequently in the not-improved group (p=0.04).

For ED visits, the analysis included 3 programs with improvement[13,16,27] and 12 without no improvement.[14,15,18,22,25,26,30,31,33,37,39,41] For hospitalizations, the analysis included 5 programs with improvement[13,14,18,25,27] and 4 without improvement.[15,22,26,40] None of the evaluated variables had significant differences between groups.

High quality score

The second sensitivity analysis was limited to studies with quality scores above the mean for each outcome.

For school absences (DB score > 17.2), the analysis included 7 programs with improved outcomes,[16,18,20,25–27,34] 6 without improved outcomes,[11,15,21,29,31,33] and 2 with mixed results.[13,17] Quality score was significantly higher in the improved-outcome group (p=0.03). As in the original analysis, studies with improvement were significantly more likely to have collected data through self-report methods, rather than through school records (p=0.05).

For ED visits (DB score > 17.7), the analysis included 4 programs with improved outcomes[13,16,20,27] and 6 programs without.[15,18,25,26,31,33] For hospitalizations (DB score > 18.1), the analysis included 5 programs with improved outcomes[13,18,20,25,27] and 3 programs without.[11,15,26] None of the evaluated variables had significant differences between groups.

DISCUSSION

This systematic literature review is the first to compare school-based asthma education programs with and without improved outcomes to determine which program characteristics lead to improved outcomes. We find that improved outcomes are not entirely attributable to differences in program format or content, as previously hypothesized. Instead, findings of improved outcomes area also partly explained by differences in study design and outcome reporting methods.

Prior systematic reviews have had mixed conclusions when evaluating the impact of school-based asthma education on school absences, ED visits, and hospitalizations.

Coffman et al. found only a minority of programs successfully reduced school absences,[6] while Ahmad et al. described that school absences were almost uniformly reduced.[5] Additionally, Ahmad et al. found only a small minority of programs successfully reduced ED visits and hospitalizations,[5] while a meta-analysis by Coffman et al. demonstrated overall benefit in these outcomes.[7] All prior reviews describe considerable heterogeneity among programs and cite possible systematic differences between programs with and without improved outcomes, such as format of sessions and comprehensiveness of content.[7] Authors also hypothesize that additional clinical interventions, such as school-based clinics and the provision of medications, may play a role.[6] Though one prior systematic literature review comments on the absence of clear benefit from certain program components (individual education, inclusion of parents / peers / school personnel),[6] no study to date has systematically compared programs with and without improved outcomes over a broad range of program and study characteristics.

Our findings suggest that differences in asthma education outcomes are only partly attributable to differences in program format and content. Programs that reduce school absences, ED visits, and hospitalizations are significantly less likely to include school-based clinical interventions, such as physician / nurse visits or AAP development. Although this finding runs contrary to our expectations, it might be explained by a "dilution" effect whereby programs that include more components may invest less substantially in any given component, thereby reducing some of the impact that stand-alone education might provide. In addition, programs that reduce school absences are more likely to target adolescents as their primary population. Thought this finding does

not reach statistical significance, it is consistent with prior literature reviews that show benefits to tailoring education to adolescent-specific issues, such as smoking and peer pressure.[42] None of the other program factors evaluated in this analysis show association with improved outcomes.

Regarding study characteristics, we find two notable associations between program outcomes and the manner in which the programs were studied or assessed. Programs that utilize a self-reporting method, as opposed to relying on school records, are significantly more likely to demonstrate reductions in school absence. This finding may represent a bias toward self-reporting positive outcomes on the part of students and their parents. Alternatively, it could represent limitations in schools' data gathering and recording techniques; for example, some schools may not distinguish asthma-related absences from other causes. In addition, we find that observational studies are more likely than randomized studies to demonstrate reductions in ED visits. Although this finding does not reach statistical significance, it raises concern that the impact of education on ED visits may be overstated in the literature based on less rigorous studies.

The current analysis is limited by the amount of detail provided in the included articles about their respective programs. For example, while we are generally able to classify programs as either occurring in a group or individual format, our results may fail to capture important differences in the degree to which education was individually or culturally tailored, as these factors tend not to be described in detail. We are therefore unable to address the hypothesis, as posed in prior literature, that tailored education has a

significant impact on outcomes.[43] Likewise, while we are able to identify the content areas addressed by each program, we generally do not have information on precisely how this content was taught. Prior studies, for example, suggest a benefit to teaching asthma medication use in a hands-on manner with demonstrations and teach-back.[44] We are limited in our ability to comment on these factors based on the limited program descriptions provided in many of the included studies. Finally, our analysis has limited power to detect significant differences due to the small number of studies available in the literature on this topic.

This analysis is the first to demonstrate that differences in the outcomes of school-based asthma education programs are not entirely attributable to differences in program characteristics and are influences by differences in study methodology. Our findings raise concern that school-based asthma education programs continue to be developed without a clear understanding of which program factors lead to improved outcomes. Furthermore, asthma education delivery does not appear to reliably improve all outcomes; it seems that results for school absences and ED visits are partly predicated on study design and outcome reporting methodology. To more definitively characterize the impact of school-based asthma education, more rigorous randomized trials are needed, with outcomes measured using a mixed-methods data collection approach that includes both objective records and subjective self-report. Future reporting of interventions should include a detailed description of program variables, such as cultural tailoring and hands-on/teach-back approaches,[43,44] so they may be evaluated in a rigorous manner and utilized in the implementation and dissemination of future programs. Until a larger body of such

literature is amassed, program developers should proceed cautiously in interpreting the current data. We recommend that developers make decisions about program format and content based on factors unique to their specific population and resources.

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Figures/Tables/Charts