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# Public Health Interventions for Asthma: An Umbrella Review, 1990–2010

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2  
3 **Effectiveness of Public Health Interventions for Asthma**  
4 **An Umbrella Review: 1990–2010**  
5

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12 NC. Affiliations are from the time the work was conducted. The findings and conclusions in this  
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14

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28 **Abstract**

29 **Context:** Asthma is a chronic respiratory disease increasingly prevalent in the U.S., particularly  
30 among children and certain minority groups. This umbrella review sought to assess and  
31 summarize existing systematic reviews of asthma-related interventions that might be carried out  
32 or supported by state or community asthma control programs, and to identify gaps in knowledge.

33 **Evidence acquisition:** Eleven databases were searched through September 2010, using terms  
34 related to four concepts: “asthma,” “review,” “intervention,” and “NOT medication.” Reviews of  
35 the effectiveness of medications, medical procedures, complementary and alternative medicine,  
36 psychological interventions, family therapy, and of nutrients or nutritional supplements were  
37 excluded. Two coders screened each record and extracted data from the included reviews.

38 **Evidence synthesis:** Of 42 included reviews, 19 assessed the effectiveness of education and/or  
39 self-management, 9 the reduction of indoor triggers, 9 interventions to improve the provision of  
40 health care, and 5 examined other interventions. Several reviews found consistent evidence of  
41 effectiveness for self-management education, and one review determined that comprehensive  
42 home-based interventions including the reduction of multiple indoor asthma triggers are effective  
43 for children. Other reviews found limited or insufficient evidence due to study limitations.

44 **Conclusions:** State or community asthma control programs should prioritize: 1) implementing  
45 interventions for which this review found evidence of effectiveness; and 2) evaluating promising  
46 interventions that have not yet been adequately assessed. Future research would be improved by  
47 standardizing definitions and measures across studies and adhering to quality guidelines when  
48 conducting systematic reviews. Well-designed research on health care system and policy  
49 interventions related to asthma is needed.

## Context

A chronic respiratory disease, asthma has become increasingly prevalent in the United States. Estimates from three national surveys indicate that about 8.2 percent of the U.S. population (24.6 million people) has asthma.<sup>1</sup> Asthma prevalence has been found to be particularly high among Puerto Ricans (16.6 percent), people living in poverty (11.6 percent), non-Hispanic blacks (11.1 percent), children and adolescents (9.6 percent), and females (9.3 percent).<sup>1</sup>

Asthma symptoms can range from mild to severe, with approximately 4,000 deaths attributed to asthma each year.<sup>2</sup> In 2008, people with asthma missed 10.5 million school days and 14.2 million work days due to asthma.<sup>1</sup> In 2007, 1.75 million emergency department visits and 456,000 hospitalizations were asthma-related.<sup>1</sup>

While ways to prevent asthma from developing are not well understood, evidence-based clinical guidelines for managing and treating asthma have been issued by the National Asthma Education and Prevention Program (NAEPP). These guidelines emphasize four essential components of care: assessment and monitoring, patient education, control of factors contributing to asthma severity, and pharmacologic treatment.<sup>3</sup> The guidelines also encompass activities that may be conducted at the public health level, such as asthma education and self-management, coordination of care across different settings, institutional changes to improve quality of care, and the reduction of indoor and outdoor asthma triggers.

The Centers for Disease and Control and Prevention (CDC) National Asthma Control Program provides funding to state and local partners to carry out these types of public health

24 interventions. To provide guidance to its partners, the CDC periodically updates and summarizes  
25 the evidence base in support of interventions to increase access to and promote NAEPP  
26 guidelines-based care and to reduce exposures to asthma triggers. The purpose of this umbrella  
27 review was thus to identify, assess, and summarize existing systematic reviews of asthma-related  
28 interventions that might be carried out or supported by state or community asthma control  
29 programs. Limiting the content in this way permitted a rapid overview of a broad and evolving  
30 field, and allowed for the identification of gaps in knowledge that might be filled through future  
31 reviews, additional research, or multi-site evaluations.

32

33

### **Evidence Acquisition**

34 **Inclusion criteria.** A paper was considered if it: (1) was a systematic review (as defined below),  
35 with or without meta-analysis; (2) examined the effectiveness of asthma interventions relevant to  
36 public health; and (3) was published in English, from January 1990-September 2010. A review  
37 was considered “systematic” if it: (1) included a clear statement of the purpose of the review; (2)  
38 described the search strategy (i.e., search terms, databases, search dates); (3) indicated the  
39 criteria used to select studies for inclusion; and (4) presented all findings relevant to the main  
40 purpose of the review, including those that did not favor the intervention.

41

42 The authors of this umbrella review (hereafter referred to as “authors”) drew on a working list of  
43 possible public health interventions for asthma, developed by the National Asthma Control Program  
44 in partnership with the CDC’s Community Guide Branch and a group of federal and non-federal  
45 partners (see Table 1). Reviews of immunizations, exercise, and weight loss were also included, as  
46 they are consistent with public health practice. Reviews that evaluated the effectiveness of asthma

47 medications, medical procedures, complementary and alternative medicine, psychological  
48 interventions, family therapy, or of nutrients or nutritional supplements were excluded. Also  
49 excluded were narrative reviews, other umbrella reviews, reviews addressing other diseases in  
50 addition to asthma, discussion articles, and case studies. Only the most recent version of updated  
51 reviews was included.

52  
53 **Search strategy.** The literature search included the following databases: MEDLINE, EMBASE,  
54 ERIC, PsycINFO, CINAHL, Web of Science, Cochrane Library, Sociological Abstracts, Social  
55 Services Abstracts, Health and Safety Science Abstracts, and PILOTS. The search strategy was  
56 based on four key concepts: “asthma,” “review,” “intervention,” and “NOT medication.” The initial  
57 literature search, conducted in April 2010, was updated in September 2010. In addition, the websites  
58 of the following organizations also were searched: CDC’s Guide to Community Preventive Services;  
59 the Agency for Health Research and Quality; the Public Library of Science; U.K.’s University of  
60 York’s Centre for Reviews and Dissemination, Evidence for Practice and Policy Information (EPPI)  
61 Centre, and National Institute for Health and Clinical Excellence; and the Canadian Institutes of  
62 Health Research.

63  
64 **Data extraction and quality assessment.** The online review software DistillerSR  
65 (<http://systematic-review.net>) was used for reference screening, data extraction, and quality  
66 assessment (see Figure 1). Two readers (at least one of whom was an author of this umbrella  
67 review) independently entered data from each review using an online form specifying the  
68 methods used in the systematic review, studies and interventions included, and the reported

69 findings and conclusions. Discrepancies were resolved via discussion, with a third reader serving  
70 as an arbiter.

71  
72 The quality of execution of the reviews was assessed with an instrument adapted from another  
73 umbrella review,<sup>4</sup> which addressed: search strategy (2 questions), specification of  
74 inclusion/exclusion criteria (1 question), whether and how the quality of the included studies was  
75 assessed (2 questions), whether and how findings were integrated (1 question), and the  
76 appropriateness of the conclusions given the data presented (1 question). One point was given for  
77 each response meeting the quality criteria, leading to three possible ratings: strong (6-7 points),  
78 moderate (4-5 points), or weak (3 or fewer points). While the basic structure of the quality  
79 assessment instrument was retained, the authors revised some of the original terminology and  
80 incorporated additional instructions. The final version is provided in Appendix A ([www.ajpm-](http://www.ajpm-online.net)  
81 [online.net](http://www.ajpm-online.net)).

82

### 83 **Evidence Synthesis**

84 Of the 10,282 identified references, 42 systematic reviews met the inclusion criteria, of which 23  
85 were published in peer-reviewed journals, 18 in the Cochrane library, and one was a report by  
86 the Agency for Healthcare Research and Quality (AHRQ). The number of included studies  
87 ranged from 1 to 92, with a median of 12 studies. One review<sup>5</sup> did not identify any studies that  
88 met inclusion criteria, but was included in this review because it was a published paper that  
89 helped identify knowledge gaps. The total population of the included studies, ranged from 57 to  
90 30,021.<sup>6,7</sup> Two reviews of multiple interventions may have included larger populations, but the  
91 totals were not indicated.<sup>8,9</sup>

92

93 Among the 42 included reviews, 28 were determined to be of high quality based on the quality  
94 assessment instrument, 10 of moderate quality, 3 weak, and one could not be scored as no studies  
95 met the inclusion criteria. Twenty-eight, including the 18 Cochrane reviews, required that the  
96 included studies be randomized or quasi-randomized and controlled, but not all were of high  
97 quality, as determined by the quality assessment. The other 14 reviews considered studies using  
98 other designs, including non-randomized controlled, observational, before-and-after, and  
99 interrupted time series. Methods used to assess study quality varied, with some using the Jadad  
100 scale<sup>10</sup> or the Physiotherapy Evidence Database's PEDro scale,<sup>11</sup> others listing study weaknesses  
101 without referencing a specific instrument, and seven not indicating how study quality was  
102 assessed.

103

104 In 17 reviews, including 11 Cochrane reviews, findings were integrated via meta-analysis. Other  
105 reviews used different methods, quantitative and/or qualitative, to synthesize findings, with six  
106 describing individual study findings but not integrating them in any way. In 8 reviews, the  
107 findings of the included studies were not presented with sufficient clarity or detail to support the  
108 conclusions of the review. In two additional small reviews,<sup>12,13</sup> although the findings of the  
109 studies were appropriately presented, the conclusions were deemed to be overly positive given  
110 the limited evidence presented.

111

112 Of 42 included reviews, 19 assessed education and/or self-management, 9 the reduction of  
113 indoor allergens, 9 interventions to improve the provision of health care, and 5 examined other  
114 interventions. Two related reviews funded by AHRQ assessed multiple interventions, including

115 education and/or self-management and the provision of health care. To avoid duplication, they  
116 are counted in the latter category but discussed in both. The search did not identify any reviews  
117 of air quality alerts, policies to reduce exposure to diesel exhaust, interventions implemented in  
118 schools settings (other than asthma education), or asthma case identification or case detection.  
119 Detailed summaries of the reviews are provided in Appendix B ([www.ajpm-online.net](http://www.ajpm-online.net)).

120

### 121 **Asthma Education and/or Self-Management Education (SME)**

122 Nineteen reviews (see Tables 2 and 3) assessed one or some combination of the following:  
123 general asthma education, self-management education (individualized instruction on how to  
124 modify treatment when symptoms occur), self-monitoring (ways to routinely check if asthma is  
125 controlled), and/or written asthma action plans (WAAPs). Of these, five focused specifically on  
126 self-management education (SME), with three of the five focusing on interventions for children  
127 with asthma. The first found no benefit;<sup>14</sup> a later Cochrane review reported benefits regarding  
128 lung function, symptoms, school absences, and emergency room (ER) visits;<sup>15</sup> the third and most  
129 recent did not look at proximal outcomes but found improvements in hospitalizations and ER  
130 visits.<sup>16</sup> A Cochrane review of SME with regular practitioner review among adult asthma  
131 patients found improvements in symptoms, productivity (fewer missed work days), ER visits,  
132 and hospitalizations.<sup>17</sup> A review examining the cost-effectiveness of SME using peak flow  
133 monitoring reached no conclusions due to heterogeneity in interventions, costs, and outcomes.<sup>18</sup>

134

135 Two other reviews that are grouped with reviews of interventions to improve the provision of  
136 health care<sup>8,9</sup> (see Table 5) also assessed SME and/or asthma education, and found them to be

137 associated with modest improvements in symptoms and reduced school absenteeism among  
138 children<sup>8</sup> and improved lung function in children and adults.<sup>9</sup>

139

140 Many reviews combined studies representing a continuum from general asthma education to  
141 skill-based SME and self-monitoring. Among these were two reviews of asthma education  
142 following ER visits for asthma, which found reduced hospitalizations and ER visits among  
143 children<sup>19</sup> and reduced hospitalizations among adults.<sup>20</sup> Reviews of school-based education and  
144 computerized education found improvements in knowledge, self-efficacy, and symptoms but not  
145 in distal outcomes.<sup>21,22</sup> Two reviews that assessed the effectiveness of culturally-tailored  
146 educational interventions found few studies and limited evidence of effectiveness.<sup>12,13</sup>

147

148 Only one review focused exclusively on studies of limited (information only) educational  
149 interventions “that transfer information about asthma, its causes and its treatment” but do not  
150 provide SME, WAAPs, or training on self monitoring.<sup>23</sup> Among the 12 included studies, two  
151 found improvements in symptoms and one found cost savings and a decrease in ER visits.

152

153 Seven reviews focused on WAAPs, with only three comparing the effectiveness of use of a plan  
154 vs. no plan (see Table 3). A review comparing plan vs. no plan in children reported some  
155 positive outcomes based on only one study.<sup>24</sup> The two reviews of the effectiveness of plan vs. no  
156 plan in adults found few studies, and did not identify any consistent benefits associated with  
157 WAAP use.<sup>25,26</sup> Five reviews that compared symptom-based plans with plans based on peak flow  
158 monitoring found similar outcomes,<sup>24-28</sup> although children preferred symptom-based plans.<sup>24,28</sup>  
159 Another review found that individualized plans specifying when and how to modify treatment

160 were associated with improved lung function and reduced hospital admissions, ER visits, and  
161 days off for asthma; no benefits were found for less complete plans.<sup>29</sup> The remaining review,  
162 which examined the effectiveness of interventions to increase WAAP ownership and use, was  
163 unable to draw conclusions regarding the best ways to promote and sustain use.<sup>30</sup>

164

### 165 **Environmental Interventions**

166 Nine reviews (see Table 4) examined the effectiveness of environmental interventions, with all  
167 addressing the control of indoor triggers. Two reviews focused on dust mite removal, with one  
168 finding an improvement in symptoms but not in lung function, and concluding that there was  
169 insufficient evidence to recommend use.<sup>31</sup> The second review, a large Cochrane review of 54  
170 randomized controlled trials, found no effect of either chemical or physical measures to reduce  
171 mite allergens on asthma outcomes.<sup>32</sup> Limited evidence of effectiveness was found in a review of  
172 interventions that used counseling and education to reduce the residential exposure of children  
173 with asthma to environmental tobacco smoke (ETS), with three studies finding small to moderate  
174 reductions in reported ETS exposure.<sup>33</sup>

175

176 Four other reviews that focused on specific asthma triggers found insufficient evidence of  
177 effectiveness. A review of interventions to reduce allergen levels or symptoms due to pets found  
178 that the available studies were underpowered to provide evidence for or against the effectiveness  
179 of air filtration, and identified no studies of other pet allergen reduction measures.<sup>6</sup> A review of  
180 non-feather bedding vs. feather bedding identified no studies meeting inclusion criteria.<sup>5</sup> Another  
181 review, which examined the use of air ionizers, found that neither negatively- (5 studies) or  
182 positively-charged (1 study) air improved asthma outcomes.<sup>34</sup> Data from a review of the

183 effectiveness of residential air filters were equivocal, with meta-analyses of a small number of  
184 studies indicating improvements in symptoms, but inferences being weakened by heterogeneity  
185 of results and inconsistent use of validated scales to measure clinical symptoms or quality of  
186 life.<sup>35</sup>

187

188 In contrast to the reviews focusing on single triggers or single interventions, a review of multi-  
189 component interventions addressing multiple asthma triggers in the home found substantial  
190 evidence of effectiveness.<sup>36</sup> The review found meaningful improvements in asthma symptoms  
191 and school days missed, as well as small improvements in health care utilization, in 20 studies  
192 targeting children and adolescents (but not in 3 studies targeting adults). An economic review of  
193 the included studies, published in a companion paper, identified minor or moderate remediation  
194 costs ranging from \$12 to \$57 per additional asthma symptom-free day (3 studies), indicating  
195 good value for money invested.<sup>37</sup> The final review in this category examined home-based asthma  
196 interventions addressing multiple asthma triggers, as delivered by community health workers.<sup>38</sup>  
197 Although the review concluded that the data favored the interventions, findings were not  
198 integrated, so the strength of the evidence is unclear.

199

## 200 **Interventions Related to the Provision of Health Care**

201 The nine reviews in this area addressed two topics from the list of possible interventions:  
202 administrative/systems change and provider education (see Table 5). Two of these were drawn  
203 from a search funded by AHRQ: one presented findings related to children;<sup>8</sup> the other included  
204 data for all ages.<sup>9</sup> The review of studies targeting children identified 13 studies that used  
205 organizational change strategies (most often, adding specially trained personnel in pediatric

206 clinics or augmenting asthma care in schools).<sup>8</sup> These relatively heterogeneous interventions  
207 tended to find improvement in use of medications. In the broader review that focused primarily  
208 on adults,<sup>9</sup> the effect of organizational changes, such as adding a pharmacist to the team, could  
209 not be determined because the studies did not isolate these changes from patient education and  
210 training. The review found insufficient evidence to assess the effectiveness of audit and feedback  
211 strategies, provider reminders, facilitated relay of clinical data, or financial incentives

212  
213 Reviews of adult asthma disease management,<sup>7</sup> and special asthma services within primary care  
214 clinics<sup>39</sup> found insufficient evidence to recommend these interventions. Similarly, a review<sup>40</sup> of  
215 different organizational methods of delivery across both primary and specialist care found no  
216 evidence to favor any particular organizational form. The conclusions suggested that specialist  
217 care may be better than generalist care but the findings to support this were not presented.

218  
219 Two of the reviews in this grouping, although inconclusive, had promising findings. There was  
220 no evidence that inpatient clinical pathways (systematic approaches or protocols for the multi-  
221 disciplinary management of clinical problems) for children with asthma improved patient-level  
222 quality of care measures, yet they appeared to be effective in reducing length of stay and hospital  
223 costs.<sup>41</sup> The review of pharmacist involvement in improving asthma outcomes suggested that  
224 interventions conducted in community pharmacies yielded improvements in pulmonary function,  
225 symptoms, and health care utilization, but better synthesis of the results is needed.<sup>42</sup>

226  
227 Findings regarding the effectiveness of continuing medical education were mixed. Although  
228 some of the individual studies included in the broad review conducted by AHRQ<sup>9</sup> showed

229 outcomes ranging from improved adherence to guidelines to increased symptom-free days,  
230 heterogeneity in the types of intervention made it impossible to determine which components  
231 lead to benefit. Similarly, Barton et al.<sup>43</sup> did not find convincing evidence of effectiveness of  
232 continuing medical education for improving the health outcomes of patients with asthma, but  
233 their search yielded only three studies. The review noted that seven additional studies found  
234 benefits, including cost savings, improved continuity of care, better prescribing behavior, and  
235 increased doctor knowledge.

236

237 The last review in this grouping assessed the cost-effectiveness of current national guidelines for  
238 the treatment of children with asthma, and concluded that SME is cost-effective for patients with  
239 severe asthma, and that the employment of asthma nurses may result in cost savings.<sup>44</sup> However,  
240 the review did not describe the process by which cost effectiveness across studies was  
241 determined.

242

### 243 **Other Asthma Interventions**

244 Among the five remaining reviews of relevance to public health programs, two addressed  
245 vaccines. A paper assessing the efficacy and harms of influenza vaccine in children and adults  
246 with asthma found insufficient evidence of its effectiveness in reducing asthma exacerbations  
247 due to influenza.<sup>45</sup> Nonetheless, there was no indication of adverse effects except in infants given  
248 live intranasal vaccination. A review of pneumococcal vaccine for asthma also yielded  
249 insufficient evidence of effectiveness in reducing asthma exacerbations.<sup>46</sup> None of the studies in  
250 the two vaccine reviews were adequately powered to detect reductions in respiratory failure or  
251 death.

252  
253 Two papers examined the safety and effectiveness of physical training for people with  
254 asthma.<sup>47,48</sup> Although the reviews did not find evidence that physical training improves lung  
255 function or reduces the occurrence or severity of exercise-induced asthma, both concluded that  
256 physical training is safe and can improve aerobic fitness.

257  
258 Because of the association between asthma symptoms and increased body mass index,<sup>49</sup> a  
259 systematic review of medical and surgical interventions for obesity reduction was considered.  
260 Although all 15 studies in the review reported at least one favorable asthma outcome, small  
261 sample sizes and weak study designs made it difficult to determine the effectiveness of these  
262 interventions.<sup>50</sup>

263

## 264 **Conclusions**

265 This umbrella review provides a general overview of the state of the evidence in support of  
266 asthma interventions that might be implemented by public health programs at the state or  
267 community level. Programs can use these findings, along with the NAEPP guidelines, to advance  
268 progress towards meeting the asthma-related objectives of Healthy People 2020.

269

270 This paper differs from another recent asthma umbrella review in that it was not limited to  
271 Cochrane reviews or to studies of adults, did not consider reviews of psychological or  
272 complementary/alternative medicine interventions, and included reviews of health care system  
273 interventions.<sup>51</sup> Further, as randomization often is not acceptable in community-based  
274 implementation research, this umbrella review considered evidence from systematic reviews that

275 included a broader range of study designs. Nonetheless, there was some overlap in the two  
276 umbrella reviews, with both finding the strongest evidence in favor of SME. The current  
277 umbrella review also found support for the effectiveness of comprehensive home-based multi-  
278 trigger reduction interventions, many of which included SME.

279

280 Despite the existing evidence of effectiveness in support of these two interventions, uptake of  
281 these strategies remains suboptimal, with only 12.2% of persons with current asthma reporting  
282 taking a class on how to manage their asthma, and 49.3% reporting receipt of counseling to  
283 reduce triggers in their home or work environment.<sup>52</sup> This suggests a need to shift the focus of  
284 future efforts from demonstrating the effectiveness of these interventions, to achieving broader  
285 implementation, particularly in communities suffering a disparate burden of asthma.

286

287 Three reviews comparing the provision of a WAAP (a self-management tool recommended by  
288 NAEPP) with no plan did not find consistent benefits associated with WAAPs. However, this  
289 finding was primarily due to the lack of good quality studies and the difficulty of isolating the  
290 use of a WAAP from the effect of appropriate clinical management and asthma SME. Reviews  
291 of asthma disease management and other health systems interventions designed to achieve the  
292 implementation of the NAEPP clinical guidelines also found “insufficient evidence” of  
293 effectiveness due to a common list of limitations: small number of studies, small sample sizes,  
294 poor study design, lack of information on key variables, and heterogeneity of interventions,  
295 outcome measures, and methods of analysis.

296

297 This lack of conclusive evidence leaves programs with limited guidance, yet there is a continuing  
298 need to ensure that every person with asthma receives guidelines-based assessment, diagnosis,  
299 treatment, and follow-up. Many programs and health plans are currently implementing programs  
300 to improve the quality of medical care (<http://www.asthmacommunitynetwork.org>). Systematic  
301 multi-site evaluations of promising programs<sup>53</sup> could provide useful guidance. Further, reviews  
302 of educational outreach visits,<sup>54</sup> audit and feedback,<sup>55</sup> clinical pathways<sup>56</sup> and other interventions  
303 for non-asthma medical conditions have identified health system interventions of modest  
304 effectiveness. Multifaceted health system interventions also appear to be more effective than  
305 single interventions in improving quality of care.<sup>57</sup> The development of appropriate program  
306 guidance might be expedited by research and evaluation activities that consider packages of  
307 health system interventions that have improved the quality of care related to other chronic  
308 diseases.

309  
310 This umbrella review did not identify reviews of interventions addressing broader policy and  
311 environmental changes, such as self-carry laws (regarding quick relief inhalers) for schools or  
312 interventions to decrease exposure to diesel exhaust. As these interventions have the potential for  
313 population rather than individual impact, they may be a priority for additional research. There is  
314 evidence that public health interventions such as influenza vaccination and engagement in  
315 physical training are safe for persons with asthma, and are important interventions in themselves,  
316 but they may not improve asthma outcomes. In addition, the studies in the reviews of vaccines  
317 were not sufficiently powered to detect reductions in life-threatening outcomes.

318

319 There are many reasons for the limitations identified in this umbrella review. Defining and  
320 interpreting outcome measures (e.g., hospitalizations, symptoms, quality of life, lung function)  
321 across asthma studies is challenging, and each measure has its limitations. The included reviews  
322 contained many studies that can be classified as implementation research or program evaluation.  
323 As many of these studies are carried out in “real-world” settings, their choice of interventions,  
324 inclusion criteria, and outcome measures reflect local needs and resources, investigator interests,  
325 funding requirements, and settings. Further, to ensure that findings are an original contribution  
326 meriting publication in a peer-reviewed journal, investigators may be motivated to develop  
327 interventions that differ from, rather than replicate (and thus strengthen), previous work.

328

329 Nonetheless, at the program level, there is a need to identify and carry out interventions with  
330 strong evidence of effectiveness and, hopefully, cost-effectiveness. Thus, it is critical that  
331 federal, academic, non-governmental, and other partners working on asthma ensure that future  
332 studies advance the field, moving beyond the state of insufficient evidence. Substantial steps  
333 have already been taken toward standardizing definitions and endpoints for clinical asthma trials  
334 and clinical practice.<sup>58</sup> Further collaboration is needed to standardize measures of program  
335 inputs, the reach of interventions, characteristics of the populations enrolled, program outputs,  
336 and proximal outcomes, such as knowledge, behavior change, and asthma control.

337

338 Beyond the standardization of indicators, there is a need for cross-agency collaboration on  
339 identifying and filling gaps in knowledge about effective public health interventions. No single  
340 agency or organization has sufficient resources to do this alone. To start, work on interventions  
341 of demonstrated effectiveness, such as SME, should move beyond additional studies or reviews

342 to focus on implementation issues such as identifying, reaching, and engaging the participants  
343 most likely to benefit, and on collecting information on the costs, advantages, and drawbacks of  
344 different strategies for doing so on a large scale. Rather than supporting further trials of single  
345 trigger interventions, future research should address the added value of packages of trigger-  
346 reduction activities appropriate to a geographic area.

347

348 Given that SME and optimal medical management are core recommendations of the NAEPP  
349 guidelines, these two interventions should be the baseline against which the added value of other  
350 interventions is measured in implementation research. The core components of SME and medical  
351 management are defined in the NAEPP guidelines. The tools and materials needed to implement  
352 those components should be standardized. Funding agencies could assure the quality of funded  
353 research by requiring that studies include the core components of SME, and use standardized  
354 tools, materials, and outcome measures.

355

356 Clearly, further reviews of other interventions about which there are published studies of good  
357 quality would be an important contribution. This umbrella review found that systematic reviews  
358 of two types of interventions may be feasible to conduct at this time: community-based  
359 pharmacy interventions, and interventions using inpatient and outpatient clinical pathways. In  
360 many intervention areas, however, there are few or no studies of adequate quality. Given the  
361 breadth of the field and the number of unanswered questions, it is crucial to prioritize research to  
362 inform the work of public health programs charged with reducing the burden of asthma. Further  
363 expanding the quality and scope of evidence related to public health interventions for asthma will  
364 advance control of this common and costly condition.

365

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371

372

373  
374

## References

- 375 1. Akinbami L, Moorman J, Liu X. *Asthma prevalence, health care use, and mortality:*  
376 *United States, 2005-2009.* Vol 32. Hyattsville, MD: National Center for Health Statistics;  
377 2011.
- 378 2. Moorman JE, Rudd RA, Johnson CA, et al. National surveillance for asthma--United  
379 States, 1980-2004. *MMWR Surveill Summ.* Oct 19 2007;56(8):1-54.
- 380 3. NHLBI. National Asthma Education and Prevention Program. NHLBI Expert Panel  
381 Report 3: Guidelines for the Diagnosis and Management of Asthma. 2007;  
382 <http://www.nhlbi.nih.gov/guidelines/asthma/asthgdln.htm>. Accessed November 15, 2010.
- 383 4. Micucci S, Thomas H, Vohra J. The effectiveness of school-based strategies for the  
384 primary prevention of obesity and for promoting physical activity and/or nutrition, the  
385 major modifiable risk factors for type 2 diabetes: a review of reviews. City of Hamilton,  
386 ON: The Effective Public Health Practice Project; 2002.
- 387 5. Campbell F, Jones K. Feather vs. non-feather bedding for asthma. *Cochrane Database*  
388 *Syst Rev.* 2000(4):CD002154.
- 389 6. Kilburn S, Lasserson TJ, McKean M. Pet allergen control measures for allergic asthma in  
390 children and adults. *Cochrane Database Syst Rev.* 2003(1):CD002989.
- 391 7. Maciejewski ML, Chen SY, Au DH. Adult asthma disease management: an analysis of  
392 studies, approaches, outcomes, and methods. *Respir Care.* Jul 2009;54(7):878-886.
- 393 8. Bravata DM, Gienger AL, Holty JE, et al. Quality improvement strategies for children  
394 with asthma: a systematic review. *Arch Pediatr Adolesc Med.* Jun 2009;163(6):572-581.
- 395 9. Bravata DM, Sundaram V, Lewis R, et al. Closing the quality gap: A critical analysis of  
396 quality improvement strategies. AHRQ Publication No. 04(07)-0051-5. Rockville, MD:  
397 Agency for Healthcare Research and Quality; 2007.
- 398 10. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized  
399 clinical trials: is blinding necessary? *Control Clin Trials.* Feb 1996;17(1):1-12.
- 400 11. Centre for Evidence-Based Physiotherapy. PEDro Scale. 1999;  
401 <http://www.pedro.org.au/english/downloads/pedro-scale/>. Accessed December 3, 2010.
- 402 12. Bailey EJ, Cates CJ, Kruske SG, Morris PS, Brown N, Chang AB. Culture-specific  
403 programs for children and adults from minority groups who have asthma. *Cochrane*  
404 *Database Syst Rev.* 2009(2):CD006580.
- 405 13. Chang AB, Taylor B, Masters IB, Laifoo Y, Brown AD. Indigenous healthcare worker  
406 involvement for Indigenous adults and children with asthma. *Cochrane Database Syst*  
407 *Rev.* 2010(5):CD006344.
- 408 14. Bernard-Bonin AC, Stachenko S, Bonin D, Charette C, Rousseau E. Self-management  
409 teaching programs and morbidity of pediatric asthma: a meta-analysis. *J Allergy Clin*  
410 *Immunol.* Jan 1995;95(1 Pt 1):34-41.
- 411 15. Wolf FM, Guevara JP, Grum CM, Clark NM, Cates CJ. Educational interventions for  
412 asthma in children. *Cochrane Database Syst Rev.* 2002(1):CD000326.
- 413 16. Coffman JM, Cabana MD, Halpin HA, Yelin EH. Effects of asthma education on  
414 children's use of acute care services: a meta-analysis. *Pediatrics.* Mar 2008;121(3):575-  
415 586.

- 416 **17.** Gibson PG, Powell H, Coughlan J, et al. Self-management education and regular  
 417 practitioner review for adults with asthma. *Cochrane Database Syst Rev.*  
 418 2002(1):CD001117.
- 419 **18.** Willems DC, Joore MA, Hendriks JJ, Wouters EF, Severens JL. Cost-effectiveness of  
 420 self-management in asthma: a systematic review of peak flow monitoring interventions.  
 421 *Int J Technol Assess Health Care.* Fall 2006;22(4):436-442.
- 422 **19.** Boyd M, Lasserson TJ, McKean MC, Gibson PG, Ducharme FM, Haby M. Interventions  
 423 for educating children who are at risk of asthma-related emergency department  
 424 attendance. *Cochrane Database Syst Rev.* 2009(2):CD001290.
- 425 **20.** Tapp S, Lasserson TJ, Rowe B. Education interventions for adults who attend the  
 426 emergency room for acute asthma. *Cochrane Database Syst Rev.* 2007(3):CD003000.
- 427 **21.** Bussey-Smith KL, Rossen RD. A systematic review of randomized control trials  
 428 evaluating the effectiveness of interactive computerized asthma patient education  
 429 programs. *Ann Allergy Asthma Immunol.* Jun 2007;98(6):507-516; quiz 516, 566.
- 430 **22.** Coffman JM, Cabana MD, Yelin EH. Do school-based asthma education programs  
 431 improve self-management and health outcomes? *Pediatrics.* Aug 2009;124(2):729-742.
- 432 **23.** Gibson PG, Powell H, Coughlan J, et al. Limited (information only) patient education  
 433 programs for adults with asthma. *Cochrane Database Syst Rev.* 2002(2):CD001005.
- 434 **24.** Zemek RL, Bhogal SK, Ducharme FM. Systematic review of randomized controlled  
 435 trials examining written action plans in children. *Archives of Pediatrics & Adolescent*  
 436 *Medicine.* 2008;162(2):157-163.
- 437 **25.** Toelle BG, Ram FS. Written individualised management plans for asthma in children and  
 438 adults. *Cochrane Database Syst Rev.* 2004(2):CD002171.
- 439 **26.** Lefevre F, Piper M, Weiss K, Mark D, Clark N, Aronson N. Do written action plans  
 440 improve patient outcomes in asthma? An evidence-based analysis. *J Fam Pract.* Oct  
 441 2002;51(10):842-848.
- 442 **27.** Powell H, Gibson PG. Options for self-management education for adults with asthma.  
 443 *Cochrane Database Syst Rev.* 2002(1):CD004107.
- 444 **28.** Bhogal S, Zemek R, Ducharme FM. Written action plans for asthma in children.  
 445 *Cochrane Database Syst Rev.* 2006;3:CD005306.
- 446 **29.** Gibson PG, Powell H. Written action plans for asthma: an evidence-based review of the  
 447 key components. *Thorax.* Feb 2004;59(2):94-99.
- 448 **30.** Ring N, Malcolm C, Wyke S, et al. Promoting the use of Personal Asthma Action Plans:  
 449 a systematic review. *Prim Care Respir J.* Oct 2007;16(5):271-283.
- 450 **31.** MacDonald C, Sternberg A, Hunter PR. A systematic review and meta-analysis of  
 451 interventions used to reduce exposure to house dust and their effect on the development  
 452 and severity of asthma. *Environ Health Perspect.* Dec 2007;115(12):1691-1695.
- 453 **32.** Gotzsche PC, Johansen HK. House dust mite control measures for asthma: systematic  
 454 review. *Allergy.* Jun 2008;63(6):646-659.
- 455 **33.** Adair CE, Patten S. A review of interventions for reduction of residential environmental  
 456 tobacco smoke exposures among children. *Paediatr Child Health.* Feb 2001;6(2):70-79.
- 457 **34.** Blackhall K, Appleton S, Cates CJ. Ionisers for chronic asthma. *Cochrane Database Syst*  
 458 *Rev.* 2003(3):CD002986.
- 459 **35.** McDonald E, Cook D, Newman T, Griffith L, Cox G, Guyatt G. Effect of air filtration  
 460 systems on asthma: a systematic review of randomized trials. *Chest.* Nov  
 461 2002;122(5):1535-1542.

- 462 **36.** Crocker DD, Kinyota SK, Dumitru G, et al. Effectiveness of home-based multi-trigger,  
463 multicomponent interventions with an environmental focus for reducing asthma  
464 morbidity: a Community Guide systematic review. *Am J Prev Med.* 2011;41(2,  
465 Supplement 1):S5-S30.
- 466 **37.** Nurmagambetov TA, Barnett SBL, Jacob V, et al. Economic value of home-based, multi-  
467 trigger, multicomponent interventions with an environmental focus for reducing asthma  
468 morbidity: a Community Guide systematic review. *American Journal of Preventive*  
469 *Medicine.* 2011;41(2, Supplement 1):S33–S47.
- 470 **38.** Postma J, Karr C, Kieckhefer G. Community health workers and environmental  
471 interventions for children with asthma: a systematic review. *J Asthma.* Aug  
472 2009;46(6):564-576.
- 473 **39.** Jones A, Fay JK, Ram FS. Primary care based clinics for asthma. *Cochrane Database of*  
474 *Systematic Reviews.* 2002(1):Art. No. CD003533.
- 475 **40.** Eastwood A, Sheldon T. Organisation of asthma care: what difference does it make? A  
476 systematic review of the literature. *Quality in health care.* 1996;5(3):134.
- 477 **41.** Banasiak NC, Meadows-Oliver M. Inpatient asthma clinical pathways for the pediatric  
478 patient: an integrative review of the literature. *Pediatr Nurs.* Nov-Dec 2004;30(6):447-  
479 450.
- 480 **42.** Benavides S, Rodriguez JC, Maniscalco-Feichtl M. Pharmacist involvement in improving  
481 asthma outcomes in various healthcare settings: 1997 to present. *Ann Pharmacother.* Jan  
482 2009;43(1):85-97.
- 483 **43.** Barton C, Sulaiman N, Liaw S. Continuing medical education for asthma in primary care  
484 settings: a review of randomised controlled trials. *Prim Care Respir J.* 2003;12(4):119-  
485 123.
- 486 **44.** Feenstra TL, Rutten-Van Molken MP, Jager JC, Van Essen-Zandvliet LE. Cost  
487 effectiveness of guideline advice for children with asthma: a literature review. *Pediatr*  
488 *Pulmonol.* Dec 2002;34(6):442-454.
- 489 **45.** Cates C, Jefferson T, Rowe B. Vaccines for preventing influenza in people with asthma.  
490 *status and date: Edited (no change to conclusions), published in.* 2008;2.
- 491 **46.** Sheikh A, Alves B, Dhami S. Pneumococcal vaccine for asthma. *Cochrane Database of*  
492 *Systematic Reviews.* 2002(1):CD002165.
- 493 **47.** Ram FS, Robinson SM, Black PN, Picot J. Physical training for asthma. *Cochrane*  
494 *Database Syst Rev.* 2005(4):CD001116.
- 495 **48.** Welsh L, Kemp JG, Roberts RG. Effects of physical conditioning on children and  
496 adolescents with asthma. *Sports Med.* 2005;35(2):127-141.
- 497 **49.** Ford E. The epidemiology of obesity and asthma. *J Allergy Clin Immunol.*  
498 2005;115(5):897-909.
- 499 **50.** Eneli IU, Skybo T, Camargo CA, Jr. Weight loss and asthma: a systematic review.  
500 *Thorax.* Aug 2008;63(8):671-676.
- 501 **51.** Roberston-Malt S. Non-medical management of asthma in adults. *Int J Nurs Pract.* Apr  
502 2010;16(2):208-219.
- 503 **52.** Centers for Disease Control and Prevention (CDC). Vital signs: asthma prevalence,  
504 disease characteristics, and self-management education--United States, 2001-2009.  
505 *MMWR Morb Mortal Wkly Rep.* 2011;60(17):547-552.
- 506 **53.** Leviton L, Gutman M. Overview and rationale for the Systematic Screening and  
507 Assessment Method. *New Directions for Evaluation. Special Issue: The Systematic*

- 508            *Screening and Assessment Method: Finding Innovations Worth Evaluating*. 2010;125:7–  
509            31.
- 510    **54.**    O'Brien MA, Rogers S, Jamtvedt G, et al. Educational outreach visits: effects on  
511            professional practice and health care outcomes. *Cochrane Database Syst Rev*.  
512            2007(4):CD000409.
- 513    **55.**    Jamtvedt G, Young JM, Kristoffersen DT, O'Brien MA, Oxman AD. Does telling people  
514            what they have been doing change what they do? A systematic review of the effects of  
515            audit and feedback. *Qual Saf Health Care*. Dec 2006;15(6):433-436.
- 516    **56.**    Rotter T, Kinsman L, James E, et al. Clinical pathways: effects on professional practice,  
517            patient outcomes, length of stay and hospital costs. *Cochrane Database Syst Rev*.  
518            2010(3):CD006632.
- 519    **57.**    Renders CM, Valk GD, Griffin S, Wagner EH, Eijk JT, Assendelft WJ. Interventions to  
520            improve the management of diabetes mellitus in primary care, outpatient and community  
521            settings. *Cochrane Database Syst Rev*. 2001(1):CD001481.
- 522    **58.**    Reddel H, Taylor D, Bateman E, et al. An official American Thoracic Society/European  
523            Respiratory Society statement: asthma control and exacerbations: standardizing endpoints  
524            for clinical asthma trials and clinical practice. *Am J Respir Crit Care Med*.  
525            2009;180(1):59.
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## **List of Figures and Tables**

### **Figures**

Figure 1. Umbrella review flow chart

### **531 Tables**

532 Table 1. Possible public health interventions for asthma

533 Table 2. Findings from systematic reviews of interventions addressing asthma education, self-  
534 management, and/or monitoring of symptoms

535 Table 3. Findings from systematic reviews of interventions addressing written asthma action  
536 plans (WAAPs)

537 Table 4. Findings from systematic reviews of environmental interventions

538 Table 5. Findings from systematic reviews of interventions related to the provision of health care

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### **540 Supplementary Data (to be posted online)**

541 Appendix A. Quality assessment instrument

542 Appendix B. Summary of included reviews

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# Public Health Interventions for Asthma

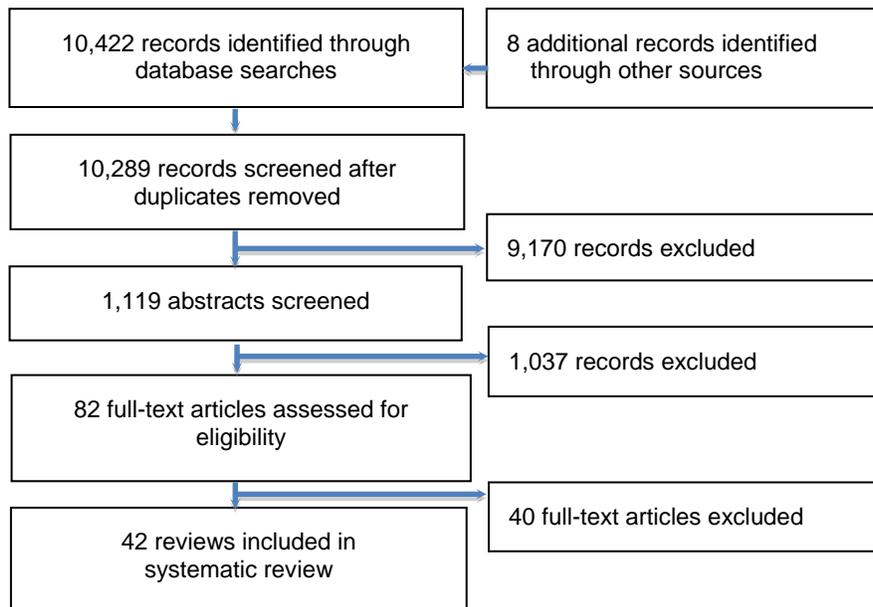
## An Umbrella Review, 1990–2010

Magdala P. Labre, PhD, MPH, Elizabeth J. Herman, MD, MPH, Gema G. Dumitru, MD, MPH,  
Kristine A. Valenzuela, BA, Christy L. Cechman, BA, MLIS, DC

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### Appendix A

#### Umbrella Review Flow Chart



## Appendix B

### Quality-Assessment Instrument

Item <sup>a</sup>
1. Does the review describe the search strategy used to identify studies (i.e., search terms, databases)?
2. Was the search comprehensive (i.e., do you trust that appropriate sources were used and that relevant studies were not missed)? Relevant databases include PubMed (includes MEDLINE), EMBASE, CINAHL, PsychInfo, ERIC, and Cochrane. Other possible sources include reference lists, hand searches of journals, and experts.
3. Does the review list the inclusion and exclusion criteria used to select studies and adhere to these criteria?
4. Does the review assess the quality of the included studies?
5. Does the quality assessment consider at least three of the following: Type of study design Random allocation of subjects to interventions (Jadad, <sup>1</sup> PEDro <sup>2</sup> ) Allocation concealment (Cochrane grades A–D) and/or blinding Confounders Adequate description of the interventions Withdrawals and dropouts (Jadad <sup>1</sup> )
6. Does the review integrate findings beyond describing or listing the results of the included studies?  Yes: Conducts meta-analysis; or Provides forest plot or other graphic summary presentation of results by outcome; or Includes a narrative integration of outcomes (e.g., three of five studies found significant improvements in symptom scores)  Ideally, the summary of findings should differentiate studies with rigorous and nonrigorous designs (unless the review is limited to rigorous designs).  No: Qualitative summary that does not integrate findings in a systematic way (e.g., most of the studies indicated improvement in at least one outcome; overall results suggest effectiveness)
7. Do the conclusions presented in the review accurately represent the findings of the included studies?  Yes: Results are clear (all studies show effectiveness or lack thereof) and the conclusions are consistent with the findings; or Results are mixed and the process for determining the direction of the evidence is articulated in the text or clear from the presentation of the data  No: The method by which the conclusions were reached is not clear; or Conclusions are generalized from a single study; or Conclusions are not consistent with the data

Source: Adapted from Reference 3.

<sup>a</sup> Possible answers are: *yes* (1 point); *no*; *unknown*.

PEDro, Physiotherapy Evidence Database's PEDro scale

## References for Appendix B

1. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized clinical trials: Is blinding necessary? *Control Clin Trials* 1996;17(1):1–12.
2. Centre for Evidence-Based Physiotherapy. PEDro Scale, 1999. [www.pedro.org.au/english/downloads/pedro-scale/](http://www.pedro.org.au/english/downloads/pedro-scale/)
3. Micucci S, Thomas H, Vohra J. The effectiveness of school-based strategies for the primary prevention of obesity and for promoting physical activity and/or nutrition, the major modifiable risk factors for type 2 diabetes: a review of reviews. Hamilton, Ontario: The Effective Public Health Practice Project, 2002.

## Appendix C

### Summary of Included Reviews

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
<b>SME</b>				
Bernard-Bonnin (1995) <sup>1</sup>	11 RCT  Educational interventions on self-management of asthma, which were interactive and delivered one-on-one or in a group setting	Children aged 1–18 years, with a confirmed diagnosis of asthma  Overall, asthma severity was classified as mild to moderate, but information on severity was often incomplete or missing.	As indicated by the following effect sizes of the pooled studies, self-management teaching did not reduce: school absenteeism (0.04 ± 0.08); asthma attacks (0.09 ± 0.14); hospitalizations (0.06 ± 0.08); hospital days (–0.11 ± 0.08); or emergency visits (0.14 ± 0.09).	Strong  Interventions were not described in detail.
Wolf (2002) <sup>2,a</sup>	26 RCT, 6 NRCT  SME programs, which differed by type of educational session (15 used group sessions, 14 used individual sessions, three used both); intensity (five using one session, two using two, 25 using three or more); self-monitoring strategy (13 peak flow-based, 19 symptom-based); and length of the intervention  All included asthma prevention measures (e.g., avoidance of triggers) and/or attack management plans (e.g., use of WAAP).	Children (n=12) and adolescents (n=15) with asthma, and their caregivers  Of the 32 trials, 15 included participants with moderate-to-severe asthma, four with mild-to-moderate asthma, and 13 with asthma of unclear severity. Six studies (five in the U.S.) indicated that participants had low income.	Moderate improvement in lung function (n=4, SMD: 0.50 [95% CI=0.25, 0.75]) and self-efficacy (n=6, SMD: 0.36 [95% CI=0.15, 0.57]); modest reductions in days of school absence (n=16, SMD: –0.14 [95% CI= –0.23, –0.04]) and days of restricted activity (n=16, SMD: –0.29 [95% CI= –0.49, –0.08]); and a reduction in emergency room visits (n=12, SMD: –0.21 [95% CI= –0.33, –0.09]). Effects were greater for most outcomes in moderate-severe, compared with mild-moderate asthma, and in studies using peak flow-versus symptom-based self-monitoring strategies.	Strong
Coffman (2008) <sup>3</sup>	30 RCT, 4 Obs, 3 Other  Various educational interventions, including individualized education, group classes, and educational computer games  Just over half of the studies reported providing comprehensive education that addressed all four topics recommended in NHLBI guidelines. Outpatient clinics and physician offices were the most common settings. Duration ranged from a few weeks to >12 months; number of sessions ranged from 1 to 90.	Children aged 2–17 years with clinical diagnosis of asthma and their caregivers (n=22); children only (n=12); or caregivers only (n=3)  In 70% of the studies, most participants received Medicaid, were uninsured, and had low income. In two thirds of the studies, two thirds or more of children were black or Latino.	Studies that compared asthma education vs usual care (n=27) found that education decreased mean hospitalizations (n=5, SMD: –0.35 [95% CI= –0.063, –0.08]) and mean emergency department visits (n=13, SMD: –0.17 [95% CI= –0.31, –0.03]).  Findings of studies that compared two or more asthma education interventions (n=10) could not be pooled due to the small number of studies and heterogeneity of outcomes.	Moderate  Search dates not provided  Quality assessment of included studies not described

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
Gibson (2002) <sup>4,a</sup>	<p>36 RCT</p> <p>SME compared with usual care</p> <p>All 36 trials included some degree of patient education; 33 included self-monitoring of symptoms and/or peak expiratory flow; 24 included regular review of treatment and asthma severity by a medical practitioner; and 18 included a WAAP.</p>	<p>Patients with asthma aged <math>\geq 16</math> years</p> <p>Most trials indicated that participants had diagnosed asthma. Asthma severity was not indicated in most studies, but a few included only patients with moderate to severe asthma.</p>	<p>Compared to usual care, SME reduced hospitalizations (<math>n=12</math>, relative risk: 0.64 [95% CI=0.50, 0.82]); emergency room visits (<math>n=13</math>, relative risk: 0.82 [95% CI=0.73, 0.94]); unscheduled visits to the doctor (<math>n=7</math>, relative risk: 0.68 [95% CI=0.56, 0.81]); days off work or school (<math>n=7</math>, relative risk: 0.79 [95% CI=0.67, 0.93]), and nocturnal asthma (<math>n=5</math>, relative risk: 0.67 [95% CI=0.56, 0.79]), and improved quality of life (<math>n=6</math>, SMD: 0.29 [95% CI=0.11, 0.47]). Measures of lung function were little changed. The review also found a reduction in total costs, but it did not reach significance (<math>n=3</math>, SMD: -0.26 [95% CI= -0.55, 0.03]).</p>	Strong
Willems (2006) <sup>5</sup>	<p>13 RCT, 5 BAS, 3 Obs</p> <p>Studies in which self-management based on peak-flow monitoring was the main intervention and that included separate cost data</p> <p>All included some type of health education, 14 indicated self-treatment by medication at home based on peak-flow monitoring. Most studies lacked a full description of the intervention, but some used group-only sessions, and others combined individual and group sessions.</p>	Patients with asthma	<p>In 18 studies, the interventions led to net savings compared with usual care or a less-intensive intervention. Only three studies found the total costs to be higher in the intervention group. In 13 of the 17 studies that analyzed health outcomes, at least one of the reported health outcomes improved significantly. Because methods of economic evaluation differed among the studies and were not always consistent with the standard methodology, no conclusions were reached regarding cost effectiveness.</p>	Strong
<b>Asthma education (with or without SME)</b>				
Boyd (2009) <sup>6,a</sup>	<p>38 RCT</p> <p>A variety of educational interventions for children who had visited the emergency room for asthma, delivered in the hospital, home, community, schools, or outpatient settings</p> <p>Six included WAAPs. Some also addressed care coordination or environmental triggers.</p>	<p>Children and their caregivers</p> <p>Seventeen studies targeted low-income groups. Although most did not report race/ethnicity, more than ten included African Americans and at least two included Hispanics.</p>	<p>Reduced risk of subsequent emergency department visits (<math>n=17</math>, risk ratio: 0.73 [95% CI=0.65, 0.81]) and hospital admissions (<math>n=18</math>, risk ratio: 0.79 [95% CI=0.69, 0.92]) compared with the control; fewer unscheduled doctor visits (<math>n=7</math>, risk ratio: 0.68 [95% CI=0.57, 0.81]); data for other outcomes (lung function, rescue medication use, quality of life or symptoms) were limited, and no significant differences found.</p>	Strong

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
Tapp (2007) <sup>7,a</sup>	<p>12 RCT</p> <p>A diverse mix of educational interventions targeting adults who had attended an emergency room setting for treatment of an asthma exacerbation</p> <p>The interventions took place within 1 week of the emergency room visit. Most addressed written self-management plans and information on symptoms and trigger control.</p>	<p>Adults (one also included children, but they were excluded from the analysis)</p> <p>Asthma severity was not reported, but participants had to have at least one severe exacerbation. Race/ethnicity generally was not reported, but in two studies most participants were African American.</p>	<p>Reduced admission to hospital (<math>n=5</math>, relative risk: 0.50 [95% CI=0.27, 0.91], but not risk of re-presentation at emergency departments during follow-up (<math>n=7</math>, relative risk: 0.69 [95% CI=0.40, 1.21]); no differences regarding peak flow, quality of life, study withdrawal, or days lost, but few studies examined these outcomes.</p>	<p>Strong</p>
Coffman (2009) <sup>8</sup>	<p>18 RCT, 6 Obs</p> <p>School-based asthma education</p> <p>In 18 of 20 interventions that reported contents of the education, all four topics recommended by NHLBI were addressed. The number of sessions ranged from two to 34, with a median of six. Duration ranged from 2 weeks to 1 year, with a median of 6 weeks.</p>	<p>Students with asthma aged 4–17 years</p> <p>Nine interventions were delivered to children only, and 15 also targeted parents, school personnel, and/or classmates. Many children had mild asthma. In 12 of 19 reporting race/ethnicity, most were black or Latino.</p>	<p>Improved knowledge of asthma in seven of ten studies, self-efficacy in six of eight studies, and self-management behaviors in seven of eight studies. Fewer studies reported favorable effects on distal outcomes, with school-based asthma education improving quality of life in four of eight studies, days with symptoms in five of 11 studies, nights with symptoms in two of four studies, and school absences in five of 17 studies.</p>	<p>Strong</p> <p>Conclusions appear to be based on whether &gt;50% of studies measuring a specific outcome reported results favorable to the intervention.</p>
Bussey-Smith (2007) <sup>9</sup>	<p>9 RCT</p> <p>Interactive CAPEPs</p> <p>Four were computer games aimed at children or adolescents. In two of these, the program was tailored to the specific features of asthma in the individual playing the game. Web-based education and a personal interactive communication device were other educational methods evaluated. Some interventions included educational group visits or home visits.</p>	<p>Patients aged 3–75 years, with seven studies including children only (aged <math>\leq 17</math> years), and two adults only</p> <p>Four studies enrolled urban or inner-city populations, of which 57%–92% were receiving Medicaid or were uninsured. In four of seven studies reporting race/ethnicity, most were African-American and one included many Hispanics. Asthma severity reported in seven studies ranged from mild to severe.</p>	<p>Meta-analysis (<math>n=4</math>) found no improvement in lung function. Asthma symptoms improved in five studies and asthma knowledge improved in four. Parallel improvements in both experimental patients and controls were found in several studies. The less-intense educational intervention provided to the control groups may have made it difficult to detect intervention effects. The studies that provided more CAPEP exposure reported improvements in asthma knowledge.</p>	<p>Moderate</p> <p>Some review findings were summarized in a general way (e.g., two of four studies).</p> <p>Quality assessment of included studies not described</p>

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
Bailey (2009) <sup>10,a</sup>	<p>4 RCT</p> <p>Asthma education programs specifically tailored to minority groups</p> <p>Strategies included: educational sessions (in appropriate languages); culturally tailored print materials and videotape; follow-up written materials; phone calls; and distribution of resources such as WAAPs and free peak-flow meters.</p>	<p>Low-income Puerto Rican families with children; low-income Hispanic and African-American families with children diagnosed with asthma; African-American adult patients; and minority children and adults with asthma in the UK</p>	<p>A meta-analysis of two studies with adults found that, compared with generic programs or usual care, culture-specific programs improved asthma quality-of-life scores (WMD: 0.25 [95% CI=0.09, 0.41]). Findings from the two pediatric studies were mixed, with few outcomes being included in more than one study.</p> <p>In one study, the intervention reduced hospitalizations in children (risk ratio: 0.32 [95% CI=0.15, 0.70]). The other pediatric study estimated economic savings based on reduction of emergency room visits.</p>	<p>Strong</p>
Chang (2010) <sup>11,a</sup>	<p>2 RCT</p> <p>Indigenous healthcare workers</p> <p>In one study, a Hispanic and African-American educator/psychologist delivered a program that addressed asthma within a historical and socioeconomic context and emphasized collaborative asthma management. The other provided children with education, consultation with respiratory specialists, guidance on use of an action plan, personalized booklets, and three visits from a health worker. The control group did not receive a booklet and was not visited by a health worker. All children (i.e., both arms) received routine education.</p>	<p>Children aged 1–17 years with asthma, and parents/caretakers</p> <p>Asthma severity was not reported. One trial included Hispanic (73%) and African-American (27%) families from an inner-city community. All were from low SES background. The other enrolled 113 children from a remote indigenous region in Australia.</p>	<p>Meta-analyses found no difference in asthma exacerbations but significant differences in parents' asthma knowledge scores (<math>n=2</math>, SMD: 1.23 [95% CI=0.59, 1.87]), and in parents' asthma skill scores (<math>n=2</math>, SMD: 0.67 [95% CI=0.28, 1.06]) favoring the intervention. One study found an improvement in days absent from school (100% school-aged children in the intervention group missed &lt;7 days; 21% of controls missed 7–14 days; difference=21% [95% CI=5%–36%]).</p>	<p>Moderate</p> <p>Studies had small samples and quality limitations.</p> <p>One study of Hispanic and African-American children should not have been included, as participants did not meet the authors' definition of "indigenous."</p>

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
<b>Asthma education only</b>				
Gibson (2002) <sup>12,a</sup>	<p>12 RCT</p> <p>Interventions for adults with asthma that used limited asthma education (i.e., interactive and non-interactive education that transfers information about asthma, its causes, and its treatment)</p> <p>Interventions that used self-monitoring, assessed or modified medical therapy, or developed an individualized action plan were excluded from the review.</p>	All targeted adults with diagnosed asthma, but three also included children or adolescents.	<p>There was no reduction in days lost from normal activity, but in two studies, perceived asthma symptoms improved (OR: 0.44 [95% CI=0.26, 0.74]). No decrease in hospitalization for asthma (<math>n=3</math>, WMD: <math>-0.03</math> average hospitalizations per person per year [95% CI= <math>-0.09</math>, <math>0.03</math>]); no effect on doctor visits, lung function, or medication use; emergency department visits reduced in one study (reduction of <math>-2.76</math> average visits per person per year [95% CI=<math>1.18</math>, <math>4.34</math>])</p> <p>Costs were measured in two studies: one found an average saving in healthcare costs of \$1913 per person over a 12-month period, but the other did not demonstrate cost effectiveness.</p>	Strong
<b>WAAP</b>				
Toelle (2004) <sup>13,a</sup>	<p>7 RCT</p> <p>The review assessed the effectiveness of symptom-based and peak flow-based WAAPs, which were compared to each other or to no WAAP.</p>	<p>Adult patients, except for one study that also included children</p> <p>All patients had "well established asthma." The descriptions of participants (on inhaled corticosteroids, having presented for urgent care, or with moderate-to-severe disease) suggest that most had persistent asthma.</p>	<p>Three studies comparing use of WAAP with no WAAP found no consistent evidence that use of a WAAP produced better patient outcomes, due to the heterogeneity of outcomes. In five studies comparing peak flow- vs symptom-based plans, one type was not found to be consistently more effective than the other.</p>	Strong
Lefevre (2002) <sup>14</sup>	<p>9 RCT</p> <p>All studies used a WAAP. Other components varied across trials. Two of the studies had three arms, leading to 11 comparisons: medical management with a peak flow-based WAAP vs medical management without a WAAP (<math>n=5</math>); peak-flow meter self-monitoring with a WAAP vs peak-flow meter self-monitoring and no WAAP (<math>n=2</math>); and use of WAAP based on peak-flow monitoring vs use of symptom-based plan (<math>n=4</math>).</p>	<p>Adult patients, except for one study that included only children</p> <p>All had been treated for asthma for at least 12 weeks. Asthma severity ranged from mild to severe.</p>	<p>In seven studies comparing use of WAAP with no WAAP (in two studies the no-WAAP group received a peak-flow meter), only two studies found benefits, but both had flaws. In four studies comparing different WAAPs, outcomes were generally equivalent among groups.</p>	Strong

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
Zemek (2008) <sup>15</sup>	<p>5 RCT</p> <p>Use of WAAP with children with asthma</p> <p>One study compared WAAP to no WAAP, and four compared symptom-based to peak flow-based WAAPs. All co-interventions (both medical and education) were similar in intervention and control groups. With the exception of one study, all the children received daily preventive medication. All but one trial used three-step, street sign-colored plans.</p>	<p>School-aged children with asthma recruited from outpatient settings, and their parents</p> <p>Asthma severity was described as mild to severe (<math>n=2</math> studies); moderate (<math>n=1</math>); and moderate to severe (<math>n=2</math>).</p>	<p>One study comparing WAAP to no WAAP found that use of a peak flow-based plan reduced the mean number of acute care visits per child, school days missed, nocturnal awakenings, and symptom scores. In four studies comparing plans, symptom-based plans reduced by 27% the risk of an acute care visit, compared with peak flow-based plans (<math>n=4</math>, relative risk: 0.73 [95% CI=0.55, 0.99]), but peak flow-based plans reduced by ½ day the number of symptomatic days per week (WMD: 0.45 [95% CI=0.04, 0.25]). Children preferred symptom-based over peak flow-based plans (relative risk: 1.21 [95% CI =1.00, 1.46]). No difference were found in parental preferences or other outcomes.</p>	Strong
Powell (2002) <sup>16,a</sup>	<p>15 RCT (26 interventions)</p> <p>Interventions included asthma education and self-monitoring; regular review of treatment plans and asthma severity by a medical practitioner (25 interventions); and use of a WAAP (23 interventions). Six studies compared optimal self-management (allowing self-adjustment of medications according to WAAP) with adjustment of medications by doctor, and six compared peak flow with symptom-only self-management. In three studies, optimal self-management was compared to modifications of optimal self-management.</p>	<p>Participants were recruited from a variety of inpatient and outpatient medical settings. Only adults (aged &gt;16 years) were included in the analysis. Asthma severity ranged from mild to severe, although this was not consistently reported.</p>	<p>No differences were found between optimal self-management and adjustment of medications by a doctor regarding hospitalization, emergency room visits, unscheduled doctor visits, or nocturnal asthma (<math>n=6</math>). No differences were found between self-management interventions using a WAAP based on symptoms vs a WAAP based on peak-flow monitoring (<math>n=6</math>). In three studies that tested different options for self-management (i.e., optimal therapy without regular review vs optimal therapy with regular review, low-intensity vs high-intensity education, verbal instruction vs written action plans), findings were mixed.</p>	Strong  “Regular review” is not defined; unclear if it refers to “standard care” or to a more-intense and frequent intervention by either the primary care physician or a pulmonary specialist.

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
Bhogal (2006) <sup>17,a</sup>	4 RCT  Use of WAAPs in combination with asthma education and other elements, such as a nurse visit. The trials compared symptom-based plans with peak flow-based plans. No trial compared plan to no plan.	Schoolchildren aged $\geq 6$ years, but one study also included teenagers (aged $< 19$ years).  Asthma severity ranged from mild to severe. Race/ethnicity was reported in two studies, with one reporting that all subjects were Caucasian and the other that participants were 66% white, 24% black, and 10% other.	Use of symptom-based WAAPs reduced the risk of exacerbations that required an acute care visit ( $n=5$ , relative risk: 0.73 [95% CI=0.55, 0.99]). Peak flow-based action plans reduced by $\frac{1}{2}$ day the number of symptomatic days per week ( $n=2$ , mean difference: 0.45 days/week [95% CI=0.04, 0.86]). Children preferred symptom monitoring over peak-flow monitoring ( $n=2$ , relative risk: 1.21 [95% CI=1.00, 1.46]), but parents showed no preference ( $n=2$ ). No significant differences in rate of exacerbation requiring oral steroids or admission, school absenteeism, lung function, symptom score, or quality of life.	Strong
Gibson (2004) <sup>18</sup>	26 RCT  The review compared WAAPs classified as individualized and complete ( $n=17$ ), specifying when and where to increase treatment with incomplete plans ( $n=4$ ) that did not specify the use of early intervention with inhaled corticosteroids; and with nonspecific plans ( $n=5$ ) that only provided general information on the management of deteriorating asthma ( $n=5$ ). Fifteen of the trials also included education, self-monitoring, and regular medical review.	People with asthma	Individualized complete action plans were found to reduce hospital admissions, whether the action points were based on personal best PEF ( $n=5$ , relative risk: 0.66 [95% CI=0.48, 0.91]), or percentage predicted PEF ( $n=4$ , relative risk: 0.46 [95% CI=0.26, 0.81]). Only action plans based on personal best PEF reduced emergency room visits ( $n=4$ , relative risk: 0.78 [95% CI=0.64, 0.95]); improved lung function ( $n=3$ , SMD: PEF: 0.56 [95% CI=0.37, 0.75]); and reduced days off for asthma ( $n=2$ , relative risk: 0.07 [95% CI=0.53, 0.92]). Plans using from two to four action points improved hospitalizations, emergency room visits, and PEFs. Findings regarding incomplete WAAPs were inconclusive due to insufficient data; findings regarding nonspecific plans were mixed.	Weak  No information on database search, done as part of broader Cochrane review  No details regarding patients or interventions  Not clear how authors isolated the effectiveness of the WAAPs from the effects of other intervention components  Quality assessment not described

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
Ring (2007) <sup>19</sup>	14 RCT  Interventions to increase WAAP ownership and use Twelve targeted asthma patients, one consisted of provider education, and one was a quality-improvement effort targeting primary care teams at medical practices. Five of the 12 patient-centered interventions consisted of SME. The others used: telephone calls ( <i>n</i> =2); school asthma clinics ( <i>n</i> =2); Internet-based physician monitoring system ( <i>n</i> =1); postal prompts combined with partially completed personalized action plans ( <i>n</i> =1); and use of the 3+ asthma management plan combined with an asthma recall system ( <i>n</i> =1).	People with asthma (or caregivers), doctors, and general practice teams  Six studies investigated adults only, four included adults and children, one included children only, three included children with their health professionals, and two included patients aged >70 years. Most participants had moderate to severe asthma or were recruited following medical care for acute asthma.	Some interventions increased WAAP ownership or use, but the review found a lack of robust evidence on the best and most practical ways to sustain action plan use among patients over the long term. (The review did not assess the effect of WAAP use on health outcomes.)	Moderate  Narrative synthesis with no integration of findings by outcome  Most studies addressed ownership, rather than use of the plan.  Criteria for determining effectiveness not stated
<b>Reduction of indoor allergens</b>				
Adair (2001) <sup>20</sup>	Two RCT, one other design (Note: The review also included studies conducted with children without asthma.)  Physician counseling of parents on reduction of environmental tobacco smoke; other strategies included referral to an allergy clinic ( <i>n</i> =1 study); educational materials ( <i>n</i> =2); and personalized letter from physician on children's cotinine results ( <i>n</i> =1).	Smoking ( <i>n</i> =3) and nonsmoking ( <i>n</i> =1) parents of children with asthma	Small-to-moderate reductions in reported environmental tobacco smoke exposure or respiratory symptoms. Although parents did not smoke fewer cigarettes in each period, they reported smoking less frequently in the house and when in the same room as their asthmatic children.	Strong
Campbell (2000) <sup>21.a</sup>	0 (no studies met inclusion criteria)  Nonfeather bedding vs feather bedding	Not applicable	No evidence, as no studies met inclusion criteria.	N/A
Blackhall (2003) <sup>22.a</sup>	6 RCT  Inhalation of positively (one lab study) or negatively ionized air (five studies in the home) generated by an ionizer compared with inhalation of air from a dummy ionizer. Some studies used exercise or histamine provocation.	Children ( <i>n</i> =4) and adults ( <i>n</i> =2) with asthma	None of the five studies on negatively ionized air reported a difference in lung function, symptoms, or medication use.	Strong

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
McDonald (2002) <sup>23</sup>	10 RCT Effect of HEPA residential air filters on asthma Some studies also used trigger avoidance and containment methods, home cleaning, medications, and education.	Children only (n=1); adults only (n=5); and mixed groups (n=4) with asthma Two enrolled rhinitis or asthma patients, three specified allergies, and one specified "mild asthmatics."	Meta-analyses found improvement in symptoms but no differences in medication use or morning peak expiratory flow values. Heterogeneity of results weakens inferences from these trials. In addition, none of the trials used validated scales to measure clinical symptoms or quality of life.	Strong
Kilburn (2001) <sup>24,a</sup>	2 RCT Reduction of pet allergens One study used a Honeywell enviocare HEPA filter in bedrooms plus other allergen removal activities; the other used a Phillips air cleaner in living rooms and bedrooms only.	Children (n=1) and adults (n=1) with asthma or rhinitis, with a cat or dog in the home	No differences regarding lung function, bronchial hyper-responsiveness, symptom scores, medication usage, allergen concentrations, or biochemical markers No studies of other interventions to reduce pet allergens were found.	Strong
Gotzsche (2008) <sup>25,a</sup>	54 RCT Chemical and/or physical measures to reduce dust mite antigens in the home	Children and adults with asthma It is not clear if all were sensitive to dust mites.	No effect on various outcomes, including lung function, asthma symptoms, and medication use	Strong
MacDonald (2007) <sup>26</sup>	6 RCT (Note: The review also included other studies addressing primary prevention of asthma.)  Dust mite removal All studies included allergen removal measures, with three providing instructions on how to reduce allergens, and one providing home remediation.	Children and adults with asthma, some of whom were sensitive to dust mites	Meta-analyses found a reduction in days with symptoms (n=2), but not in lung function (n=3). One study suggested a strong placebo effect.	Strong

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
Crocker (2011) <sup>27</sup>	13 RCT, 1 NCRT, 9 BAS  Home-based multicomponent interventions addressing multiple triggers Components included environmental assessment ( <i>n</i> =21); minor or major remediation ( <i>n</i> =17); and education ( <i>n</i> =21).	Children or adolescents ( <i>n</i> =20); adults ( <i>n</i> =1); and mixed aged groups ( <i>n</i> =2) Most were urban, inner-city minority populations.	Studies with children and adolescents ( <i>n</i> =20) found improvements in asthma symptoms and school days missed due to asthma and small improvements in healthcare utilization. In three studies with adults, one found improvement in quality-of-life or symptom scores, but no improvements in healthcare utilization or productivity. Cost-benefit ratios ( <i>n</i> =3) suggest that the interventions provide substantial returns on each dollar invested. Cost-effectiveness studies ( <i>n</i> =3) reported costs ranging from \$12 to \$57 per additional asthma symptom-free day, indicating good value for money invested.	Strong
Postma (2009) <sup>28</sup>	7 RCT  Home-based interventions delivered by community health worker All provided education and pillow and mattress encasements; some provided resources for allergen removal.	Children with asthma and their caretakers Most were from low-income groups and ethnic minorities.	Overall, the studies consistently identified positive outcomes, including decreased asthma symptoms, daytime activity limitations, and emergency and urgent care. However, the review did not integrate the study findings, so strength of evidence is unclear. Improvements in trigger-reduction behaviors and allergen levels were inconsistent.	Moderate  Findings discussed qualitatively but not integrated
<b>Interventions to improve the provision of health care</b>				
Banasiak (2004) <sup>29</sup>	1 RCT, 1 NRCT, 1 BAS, 1 Obs, 1 Other (pre/post with historical controls)  Interventions using clinical pathways for inpatient treatment of asthma “Clinical pathways” were not clearly defined.	Children with asthma in an inpatient setting	Evidence of effectiveness in reducing length of stay (four of five studies) and at least a part of total hospital costs (four of five studies). No differences in readmission rates (four studies).	Moderate  Quality assessment not described
Barton (2003) <sup>30</sup>	3 RCT  Continuing medical education for general practitioners: effect on health outcomes  Small group interactive education sessions (one to seven sessions) for primary care physicians in the U.S., The Netherlands, and England Outcomes were measured in child and adult patients with asthma.	General practitioners providing care to children with asthma ( <i>n</i> =1); adults with asthma ( <i>n</i> =1); and children and adults with asthma ( <i>n</i> =1)	One study found health benefits in regard to hospital admissions, emergency department visits, scheduled visits for asthma, and number of days with symptoms in spring and summer, but only among a subgroup of patients who began using inhaled corticosteroids during the trial. When patients were followed up to 2 years later, the intervention group differed from the control group regarding hospital admissions only. The other two studies did not find benefits to patients in the intervention group for asthma morbidity or quality of life.	Strong

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
Jones (2002) <sup>31,a</sup>	1 RCT  Organized care via primary care-based clinics. Registered nurses in eight general practices in South Australia conducted a 3-hour asthma clinic session per week, which included education, self-management training, and consultation with a general practitioner.	Adult patients with asthma	Effect found for 2 of 11 outcome measures (ownership of peak-flow meters, and night symptoms)  “Firm conclusions cannot be formed until more good quality trials have been carried out.”	Strong
Benavides (2009) <sup>32</sup>	7 RCT, 7 NRCT, 8 BAS, 3 NR  Fifteen pharmacy-based interventions that provided training and resources to community pharmacists; five studies in which pharmacists provided education and compliance monitoring to patients in ambulatory clinics, sometimes in coordination with other providers; two studies in which pharmacists provided education before discharge from a hospital; and three in which education was provided in the community	Children ( <i>n</i> =15); adults ( <i>n</i> =5); and both ( <i>n</i> =5)	Pharmacy-based interventions found improvements in lung function (five of 12 studies); symptoms (six of eight); and asthma severity (two of four). Findings regarding quality of life and emergency room visits or hospitalizations were mixed. One of the two trials conducted in hospital settings found a decrease in emergency department visits and hospitalizations.	Weak  Quality assessment not described; findings of non-pharmacy-based interventions not summarized by outcome; all findings summarized in general way
Maciejewski (2009) <sup>33</sup>	5 RCT, 19 BAS, 3 Other (post-only observational with control group)  Outpatient asthma disease-management interventions Most included patient education and assessment and monitoring of patients by nurse or pharmacist involved in case management. Other components included feedback to physicians about patients ( <i>n</i> =14); action plans ( <i>n</i> =11); and physician education ( <i>n</i> =5).	Adults with asthma  The severity of asthma varied.	Due to limitations in study design, outcome assessment, and statistical adjustment, the review could not draw definite conclusions about effectiveness or cost effectiveness.	Strong

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
Eastwood (1996) <sup>34</sup>	9 RCT, 4 NRCT, 8 BAS, 6 Other (audit and descriptive reports)  Interventions using different organizational methods to deliver asthma care: community-based provision (n=6); outpatient provision (n=6); inpatient provision (n=4); asthma clinics in general practice (n=4); asthma consultations in general practice (n=3); emergency department provision (n=3); and integrated care (n=1)	Children (n=13 studies); adults (n=5); and not reported (n=9)  One study included European and Polynesian children, and one included inner-city African-American children.	The review found no conclusive evidence to favor any particular organizational form (e.g., inpatient, outpatient, asthma clinic, or specialist care). Interventions were heterogeneous, and organizational components were not isolated from other intervention elements.	Moderate  Findings not integrated
Bravata (2007) <sup>35</sup>	65 RCT, 13 BAS, 14 Other (studies with results abstracted from the full report)  Quality-improvement strategies for outpatient asthma care Many interventions had more than one component, with 59 addressing self-management, 46 patient or caregiver education, 14 organizational change, 11 provider education, five audit and feedback, three provider reminders, two facilitated relay of clinical data to providers, and one addressing financial, regulatory, or legislative incentives.	General populations with asthma consisting typically of adults  Some studies also included children. Asthma severity varied from mild to severe. Studies that focused on children were summarized in a separate publication (Bravata 2009). <sup>36</sup>	Education and/or self-management interventions improved percentage predicted FEV1 (17 studies) and mean peak flow (16 studies). Eleven of 12 interventions that combined education and/or self-management with organizational changes found improvements in processes and outcomes of care. Provider education led to some improvement in adherence to asthma management guidelines. Evidence was insufficient to assess effectiveness of other interventions.	Moderate  Quality assessment not described
Bravata (2009) <sup>36</sup>	68 RCT, 11 NRCT  (Same as above); of the 79 studies, 69 included some component of patient education, self-monitoring, or self-management; 13 included some component of organizational change; and seven included provider education.	Children aged <18 years, with six studies including only adolescents Studies enrolling both adults and children were included if data for children were reported separately.	Self-management interventions increased symptom-free days by approximately 10 days per year and reduced school absenteeism by about 0.1 day per month. Provider education and organizational change interventions reported improvements in medication use, but data were not presented.	Strong
Feenstra (2002) <sup>37</sup>	2 RCT, 1 Obs, 5 Other (cost analysis or cost-effectiveness analyses)  Interventions examining cost effectiveness of adhering to guidelines issued by four different groups. Three studies addressed education and/or self-management, and five organizational interventions (three focused on the employment of specialized asthma nurses).	Children with asthma, but one included patients aged 0–21 years.  Asthma severity varied, but some studies included only children with severe asthma.	Education and self-management (n=3) led to net savings only in children with severe asthma. The cost analyses of specialized asthma nurses suggest net savings, but results may not be generalizable. No good studies addressing the cost effectiveness of allergen avoidance or allergen immunotherapy for asthma patients were identified.	Moderate  Quality assessment not described  Process for determining cost effectiveness across studies not described

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
<b>Other systematic reviews of asthma interventions</b>				
Cates (2008) <sup>38,a</sup>	16 RCT  Influenza vaccination in people with asthma  Intramuscular injections of killed virus were most commonly studied, but four trials studied intranasal live vaccine.	The intervention was delivered to children ( $n=8$ ) and adults ( $n=7$ ) with asthma. Two studies did not report age. One study reported that the sample was Caucasian.	Benefits: One trial of 696 children did not find a reduction in influenza-related asthma exacerbations. An analysis of asthma symptoms during influenza-positive illness weeks, however, did indicate an improvement in asthma quality-of-life scores in the vaccination group. Harms: Pooled results of two large trials did not find an increase in asthma exacerbations in the 2 weeks following influenza vaccination. No indication of an increase in adverse respiratory consequences in children aged 6–17 receiving the intranasal (compared with intramuscular) vaccine, but one study on infants raised concerns over increased wheezing and hospital admissions following vaccination.	Strong  Mainly a review of vaccine safety; very few data on efficacy  All results regarding efficacy were drawn from a single study.
Eneli (2008) <sup>39</sup>	1 RCT, 14 NR (most observational or quasi-experimental)  Weight loss interventions: four medical (three low-calorie diets and one weight loss program) and 11 surgical	All studies conducted with adults (mostly women) and in white populations  One study also included one child.	All studies reported an improvement in at least one asthma outcome (i.e., symptoms, use of medications, or hospitalizations) after weight loss. However, small sample sizes and weak study designs made it difficult to reach a conclusion regarding the effectiveness of medical and surgical weight loss interventions as a treatment for asthma.	Moderate  Although the authors indicate some of the limitations of included studies, no formal quality assessment seems to have been conducted.
Ram (2005) <sup>40,a</sup>	13 RCT  Physical training (whole-body aerobic exercise) interventions undertaken for at least 20 to 30 minutes, 2 to 3 times a week, over a minimum of 4 weeks.	Children aged $\geq 8$ years ( $n=11$ ) and adults ( $n=2$ ). Participants had diagnosed asthma, but severity was not reported in most studies.	Although physical training had no effect on resting lung function or the number of days of wheeze among patients with asthma, lung function and wheeze were not worsened by physical training.  Physical training improved cardiopulmonary fitness as measured by an increase in the maximum oxygen uptake ( $n=7$ ) and maximum expiratory ventilation ( $n=4$ ).	Strong

Study	Study designs and interventions	Participants	Overall findings	Quality rating/ comments
Sheikh (2002) <sup>41,a</sup>	1 RCT  Pneumococcal immunization in young children with asthma and recurrent otitis media	Children with asthma, aged 2–6 years, recruited from an allergy clinic, who had bronchial asthma beginning at least 6 months prior to enrollment and had four or more physician-diagnosed episodes of otitis media; about 61% male	The greatest reduction in asthma attacks was seen in the children treated with pneumococcal vaccination and daily sulfisoxazole (to prevent otitis media) from the beginning of the study.	Strong  Results are not generalizable because they are based on a single study of a subset of patients recruited from a specialist allergy clinic.
Welsh (2005) <sup>42</sup>	31 NR  Physical conditioning programs for children and adolescents with asthma  The most common activities were running, swimming, and cycling. Other types of activities included ball games, rope climbing, endurance work, circuit training, and gymnastics.	Children and adolescents with asthma aged 5–17 years  Severity of asthma not reported in most studies but reported as moderate-to-severe in one study, and severe in two studies. Most studies included more boys than girls, and four studies included only boys. Race/ethnicity: NR	Effects on training performance and aerobic fitness: Most training studies proved beneficial with respect to changes in aerobic fitness.  Effects on EIA and asthma symptoms: The review identified four studies demonstrating an improvement in EIA and nine reports showing no alteration.  Effects on non-EIA asthma symptoms: Several studies [number not specified] reported improvements, such as reductions in: hospitalizations, wheeze frequency, school absenteeism, doctor consultations, and medication usage.	Weak  Although the authors indicate some of the limitations of included studies, no formal quality assessment seems to have been done.  Findings presented by study but not integrated

*Note:* Quality rating: strong (6–7 points); moderate (4–5 points); weak ( $\leq 3$  points)

<sup>a</sup> Cochrane systematic review

BAS, before-and-after study; CAPEP, computerized asthma patient education program; EIA, exercise-induced asthma; FEV1, forced expiratory volume in 1 second; HEPA, high-efficiency particulate air; ITS, interrupted time-series; *n*, number of studies; NHLBI, National Heart Lung and Blood Institute; NR, not reported; NRCT, nonrandomized controlled trial; Obs, observational study; PEF, peak expiratory flow; SMD, standardized mean difference; SME, self-management education; WAAP, written asthma action plan; WMD, weighted mean difference

## Appendix D

### Findings from systematic reviews of interventions addressing asthma education and/or self-management education

Review	Studies	Lung function	Symptoms /QOL	Hosp	Emergency	Meds	Missed work/school	Cost	Quality rating
<b>SME</b>									
<b>Pediatric</b> Bernard-Bonnin (1995) <sup>1</sup>	11 RCT	n/a	0	0	0	n/a	0	n/a	Strong
Wolf (2002) <sup>2,a</sup>	26 RCT 6 NRCT	+	+	0	+	n/a	+	n/a	Strong
Coffman (2008) <sup>3</sup>	30 RCT 4 Obs 3 Other	n/a	n/a	+	+	n/a	n/a	n/a	Moderate <sup>b</sup>
<b>With regular review, adults</b> Gibson (2002) <sup>4,a</sup>	36 RCT	0	+	+	+	0	+	0	Strong
<b>SME with peak-flow monitoring</b> Willems (2006) <sup>5</sup>	13 RCT 5 BAS 3 Obs	Review examined only cost effectiveness but did not reach a conclusion because interventions, costs, and outcomes were diverse.							Strong
<b>ASTHMA EDUCATION (WITH OR WITHOUT SME)</b>									
<b>Post-emergency, children</b> Boyd (2009) <sup>6,a</sup>	38 RCT	0 <sup>c</sup>	0 <sup>c</sup>	+	+	<sup>d</sup>	n/a	n/a	Strong
<b>Post-emergency, adults<sup>a</sup></b> Tapp (2007) <sup>7</sup>	12 RCT	0 <sup>c</sup>	0 <sup>d</sup>	+	0	n/a	0 <sup>c</sup>	0 <sup>d</sup>	Strong
<b>School-based</b> Coffman (2009) <sup>3</sup>	18 RCT 6 Obs	n/a	±	n/a	n/a	n/a	0	n/a	Strong <sup>d</sup>
<b>Computerized</b> Bussey-Smith (2007) <sup>9</sup>	9 RCT	0	+	0	0	0	n/a	+ <sup>d</sup>	Moderate <sup>b,e</sup>
<b>Culture-specific asthma education</b> Bailey (2009) <sup>10,a</sup>	4 RCT	n/a	±	± <sup>c</sup>	0 <sup>c</sup>	n/a	n/a	+ <sup>d</sup>	Strong

<b>By IHWs</b>										
Chang (2010) <sup>11,a</sup>	2 RCT	n/a	0 <sup>d</sup>	0 <sup>d</sup>	0 <sup>c</sup>	n/a	+ <sup>d</sup>	+ <sup>dc</sup>	Moderate <sup>f</sup>	
<b>ASTHMA EDUCATION ONLY (NO SME)</b>										
<b>Limited<sup>a</sup></b>										
Gibson (2002) <sup>12</sup>	12 RCT	0 <sup>c,h</sup>	+ <sup>c</sup>	0	+ <sup>d,h</sup>	0	0	± <sup>c,h</sup>	Strong	

Note: 0=no benefit; + = benefit; ± = mixed findings. Emergency includes emergency room and other unscheduled visits.

<sup>a</sup> Cochrane systematic review

<sup>d</sup> Findings are based on one study.

<sup>c</sup> Findings are based on two studies.

<sup>h</sup> Data are missing in studies examining the outcome.

<sup>e</sup> Study findings are summarized in a general way (e.g., two of four studies examining outcome had favorable findings).

<sup>b</sup> Quality assessment was not described.

<sup>f</sup> One included study did not meet inclusion criteria.

<sup>g</sup> Conclusions are general and do not address all findings.

BAS, before-and-after study; Hosp, hospitalization; IHW, indigenous healthcare worker; Meds, medications; n/a, not assessed by review; NRCT, nonrandomized controlled trial; Obs, observational study; SME, self-management education; Symp/QOL, asthma symptoms or quality of life

## Appendix E

### Findings from systematic reviews of interventions addressing written asthma action plans

Review	Studies	Main findings	Quality
Use with children, Zemek (2008) <sup>15</sup>	5	One study comparing use of a WAAP to no WAAP found that use of a peak flow-based plan reduced acute care visits, school days missed, and symptoms. In four studies comparing different types of plans, symptom-based plans reduced acute care visits, and peak flow-based plans reduced symptoms. No differences were found in other outcomes, but children preferred symptom-based plans.	Strong
Use with adults, Toelle (2004) <sup>13,a,b</sup>	7	Three studies comparing use of a WAAP with no WAAP found no consistent evidence that use of a WAAP produced better patient outcomes, due to the heterogeneity of outcomes. In five studies comparing peak flow- to symptom-based plans, neither type of plan was found to be consistently more effective than the other.	Strong
Use with adults, Lefevre (2002) <sup>14</sup>	9	In seven studies comparing use of a WAAP to no WAAP (in two studies, the no-WAAP group received a peak-flow meter), only two studies found benefits of a WAAP, but both had flaws. In four studies comparing different WAAPs, outcomes were generally equivalent among groups.	Strong
Type and monitoring—adults, Powell (2002) <sup>16,a</sup>	15	No differences were found between optimal self-management using a WAAP vs adjustment of medications by a doctor. No differences were found between self-management interventions using a WAAP based on symptoms vs a WAAP based on peak-flow monitoring.	Strong
Type of WAAP—children, Bhogal (2006) <sup>17,a</sup>	4	Symptom-based plans were more effective than peak flow-based plans in reducing acute care visits. Peak flow-based plans were more effective in reducing number of symptom days. Symptom monitoring was preferred over peak-flow monitoring by children; no differences in other outcomes.	Strong
Components, Gibson (2004) <sup>18</sup>	26	Individualized and complete WAAPs reduced hospital admissions, emergency room visits, and days off for asthma; and improved lung function. No benefits were found for other types of plans due to few studies, missing data, and mixed findings.	Weak <sup>c</sup>
Promotion of use, Ring (2007) <sup>19</sup>	14	Some interventions increased WAAP ownership or use, but the review found a lack of robust evidence on the best and most practical ways to sustain action plan use among patients over the long term.	Moderate <sup>d</sup>

Note: All studies were RCTs. Effect of plans was not isolated from other that of other intervention components; incomplete reporting of methods. Findings are not integrated by outcome. Emergency room visits also includes other unscheduled visits.

<sup>a</sup> Cochrane systematic review

<sup>b</sup> One study also included children.

WAAP, written asthma action plan

## Appendix F

### Findings from systematic reviews of interventions related to the provision of health care

Review	Studies	Lung function	Symp /QOL	Hosp	Emergency	Meds	Missed work/school	Cost	Review quality
Quality-improvement strategies—pediatric, Bravata (2009) <sup>36</sup>	68 RCT 11 NRCT	Multiple interventions; self-management interventions increased symptom-free days and reduced school absenteeism. Provider education and organizational change interventions were likely to report improvements in medication use.							Strong
Quality-improvement strategies—adults, <sup>a</sup> Bravata (2007) <sup>35</sup>	65 RCT 13 BAS 14 Other	Multiple interventions; self-monitoring, self-management, and/or patient education improved lung function. No findings for other interventions due to few studies and heterogeneity among interventions.							Moderate <sup>b</sup>
Outpatient disease management, Maciejewski (2009) <sup>33</sup>	5 RCT 19 BAS 3 Other	Poor study design and differences in or lack of information on intervention components prevented authors from drawing conclusions regarding the effectiveness of disease management interventions.							Strong
Organized care via primary care clinics—adults, <sup>c</sup> Jones (2002) <sup>31</sup>	1 RCT	n/a	+ <sup>d</sup>	0 <sup>d</sup>	0 <sup>d</sup>	0 <sup>d</sup>	0 <sup>d</sup>	n/a	Strong
Organization (delivery) of care, Eastwood (1996) <sup>34</sup>	9 RCT 4 NRCT 8 BAS 6 Other	The review found no conclusive evidence to favor any particular organizational form (e.g., inpatient, outpatient, asthma clinic, or specialist care). Interventions were heterogeneous, and organizational components were not isolated from other intervention elements.							Moderate
Inpatient clinical pathways—pediatric, Banasiak (2004) <sup>29</sup>	1 RCT 1 NRCT 1 BAS 1 Obs 1 Other	n/a	n/a	±	n/a	n/a	n/a	+	Moderate <sup>b</sup>
Use of pharmacists, Benavides (2009) <sup>32</sup>	7 RCT 7 NRCT 8 BAS 3 NR	0	±	±	±	0	0	n/a	Weak <sup>b,e</sup>
Continuing medical education, Barton (2003) <sup>30</sup>	3 RCT	n/a	0	+ <sup>d</sup>	0 <sup>d</sup>	n/a	0 <sup>d</sup>	n/a	Strong
Cost effectiveness of guideline use, Feenstra (2002) <sup>37</sup>	2 RCT <sup>f</sup> 1 Obs 5 Other	Education and self-management (three studies) led to net savings in children with severe asthma only. Net savings also were associated with three organizational interventions using specialized asthma nurses.							Moderate <sup>b</sup>

Note: 0=no benefit; + = benefit; ± = mixed findings. Emergency includes emergency room visits and other unscheduled visits.

<sup>c</sup> Cochrane systematic review

<sup>d</sup> Findings are based on one study.<sup>b</sup> Quality assessment was not described.

<sup>e</sup> Findings from the subset of 15 interventions conducted in community pharmacies; all are summarized in a general way (e.g., two of four studies examining an outcome had favorable findings).

<sup>a</sup> Information on studies targeting children was abstracted and reported separately in Bravata 2009.<sup>36</sup>

<sup>f</sup> Information on studies assessing medications was not abstracted.

BAS, before-and-after study; Hosp, hospitalization; Meds, medications; ; n/a, not assessed by review; NR, not reported; NRCT, nonrandomized controlled trial; Obs, observational study; Symp/QOL, asthma symptoms or quality of life

## Appendix G

### Findings from systematic reviews of environmental interventions

Review	Studies	Lung function	Symp/QOL	Hosp	Emergency	Meds	Missed work/school	Review quality
Reduction of exposure to dust mites, MacDonald (2007) <sup>26</sup>	6 RCT <sup>a</sup>	0	+ <sup>b</sup>	n/a	n/a <sup>c</sup>	n/a	n/a	Strong
Reduction of exposure to dust mites, <sup>d</sup> Gotzsche (2008) <sup>25</sup>	54 RCT	0	0	0 <sup>e</sup>	n/a	0	0 <sup>b</sup>	Strong
Reduction of residential ETS exposure, Adair (2001) <sup>20</sup>	2 RCT <sup>f</sup> 1 other	+ <sup>e</sup>	+ <sup>e</sup>	n/a	n/a	n/a	n/a	Strong
Pet allergen control by air filtration, <sup>d</sup> Kilburn (2001) <sup>24</sup>	2 RCT	0 <sup>b</sup>	0 <sup>b</sup>	n/a	n/a	0 <sup>b</sup>	n/a	Strong
Nonfeather bedding, <sup>d</sup> Campbell (2000) <sup>21</sup>	0 <sup>g</sup>	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ionizers, <sup>d</sup> Blackhall (2003) <sup>22</sup>	6 RCT	0	0	n/a	n/a	0	n/a	Strong
Air filtration systems, McDonald (2002) <sup>23</sup>	10 RCT	0	+ <sup>h</sup>	n/a	n/a	0	n/a	Strong
Home-based multi-trigger, multicomponent interventions, Crocker (2011) <sup>27</sup>	13 RCT 1 NRCT 9 BAS	0	+	+	+	0	+	Strong
Indoor multi-trigger reduction by CHWs, Postma (2009) <sup>28</sup>	7 RCT	n/a	?	?	?	n/a	n/a	Moderate

Note: 0 = no benefit; + = benefit; ?, unclear because findings not integrated by the authors. Emergency includes emergency room visits and other unscheduled visits.

<sup>d</sup> Cochrane systematic review

<sup>b</sup> Findings are based on two studies.

<sup>e</sup> Findings are based on one study.

<sup>c</sup> Data could not be combined.

<sup>g</sup> No studies met inclusion criteria.

<sup>h</sup> Substantial heterogeneity among studies included in meta-analyses weakens inferences.

<sup>f</sup> Subset of studies addressing children with asthma (others addressed well children).

<sup>a</sup> Subset of studies addressing reduction of asthma severity (others addressed asthma prevention).

BAS, before-and-after study; CHW, community health worker; Hosp, hospitalization; Meds, medications; n/a, not assessed by review; NRCT, nonrandomized controlled trial; Symp/QOL, asthma symptoms or quality of life

## References for Appendixes C-G

1. Bernard-Bonnin AC, Stachenko S, Bonin D, Charette C, Rousseau E. Self-management teaching programs and morbidity of pediatric asthma: a meta-analysis. *J Allergy Clin Immunol* 1995;95(1 Pt 1):34–41.
2. Wolf FM, Guevara JP, Grum CM, Clark NM, Cates CJ. Educational interventions for asthma in children. *Cochrane Database Syst Rev* 2002(1):CD000326.
3. Coffman JM, Cabana MD, Halpin HA, Yelin EH. Effects of asthma education on children's use of acute care services: a meta-analysis. *Pediatrics* 2008;121(3):575–86.
4. Gibson PG, Powell H, Coughlan J, et al. Self-management education and regular practitioner review for adults with asthma. *Cochrane Database Syst Rev* 2002(1):CD001117.
5. Willems DC, Joore MA, Hendriks JJ, Wouters EF, Severens JL. Cost-effectiveness of self-management in asthma: a systematic review of peak flow monitoring interventions. *Int J Technol Assess Health Care* 2006;22(4):436–42.
6. Boyd M, Lasserson TJ, McKean MC, Gibson PG, Ducharme FM, Haby M. Interventions for educating children who are at risk of asthma-related emergency department attendance. *Cochrane Database Syst Rev* 2009(2):CD001290.
7. Tapp S, Lasserson TJ, Rowe B. Education interventions for adults who attend the emergency room for acute asthma. *Cochrane Database Syst Rev* 2007(3):CD003000.
8. Coffman JM, Cabana MD, Yelin EH. Do school-based asthma education programs improve self-management and health outcomes? *Pediatrics* 2009;124(2):729–42.
9. Bussey-Smith KL, Rossen RD. A systematic review of randomized control trials evaluating the effectiveness of interactive computerized asthma patient education programs. *Ann Allergy Asthma Immunol Jun* 2007;98(6):507–16; quiz 516, 566.
10. Bailey EJ, Cates CJ, Kruske SG, Morris PS, Brown N, Chang AB. Culture-specific programs for children and adults from minority groups who have asthma. *Cochrane Database Syst Rev* 2009(2):CD006580.
11. Chang AB, Taylor B, Masters IB, Laifoo Y, Brown AD. Indigenous healthcare worker involvement for Indigenous adults and children with asthma. *Cochrane Database Syst Rev* 2010(5):CD006344.
12. Gibson PG, Powell H, Coughlan J, et al. Limited (information only) patient education programs for adults with asthma. *Cochrane Database Syst Rev* 2002(2):CD001005.
13. Toelle BG, Ram FS. Written individualised management plans for asthma in children and adults. *Cochrane Database Syst Rev* 2004(2):CD002171.
14. Lefevre F, Piper M, Weiss K, Mark D, Clark N, Aronson N. Do written action plans improve patient outcomes in asthma? An evidence-based analysis. *J Fam Pract* 2002;51(10):842–8.
15. Zemek RL, Bhogal SK, Ducharme FM. Systematic review of randomized controlled trials examining written action plans in children. *Archiv Ped Adol Med* 2008;162(2):157–63.
16. Powell H, Gibson PG. Options for self-management education for adults with asthma. *Cochrane Database Syst Rev* 2002(1):CD004107.
17. Bhogal S, Zemek R, Ducharme FM. Written action plans for asthma in children. *Cochrane Database Syst Rev* 2006;3:CD005306.
18. Gibson PG, Powell H. Written action plans for asthma: an evidence-based review of the key components. *Thorax* 2004;59(2):94–9.

19. Ring N, Malcolm C, Wyke S, et al. Promoting the use of Personal Asthma Action Plans: a systematic review. *Prim Care Respir J* 2007;16(5):271–83.
20. Adair CE, Patten S. A review of interventions for reduction of residential environmental tobacco smoke exposures among children. *Paediatr Child Health* 2001;6(2):70–9.
21. Campbell F, Jones K. Feather vs. non-feather bedding for asthma. *Cochrane Database Syst Rev* 2000(4):CD002154.
22. Blackhall K, Appleton S, Cates CJ. Ionisers for chronic asthma. *Cochrane Database Syst Rev* 2003(3):CD002986.
23. McDonald E, Cook D, Newman T, Griffith L, Cox G, Guyatt G. Effect of air filtration systems on asthma: a systematic review of randomized trials. *Chest* 2002;122(5):1535–42.
24. Kilburn S, Lasserson TJ, McKean M. Pet allergen control measures for allergic asthma in children and adults. *Cochrane Database Syst Rev* 2001(1):CD002989.
25. Gotzsche PC, Johansen HK. House dust mite control measures for asthma: systematic review. *Allergy* 2008;63(6):646–59.
26. MacDonald C, Sternberg A, Hunter PR. A systematic review and meta-analysis of interventions used to reduce exposure to house dust and their effect on the development and severity of asthma. *Environ Health Perspect* 2007;115(12):1691–5.
27. Crocker DD, Kinyota SK, Dumitru G, et al. Effectiveness of home-based multi-trigger, multicomponent interventions with an environmental focus for reducing asthma morbidity: a Community Guide systematic review. *Am J Prev Med* 2011;41(2, S1):S5–S30.
28. Postma J, Karr C, Kieckhefer G. Community health workers and environmental interventions for children with asthma: a systematic review. *J Asthma* 2009;46(6):564–76.
29. Banasiak NC, Meadows-Oliver M. Inpatient asthma clinical pathways for the pediatric patient: an integrative review of the literature. *Pediatr Nurs* 2004;30(6):447–50.
30. Barton C, Sulaiman N, Liaw S. Continuing medical education for asthma in primary care settings: a review of randomized controlled trials. *Prim Care Respir J* 2003;12(4):119–23.
31. Jones A, Fay JK, Ram FS. Primary care based clinics for asthma. *Cochrane Database Syst Rev* 2002(1):CD003533.
32. Benavides S, Rodriguez JC, Maniscalco-Feichtl M. Pharmacist involvement in improving asthma outcomes in various healthcare settings: 1997 to present. *Ann Pharmacother* 2009;43(1):85–97.
33. Maciejewski ML, Chen SY, Au DH. Adult asthma disease management: an analysis of studies, approaches, outcomes, and methods. *Respir Care* 2009;54(7):878–86.
34. Eastwood A, Sheldon T. Organization of asthma care: What difference does it make? A systematic review of the literature. *Qual Health Care* 1996;5(3):134.
35. Bravata DM, Sundaram V, Lewis R, et al. Closing the quality gap: a critical analysis of quality improvement strategies. AHRQ Pub. 04(07)-0051-5. Rockville MD: Agency for Healthcare Research and Quality, 2007.
36. Bravata DM, Gienger AL, Holty JE, et al. Quality improvement strategies for children with asthma: a systematic review. *Arch Ped Adol Med* 2009;163(6):572–81.
37. Feenstra TL, Rutten-Van Molken MP, Jager JC, Van Essen-Zandvliet LE. Cost effectiveness of guideline advice for children with asthma: a literature review. *Pediatr Pulmonol* 2002;34(6):442–54.
38. Cates C, Jefferson T, Rowe B. Vaccines for preventing influenza in people with asthma. status and date: Edited (no change to conclusions), published in. 2008;2.

39. Eneli IU, Skybo T, Camargo CA, Jr. Weight loss and asthma: a systematic review. *Thorax* 2008;63(8):671–6.
40. Ram FS, Robinson SM, Black PN, Picot J. Physical training for asthma. *Cochrane Database Syst Rev* 2005(4):CD001116.
41. Sheikh A, Alves B, Dhami S. Pneumococcal vaccine for asthma. *Cochrane Database Syst Rev* 2002(1):CD002165.
42. Welsh L, Kemp JG, Roberts RG. Effects of physical conditioning on children and adolescents with asthma. *Sports Med* 2005;35(2):127–41.