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## **School-based self-management interventions for asthma among primary school children: A systematic review**

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1 **Abstract**

2 A Cochrane review of school-based asthma interventions (combining all ages) found  
3 improved health outcomes. Self-management skills, however, vary according to age.  
4 We assessed effectiveness of primary school-based self-management interventions  
5 and identified components associated with successful programmes in children aged 6-  
6 12 years. We updated the Cochrane search (March 2020) and included the Global  
7 Health database. Two reviewers screened, assessed risk-of-bias and extracted data.  
8 We included 23 studies (10,682 participants); four at low risk-of-bias. Twelve studies  
9 reported at least one positive result for an outcome of interest. All 12 positive studies  
10 reported parental involvement in the intervention, compared to two-thirds of ineffective  
11 studies. In 10 of the 12 positive studies, parental involvement was substantial (e.g.  
12 attending sessions; phone/video communication) rather than being provided with  
13 written information. School-based self-management intervention can improve health  
14 outcomes and substantial parental involvement in school-based programmes seemed  
15 important for positive outcomes among primary school children.

16

17 Word count: 147 (Maximum: 150)

18

19 Keywords: systematic review, school-based, self-management, primary school  
20 children, and parental involvement

21

22

23

24

25

26 **Introduction**

27 Asthma, the commonest long-term condition among children, causes significant  
28 morbidity and mortality globally<sup>1</sup>. Asthma guidelines recommend supported self-  
29 management to improve asthma control and reduce the use of urgent healthcare  
30 services<sup>2-4</sup>. Supported self-management, which includes discussion about self-  
31 management and provision of a personalised asthma action plan supported by regular  
32 asthma review, can be delivered effectively in diverse cultural and demographic  
33 groups<sup>5,6</sup>.

34

35 School-based asthma self-management interventions have been reported to improve  
36 asthma control and reduce school absenteeism and asthma exacerbations<sup>7-11</sup>.

37 However, most systematic reviews analysed combined data from primary and  
38 secondary schools (5-18 years)<sup>7-10</sup>. One scoping review conducted in 2014 focused  
39 on primary school children, but the aim was to identify research gaps rather than  
40 assess outcomes<sup>11</sup>. The Cochrane review (Harris, 2019) used meta-analyses to  
41 assess intervention effectiveness and qualitative comparative analysis to examine the  
42 components of successful implementations<sup>7</sup>. The authors identified a number of  
43 components as being important: theoretical underpinning, parental involvement, child  
44 satisfaction and conducting the intervention during lesson time. However, the  
45 Cochrane review included interventions directed at children and adolescents (5-18  
46 years), and did not distinguish the components associated with effective interventions  
47 in primary school children, which may differ from adolescents<sup>7</sup>. Educational  
48 intervention needs to be age-appropriate as primary school children will have less  
49 autonomy and capability to self-manage asthma compared to adolescents<sup>12</sup>. Thus, we  
50 aimed to review the effectiveness of school-based self-management interventions for

51 primary school children with asthma and to examine the components associated with  
52 successful programmes.

53

## 54 **Results**

55 Figure 1 illustrates the article selection process using the PRISMA diagram. We  
56 included 23 studies; 16 studies from the Cochrane review<sup>13-28</sup>, five studies from the  
57 updated database search<sup>29-33</sup> and two studies from the pre-publication update<sup>34,35</sup>. The  
58 total number of participants was 10,682. Some studies did not report numbers in each  
59 group so we cannot provide number by allocation<sup>13,14,24</sup>. We contacted all authors for  
60 information not reported in the papers, and nine (39%) responded<sup>13,14,25,27,29,30,32-34</sup>.

61

### 62 **Characteristics of included studies**

63 The interventions were conducted from 1992 to 2019. Seventeen studies were  
64 randomised controlled trials (RCTs) (14 cluster RCT<sup>13-15,18-26,31,32</sup>, three individual  
65 RCTs<sup>27,29,34</sup>), three were non-randomised studies<sup>28,30,35</sup> and three were uncontrolled  
66 pre-and-post studies<sup>16,17,33</sup>. Fifteen studies were conducted in the United States<sup>15-  
67 18,21,23-25,27-31,34,35</sup>, four in Canada<sup>13,14,19,20</sup>, one each in Spain<sup>32</sup> and United Kingdom  
68<sup>26</sup>, and two in low- and middle- income countries (China and Thailand)<sup>22,33</sup>. All but  
69 one<sup>17</sup> of the studies in the United States were conducted in minority  
70 populations<sup>15,16,18,21,23-25,27-31,34,35</sup>, two Canadian studies were conducted in majority  
71 population<sup>19,20</sup>; none of the others<sup>13,14,22,26,32,33</sup> reported ethnicity of population studied.

72

### 73 **Overall intervention characteristics**

74 The programmes were used to deliver self-management intervention varied. Eight  
75 studies used standard programmes (Open Airway for School (OAS) or tailored

76 OAS<sup>15,17,21-24,28,29</sup>, four studies used Roaring Adventures of Puff (RAP) or tailored  
77 RAP<sup>13,14,19,20</sup>, and the other studies developed novel interventions<sup>16,18,25-27,29-35</sup>. The  
78 programmes ranged from one to eight sessions, and all were delivered by healthcare  
79 personnel, (school nurse, asthma educator, community nurse, respiratory therapist,  
80 physician) except for two that were delivered by trained school teachers<sup>22,32</sup>. Fifteen  
81 studies delivered the intervention in group sessions<sup>13-17,19-26,28,34</sup>, four used individual  
82 face-to-face sessions<sup>27,29,30,35</sup>, one used individual computer-assisted programme<sup>18</sup>  
83 and another used individual telemedicine sessions<sup>31</sup>. Two studies were unclear<sup>23,33</sup>.

84

#### 85 **Risk of bias in the included studies**

86 The overall RoB is given in summary Table 2 (first column) and illustrated in the  
87 Harvest plot (Figure 2). Details of the RoB are in Supplementary Table 5. Four studies  
88 had low overall risk of bias<sup>13,14,20,32</sup>, eleven had high risk of bias<sup>15-17,21,27-30,33-35</sup> and  
89 eight were unclear<sup>18,19,22-26,31</sup>. Only seven (30%) studies were categorised at low risk in  
90 random sequence generation<sup>13,14,20,21,23,32,34</sup>. All uncontrolled studies were categorised  
91 as high-risk in four domains (random sequence generation, allocation concealment,  
92 baseline outcome similar and baseline character similar)<sup>16,17,33</sup>.

93

#### 94 **Effectiveness of interventions**

95 The effect of the interventions on each outcome of interest is detailed in Table 2, with  
96 an explanation of how the direction of the effect was interpreted and the overall effect  
97 of the study assessed. Twelve studies (two at low risk-of-bias) were assessed as  
98 having an overall positive (beneficial) effect<sup>13-17,21,22,29,30,33-35</sup> and eleven studies (two at  
99 low risk-of-bias) as having no effect<sup>18-20,23-28,31,32</sup>. No study was categorised as harmful  
100 or mixed effect. The Harvest plot (Figure 2) illustrates the effect of varying degrees of

101 parental involvement on school absenteeism, asthma control and urgent healthcare  
102 use.

103

#### 104 **Study components according to CFIR sub-domains**

105 The CFIR domains addressed in the studies are summarised in column 2 in Table 2.

106 Cicutto et al.<sup>13</sup> was the only study that explicitly addressed all the CFIR sub-domains in

107 their intervention; in contrast, Spencer et al.<sup>17</sup> addressed only two sub-domains. All

108 included studies used and measured the impact of at least one specific component in

109 their intervention, e.g. information provision assessed as improvement of knowledge

110 and self-management behaviour. The other commonly addressed sub-domain was

111 parental involvement (19/23)<sup>13-25,29-31,33-35</sup>, though this varied in intensity (We use the

112 term 'parents' to describe parents, guardians or other care-givers). See Supplementary

113 Table 3 for definitions of involvement. Some studies had substantial involvement e.g.

114 parents attending session or actively involved in phone/video communication<sup>13-15,17,19-</sup>

115 <sup>22,24,25,29-31,33,35</sup>, while others had minimal parental involvement e.g. passive information

116 in a letter<sup>16,18,23,29,34</sup>. Ten studies used theory to guide the development of the

117 interventions; six used social cognitive theory<sup>13,14,18-20,22</sup>, two used Orem self-care

118 theory<sup>28,34</sup>, one used life stress model<sup>29</sup>, and another was guided by Bruhn's

119 theoretical model<sup>25</sup>. Nine studies considered access to healthcare of their study

120 population<sup>13-15,24,25,27,30,32,33</sup>.

121

#### 122 **Association of CFIR sub-domains and effectiveness**

123 Table 3 is a summary matrix comparing use of the 12 CFIR sub-domains in studies

124 with overall positive or no effect (See Supplementary Table 4 for more detail). The

125 number of CFIR sub-domains used varied widely (2 to 12) and was similar in the  
126 studies with positive/no effect.  
127  
128 All studies with positive effects (12/12) reported parental involvement in their  
129 intervention<sup>13-17,21,22,29,30,33-35</sup> compared to seven studies with no effects (7/11)<sup>18-20,23-  
130 25,31</sup>. The Harvest plot (Figure 2) illustrates the direction of effect with the varying  
131 degrees of parental involvement of each study intervention. Studies without parental  
132 involvement (including one at low RoB<sup>32</sup>) showed no effect in any of the outcomes of  
133 interest<sup>26-28,32</sup>. Of the five interventions with minimal parental involvement<sup>16,18,23,29,34</sup>,  
134 the three positive studies were at high RoB and of short duration ( $\leq 6$ months), and  
135 either small in sample (study population less than 100 children)<sup>29,34</sup> or pre/post  
136 design<sup>16</sup>. Studies with substantial parental involvement<sup>13-15,17,19-22,24,25,29-31,33,35</sup> were  
137 the only studies to report reduction in absenteeism, though impact on clinical  
138 outcomes varied. Cicutto et al.<sup>13</sup> (cluster RCT at low risk of bias, 170 schools and  
139 1316 children), an example of a study that included parents in care coordination and a  
140 showcase at school, had positive effects in school absenteeism and urgent healthcare  
141 service use at 12 months. No difference was found in other CFIR subdomains  
142 between studies with positive and no effects.  
143

## 144 **Discussion**

### 145 **Summary of main findings**

146 We identified 23 studies (four at low RoB) that evaluated the effectiveness of school-  
147 based asthma self-management intervention among primary school children. Twelve  
148 of the studies were categorised as being overall positive, though individual outcomes  
149 varied; no study reported overall negative impact. The number of CFIR sub-domains



150 addressed varied between studies, but the only component that seemed to be  
151 associated with positive outcomes was substantial parental involvement. This was  
152 particularly apparent in studies at low RoB.

153

#### 154 **Interpretation of findings in relation to previously published work**

155 We found substantial parental involvement to be a crucial component of a school-  
156 based asthma self-management intervention among primary school children. Reviews  
157 that included interventions targeted at teenagers, in whom parental influence might be  
158 expected to be less important, have reached similar conclusions<sup>7,8</sup>. Parental  
159 involvement was also found to be important in other school-based interventions for  
160 obesity prevention studies<sup>36,37</sup>, self-management of mental health/disorders<sup>38</sup>, and  
161 academic enhancement<sup>39</sup>.

162

163 However, we did not find other components of interventions (theory-driven, conducted  
164 during lesson time, and child satisfaction) to be essential for successful intervention,  
165 as was found in the Cochrane review<sup>7</sup>. The differences in the findings were most  
166 probably due to a difference in the age group of the children as the Cochrane review  
167 included studies among older school children. Our review defined fun, interactive  
168 delivery of intervention, as a strategy promoting child satisfaction and engagement,  
169 whereas the Cochrane review examined measurement of child satisfaction, an  
170 evaluation used mainly in studies targeting adolescents<sup>7</sup>. Primary school children had  
171 good participation rates when the sessions were conducted during school hours  
172 including during recess, in contrast to adolescents who were less willing to devote their  
173 free time including during recess<sup>7,13,16</sup>. Social cognitive and Orem self-care theories  
174 were the most used theories, adapted from adults which focuses on self-efficacy and

175 skills of individuals<sup>40-42</sup>. These theories may be suitable for interventions targeting  
176 parents and adolescents, but may not be age-appropriate for primary school children  
177 with limited decision-making abilities and independent self-management skills<sup>12,43</sup>.  
178  
179 Primary school years are a critical time for children as they spend increasing time  
180 away from their parents and begin to learn asthma self-management for  
181 themselves<sup>44,45</sup>. Six-year-old children can express opinions, typically reflecting their  
182 parents' actions and views<sup>44</sup>. Over primary school years, they learn from their own  
183 experiences and gain the confidence to make independently decisions<sup>44,45</sup>. Although  
184 involving parents to support and empower their children's self-management behaviour  
185 is a key concept in the clinical management of children<sup>2,3</sup>, direct parental involvement  
186 was not always included in school-based intervention among primary school  
187 children<sup>27,28,32</sup>. A key challenge for involving parents is the difficulty of engaging them  
188 to attend session(s) delivered in school<sup>24,46</sup>. With the ease of modern  
189 telecommunication, alternative methods of engagement such as the use of telephone  
190 calls or video sessions could be explored as a convenient alternative to enable  
191 substantial parental involvement in the intervention<sup>31,47</sup>.  
192  
193 Although parental involvement is important, an aim of a school-based intervention is to  
194 shift the focus of self-management education from parents to children<sup>48,49</sup>. Studies in  
195 this review included up to eight educational sessions for children compared to only one  
196 to two sessions for parents<sup>13,27,30</sup>. A recent school-based health intervention has  
197 recommended the socio-ecological theory where children are the primary focus of an  
198 intervention that also involves the children's social network, e.g. parents, teachers,  
199 friends and the school plan/policy<sup>48,50</sup>. Schools could be an ideal setting for this

200 approach, smoothing children's transition to independent self-management by being  
201 located in the child's environment and including parents as part of the children's social  
202 network<sup>51-53</sup>. Schools also provide a platform for interactive fun groups activities and  
203 peer support for children with similar conditions, which could reduce stigma and  
204 support self-management practices<sup>13,32</sup>.

205

206 The effectiveness of self-management also depends on access and adherence to  
207 evidence-based treatments such as controller asthma medications, which is  
208 conventionally delivered in healthcare settings<sup>2,5</sup>. 'Access to healthcare', however, was  
209 a sub-domain least likely to be addressed in the studies included in this review.

210 Although most US-based studies were conducted among minority deprived  
211 populations, in whom poor health outcomes may be due to the large disparities in  
212 healthcare provision<sup>54</sup>, only five studies reported the access of the children to effective  
213 controller medication<sup>15,24,25,27,30</sup>. Even in countries with universal health coverage, such  
214 as Canada and United Kingdom, equitable access to high quality healthcare for  
215 children cannot be assumed<sup>55</sup>. In low- and middle-income countries, socio-cultural  
216 beliefs, physical inaccessibility and lack of education and information are extremely  
217 common barriers to healthcare despite universal health coverage<sup>56,57</sup>. Similar barriers  
218 are widely described in the US<sup>30,31,34</sup>. Encouragingly, bridging school-based education  
219 with the children's healthcare providers has been a core component of recent school-  
220 based interventions<sup>53,58</sup>.

221

## 222 **Strengths and limitations**

223 A strength of this review is that we used comprehensive search terms similar to the  
224 Cochrane review and searched seven relevant databases. Two reviewers conducted

225 full text screening and data collection was duplicated. A pre-publication update was  
226 performed to ensure the findings was up to date this review.

227 This review has some limitations. Despite a rigorous search strategy, it is possible that  
228 we may miss some studies. The screening of title and abstract was conducted by one  
229 reviewer, but good agreement resulted after training. Only two studies were conducted  
230 in low- and middle-income countries and many studies (15/23) were conducted in the  
231 US, reducing generalisability of the review. The included studies were variable in  
232 methodologies, instrumentation and data analysis. However, three low RoB studies  
233 coincided with the findings and some variability was illustrated in the Harvest plot with  
234 the other details described in Table 2. Poor reporting of interventions was a challenge  
235 and we may have overlooked some intervention components that were not explicitly  
236 described. We contacted all the authors to reduce the number of missing information  
237 and obtained 39% responses.

238

### 239 **Implications for policy, practice and research**

240 A multi-level intervention focusing on the children and involving their social network  
241 could provide a useful self-management interventions framework for primary school  
242 children and their parents. Specifically, there is a gap in our current understanding of  
243 school-based self-management education in younger children in low- and middle-  
244 income countries. Future research needs to focus on implementation strategies and  
245 effectiveness using this framework. Partnership between schools, parents and  
246 healthcare services could create a pragmatic and effective school plan/policy to  
247 improve asthma control among children.

248

## 249 **Conclusions**

250 School-based self-management interventions for asthma among primary education  
251 children can improve asthma outcomes and reduce absenteeism. Parental  
252 participation is an important component in this age group, but other features  
253 highlighted in secondary school interventions proved less relevant, perhaps reflecting  
254 the greater role of parents in younger children.

255

## 256 **Methods**

257 This systematic review follows Cochrane methodology<sup>59</sup>, and PRISMA reporting  
258 standards. The protocol is registered with the PROSPERO database (registration  
259 number: CRD42019131955).

260

## 261 **Study eligibility criteria**

262 We used a Population, Intervention, Comparator/Control, Outcomes and Study Design  
263 (PICOS) strategy to define eligible studies (Table 1)<sup>60</sup>, using definitions similar to the  
264 Cochrane review<sup>3,7,61</sup>. Self-management intervention was defined as the active  
265 transfer of information to children with asthma to enhance their self-management  
266 skills; this was interpreted with reference to components of self-management  
267 recommended by global guidelines (Table 1)<sup>2,3</sup>. In line with the Cochrane review, we  
268 included non-randomised trials to capture a broader range of studies and thence  
269 components used.

270

## 271 **Outcomes of interest**

272 We chose three outcomes of interest (school absenteeism and two health outcomes -  
273 asthma control and urgent use of healthcare services) to reflect the impact on children  
274 with poorly controlled asthma<sup>2,7,61</sup>.

275 **Search strategy**

276 The details of the search terms and databases used are in Supplement Table 1. The  
277 Cochrane review conducted searches in August 2017 using search terms developed  
278 by the Cochrane Airway Information Specialist in 23 electronic databases from 1995  
279 onwards and included 55 papers<sup>7</sup>. Using the same search terms, with no language  
280 limitations, we updated the search in February 2019 in six-core databases (CENTRAL,  
281 MEDLINE, Embase, PsycINFO, CINAHL, AMED)<sup>7</sup>. In addition, we searched the Global  
282 Health database using similar search terms without date limits to include studies from  
283 low- and middle-income countries. We included all studies identified in the review that  
284 met our eligibility criteria (principally excluding those not delivered to primary school  
285 children). We checked the reference list and undertook forward citation of studies in  
286 the Cochrane review conducted among primary school children<sup>62</sup>.

287 A pre-publication update was conducted on 17th March 2020 using forward citation of  
288 the Cochrane review (published 28 January 2019)<sup>7</sup> and all the studies included in this  
289 review<sup>62</sup>.

290

291 **Study selection and data extraction**

292 We imported the list of articles from the electronic databases into Endnote software  
293 (version 7) to facilitate screening, de-duplication and overall management of the  
294 results. SNR and JS independently screened a random selection of 10% of the titles  
295 and abstracts<sup>5</sup>. A 96.3% agreement was achieved prior to discussion, which reached  
296 total agreement after clarification of the screening criteria. SNR then completed title  
297 and abstract screening. Both reviewers independently conducted full-text screening  
298 (which included all the studies in the Cochrane review and those satisfying title and  
299 abstract screening), met to discuss discrepancies and decided on the final included

300 papers. Supplementary Table 2 lists studies excluded from this review. A modified  
301 Cochrane data extraction form was used for duplicate data extraction (SNR and JS)<sup>63</sup>.  
302 SNR contacted authors for missing data by email and any further information received  
303 was added to the data extraction forms<sup>59</sup>.  
304 At all stages, any discrepancies not resolved by discussion between the two reviewers  
305 were arbitrated by the study team (HP, KEM, LSM, SC).

306

### 307 **Risk of bias of included studies**

308 We used the Cochrane Effective Practice and Organisation of Care (EPOC) Risk of  
309 Bias (RoB) tool<sup>64</sup> to categorise risk into low, high and unclear risk in nine domains,  
310 which were then used to generate an overall assessment of the RoB for each study.  
311 The Cochrane EPOC RoB tool applies to randomised trials and non-randomised  
312 trials.<sup>64</sup> Studies with at least one high-risk domain were summarised as high risk;  
313 studies with no high-risk domains but at least one unclear domain were summarised  
314 as unclear risk and studies at low risk in all domains were summarised as low risk<sup>64</sup>.

315

### 316 **Data handling**

317 The Consolidated Framework for Implementation Research (CFIR) is a  
318 comprehensive framework that systematically identifies factors (sub-domains) that  
319 influence the effectiveness of implementation in multi-level interventions<sup>65</sup>.  
320 Supplementary Table 3 outlines the 12 CFIR sub-domains. We used CFIR sub-  
321 domains to identify context and components in each study (e.g. intervention  
322 characteristics, features of the setting and strategies for implementation) that might  
323 influence effectiveness of the interventions<sup>66,67</sup>.

324 We used a structured approach to divide the studies into four categories according to  
325 the change in the outcomes of interest<sup>68</sup>. This was a two-step process.

326 First, we determined the direction of effect in each of the three outcomes of interest  
327 (school absenteeism; asthma control; urgent use of healthcare service) for each  
328 included study. In some studies, several measures mapped to each outcome of  
329 interest: for example, emergency room visits and hospitalisation are both measures of  
330 unscheduled care potentially with conflicting findings. The rules at the top of Table 2  
331 define how we prioritised outcomes defined as 'primary' in the included study,  
332 outcomes measured with a validated instrument, and results that were clinically as well  
333 as statistically significant. The table then describes how the decision process was  
334 applied for each outcome of interest in each study.

335 Second, we categorised the overall effect of the intervention in each study as positive,  
336 negative, no effect or mixed effects, as follows:

- 337 • Positive (beneficial): Studies with a positive effect in  $\geq 1$  of the outcomes and no  
338 negative effects.
- 339 • Negative (harmful): Studies with a negative effect in  $\geq 1$  of the outcomes and no  
340 positive effects.
- 341 • No effect: Studies with no positive effects in any of the outcomes.
- 342 • Mixed: Studies with at least one positive and one negative outcome.

343

344

### 345 **Data synthesis**

346 Our preliminary scoping suggested that the studies would be heterogenous in terms of  
347 context, components delivered and study design, so we undertook a narrative  
348 analysis. We used a Harvest plot<sup>69</sup> (coded to indicate number of participants, RoB and



349 follow-up duration) to illustrate the effectiveness of the interventions on the three  
350 outcomes of interest for each study. A Harvest plot graphically displays not only  
351 outcomes but also the weight of the evidence in complex and diverse studies by  
352 illustrating selected methodological criteria<sup>69</sup>. We used a matrix to examine the  
353 association of the CIFR sub-domains with the overall effectiveness of the  
354 interventions. Supplementary Table 4 lists the CFIR sub-domains and how we  
355 interpreted them in our analysis.  
356

357 **Data Availability**

358 All data that support the findings of this systematic review are already in the public domain.

359

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374

375 **Competing interest**

376 None declared.

377

378 **Author contributions**

379 All authors contributed to study conception. SNR and JS performed screening, data extraction  
380 of the included studies. All authors (SNR, JS, KMH, EMK, SML, SC, HP) contributed to the  
381 interpretation of data. SNR drafted the manuscript and all authors provided critical revisions  
382 and editing of the manuscript.

383

384

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## Figure Legends

Figure 1: PRISMA diagram of selection process

Figure 2: Harvest plot illustrating the effectiveness on school absenteeism, asthma control and urgent healthcare services across parental involvement for school-based self-management asthma educational intervention.



<b>Table 1: PICO study strategy and definition of terminology</b>	
Participant/population	Children with asthma aged 6-12 years
Intervention	<p>School-based self-management education intervention.</p> <p>Definition as active transfer of information to enhance self-management of asthma containing at least one of the core-components of self-management education<sup>2,3</sup>:</p> <ul style="list-style-type: none"> <li>• A basic explanation about asthma, triggers and the factors that influence control</li> <li>• Training about correct inhalation technique</li> <li>• Information on the importance of the child's adherence to the prescribed medication regimen</li> <li>• Written asthma action plan</li> </ul> <p>Children with asthma had to be the primary target for the intervention, though others (such as peers without asthma, parents, school staff) could also be included.</p>
Comparator(s)	Standard care or other (non-asthma, or not related to self-management or delayed intervention) education intervention or none
Outcomes	<p>School absenteeism or/and asthma control or/and urgent use of healthcare service</p> <p>The definition of the three categories of outcomes of interest were guided by the American Thoracic Society/European Respiratory Society statement<sup>61</sup>:</p> <ol style="list-style-type: none"> <li>1. School absenteeism: Number of days a participant was absent from school (priority due to asthma).</li> <li>2. Asthma control: Clinical level of asthma control based on symptoms and capability to perform daily activities measured using asthma symptoms questionnaire/asthma diary with/without objective validation of asthma control, e.g. peak flows or lung function test.</li> <li>3. Urgent use of healthcare service: Number of an unscheduled visit to a general practitioner and/or emergency department due to asthma, and the number of days of hospitalisation due to asthma.</li> </ol>
Setting	School (primary, elementary or middle school)
Study designs	Experimental study e.g. randomised controlled trial (RCT), cluster RCT, non-randomised study and uncontrolled before-and-after study.

Table 2: Summary of study, CFIR domains and researchers' interpretation of included studies

Where outcomes within a category were conflicting, the decision process attached priority as follows:

- Defined primary outcomes in an adequately powered study
- Outcomes which were measured with a validated instrument (as opposed to responses of non-validated instrument)
- Outcomes that were clinically as well as statistically significant (e.g. defined as minimum clinically important difference)
- Outcomes which were measured using continuous versus categorical/dichotomy scale (e.g. days of school absenteeism versus yes/no to school absenteeism in a year)
- Outcomes reported by children as opposed to parents (in the absence of a validated instrument which measured both)

Finally, if there were any remaining doubts, the authors' interpretation was considered as providing the context for our decision

Citation design, size, risk of bias, and intervention	CFIR domains ( <sup>x</sup> indicates component of study not fulfilling criteria)	Reported outcomes (* indicates primary outcome if stated)	Researchers' interpretation for Harvest plot
<b>STUDIES WITH OVERALL POSITIVE EFFECT</b>			
<b>Cicutto, 2005<sup>14</sup></b> cRCT FU:12m Canada. Urban 26 schools: 256 children, Age: 6-11yrs  Intervention: Roaring Adventures of Puff  <b>RoB: Low</b>	<b>Intervention characteristics</b> Social cognitive theory and self-regulation Based on Canadian guideline Involved HCPs and families in development Tailored at individual level  <b>Outer setting</b> Parents attended showcase + homework Universal Health Coverage Communicated/coordinated with HCP  <b>Inner setting</b> <sup>x</sup> Only permission/advertisement at schools Delivered mostly during lunch/class time  <b>Individual characteristics</b> Self-efficacy assessed  <b>Process</b> Fidelity: Implemented as designed Puppetry, games, role-play, model building, etc	<b>School absenteeism</b> <i>Days lost from school:</i> Significant between group difference • Mean (SD) days/yr: I: 3.0 ±4.4 vs C: 4.3 ±5.7 (p<0.05)	Significant reduction in missed school in intervention group  <b>Illustrated as positive effect</b>
		<b>Asthma control</b> Not reported	
		<b>* Urgent use of healthcare services</b> <i>Number of urgent health care visits (ED, walk-in or same-day visits)</i> Significant between group difference • Mean (SD) visits/yr: I: 1.7 (1.9) vs C: 2.5 (2.5), p <0.01	Significant reduction in urgent healthcare visits in intervention group  <b>Illustrated as positive effect</b>
<b>Cicutto, 2013<sup>13</sup></b> cRCT FU:12m Canada.	<b>Intervention characteristics</b> Social cognitive theory Based on Canadian guideline Developed by schools	<b>School absenteeism</b> <i>Proportion of children with asthma-related absence.</i> Significant between-group reduction in proportion with	Significant reduction in absenteeism in intervention group  <b>Illustrated as consistently positive</b>

<p>170 schools; 1316 children, Age 6-11yrs</p> <p>Intervention: Roaring Adventures of Puff + asthma resource kit</p> <p>RoB: Low</p>	<p>Locally tailored</p> <p><b>Outer setting</b> Parents attended showcase + coordination of care Universal health coverage Letter to HCP via family</p> <p><b>Inner setting</b> Resource kit and school community session Delivered during lunch time</p> <p><b>Individual characteristics</b> Inhaler technique assessed</p> <p><b>Process</b> Fidelity: Implemented as designed Interactive games, puppetry, art, skits, homework</p>	<ul style="list-style-type: none"> <li>any school absence: I: 50% vs C: 60% (p=0.01)</li> <li>&gt;20 missed school days: I: 1.4% vs C: 4.5% p-value= 0.01</li> </ul> <p><b>Asthma control</b> Not reported</p> <p><b>* Urgent use of healthcare services</b> <i>Proportion of children attending urgent care.</i> Significant between-group reduction in:</p> <ul style="list-style-type: none"> <li>* Any urgent care: I: 41.3% vs C: 51.4% (p=0.0001)</li> <li>Unscheduled physician's visit: I: 24.1% vs 31.2% (p=0.001)</li> <li>ED attendances: I: 8.2% vs 2.8% (p=0.02)</li> <li>Walk-in clinic use: I: 18.4% vs 21.6%, p=NS</li> </ul>	<p>effect.</p> <p>Significant reduction in use of healthcare resources in intervention group.</p> <p><b>Illustrated as positive effect</b></p>
<p>Clark, 2005<sup>22</sup></p> <p>cRCT. FU:12m China. Urban/rural. 21 schools: 639 children, Age 7-11</p> <p>Intervention: Tailored Open Airway for School</p> <p>RoB: Unclear</p>	<p><b>Intervention characteristics</b> Social cognitive theory Based on GINA &amp; NAEPP Adapted to local needs</p> <p><b>Outer setting</b> School fair for parents with Q&amp; A session *HCP requested to provide PAAP</p> <p><b>Inner setting</b> Session for school principals and counsellors</p> <p><b>Individual characteristics</b> Parent management index of items</p> <p><b>Process</b> *Fidelity: good except for HCP response Games, problem solving exercises</p>	<p><b>School absenteeism</b> <i>Days lost from school:</i> Significant between group reduction in:</p> <ul style="list-style-type: none"> <li>adjMean diff days/yr I: -0.32 vs C: -0.56 (p=0.02)</li> </ul> <p><b>Asthma control</b> <i>Days with symptoms:</i> No significant between group difference</p> <ul style="list-style-type: none"> <li>adjMean diff days/yr I: -9 vs C: -6 p=0.13</li> </ul> <p><b>Urgent use of healthcare services</b> <i>Number of hospitalisations or ED visits:</i> no significant between group difference in odds of a reduction in:</p> <ul style="list-style-type: none"> <li>Hospitalisations: adjOR 1.43 (p=0.36)</li> <li>ED attendances: adjOR 1.00 (p=0.98)</li> </ul>	<p>Significantly fewer days lost from school in the intervention group.</p> <p><b>Illustrated as positive effect</b></p> <p>No significant effect of the intervention on days with symptoms.</p> <p><b>Illustrated as no effect</b></p> <p>No significant effect of intervention on hospitalisations or ED visits.</p> <p><b>Illustrated as no effect</b></p>
<p>Clark, 2004<sup>21</sup></p> <p>cRCT, FU: 24m USA: Urban, minority 14 schools: 835 children, Age: 7-11yrs</p> <p>Intervention: Tailored Open Airway for School plus</p>	<p><b>Intervention characteristics</b> Tailored to local needs</p> <p><b>Outer setting</b> School fair and assignments to include parents * contact HCP (not successfully done)</p> <p><b>Inner setting</b> Session with principle and counsellors</p> <p><b>Individual characteristics</b> Parent management index</p>	<p><b>School absenteeism</b> <i>Proportion of children with asthma-related absence.</i> Significant between-group reduction in:</p> <ul style="list-style-type: none"> <li>School absence: I: reported 8% fewer absences than C (p&lt;0.05)</li> </ul> <p><b>Asthma control</b> <i>Proportion reporting symptoms.</i> Significant between-group difference in the relative change of adjusted:</p> <ul style="list-style-type: none"> <li>Day symptoms: I reported 17% fewer symptoms than C (p=0.0001) (Persistent symptoms; 14% fewer; Intermittent symptoms 22% fewer)</li> </ul>	<p>Significant reduction in asthma related absence in intervention group.</p> <p><b>Illustrated as positive effect</b></p> <p>Unclear definitions of 'symptomatic', contradicting results, and limited reporting of data (no absolute values)</p> <p><b>Illustrated as no effect but hatched</b></p>

<b>RoB: High</b>	<b>Process</b> X one key element not successful (contact HCP)	<ul style="list-style-type: none"> <li>Night symptoms: I reported 40% more symptoms than C (<math>p &lt; 0.0001</math>) (Persistent symptoms; 14% fewer; Intermittent symptoms 255% more)</li> </ul>	<b>to indicate inconsistency</b>
		<b>Urgent use of healthcare services</b> Not reported	
<b>Isik, 2020<sup>34</sup></b> RCT FU: 12 weeks USA, Urban minority 8 schools: 73 children Age: 7-12yrs Intervention: School Nurse-led  <b>RoB: High</b>	<b>Intervention characteristics</b> Orem self-care theory Based on ALA guideline Developed with school nurse Tailored to children's condition <b>Outer setting</b> Parental received information sheet X assessment of asthma care access X Coordination with HCP <b>Inner setting</b> X school staff participation Delivered during school hours <b>Individual characteristics</b> Asthma management plan <b>Process</b> Fidelity: implemented as planned Storytelling, colouring, drawing, etc	<b>School absenteeism</b> <i>Number of absences.</i> No significant between group difference in: <ul style="list-style-type: none"> <li>mean (SD) all cause absences I: 1.3 (1.6) vs C: 1.8 (1.5), <math>p = 0.179</math></li> </ul>	No significant effect of intervention on all cause of school absenteeism <b>Illustrated as no effect.</b>
		<b>Asthma control</b> <i>Validated symptom score and control.</i> Significant difference between group difference at baseline to 6 week and baseline to 12 weeks in: <ul style="list-style-type: none"> <li>Mean ACQ scores: <math>F(2, 138) = 14.2, p &lt; 0.001</math></li> </ul>	No data provided: Authors stated significant improvement in symptoms in intervention group <b>Illustrated as positive effect</b>
		<b>Urgent healthcare services</b> Not reported	
<b>Levy, 2006<sup>15</sup></b> cRCT, step wise FU: 12m USA, Urban minority 20 schools: 329 children, Age: 6-10yrs  Intervention: Open Airway for School plus  <b>RoB: High</b>	<b>Intervention characteristics</b> Based on US guideline <b>Outer setting</b> Parents in coordination care + follow-up calls 80% of children were insured Contacted HCP <b>Inner setting</b> Training for school staff + dialogues if needed <b>Individual characteristics</b> Asthma knowledge <b>Process (none)</b>	<b>*School absenteeism</b> <i>Days lost from school:</i> Significant between group difference in: <ul style="list-style-type: none"> <li>Mean days/school yr: 4.38 vs C: 8.18</li> </ul>	No p value provided: Authors stated 'significant improvement in school attendance'. <b>Illustrated as positive effect</b>
		<b>Asthma control</b> Not reported	
		<b>*Urgent healthcare services</b> Significant between-group difference mean number of visits in <ul style="list-style-type: none"> <li>Mean (SD) Urgent/ED visits. I: 1.36 (0.49) vs C: 1.59 (1.0), <math>p &lt; 0.0001</math></li> <li>Mean days in hospital, I: 0.18 (0.73) vs C: 0.45 (1.06), <math>p &lt; 0.05</math></li> </ul>	Significant fewer in urgent care, ED visits and hospitalisations in intervention group <b>Illustrated as consistently positive effect</b>

<p><b>Magzamen, 2008<sup>16</sup></b>  Uncontrolled study  FU: 3 m  USA, Urban minority  18 schools: 990 children (3-yr groups),  Age:11-12 yrs</p> <p>Intervention: Kickin' Asthma [Delivered to three year groups (YG1/2/3)]</p> <p><b>RoB: High</b></p>	<p><b>Intervention characteristics</b>  School staff and children involved in development  Developed by local schools</p> <p><b>Outer setting</b>  Customised letter to parents</p> <p><b>Inner setting</b>  <sup>x</sup> School staff delivered/received intervention  Delivered during lunchtime</p> <p><b>Individual characteristics</b>  Asthma management behaviour + spacer technique</p> <p><b>Process</b>  Skits, games, videos, role-play</p>	<p><b>School absenteeism</b>  <i>Days lost from school:</i> Variable within-group impact in the three-year groups (YG) in:</p> <ul style="list-style-type: none"> <li>• Days /3m mean diff (SE): YG1 (reduced): -0.54 (0.30), p&lt;0.03; YG2 (no effect): -0.26 (0.12), p&lt;0.1; YG3 (no effect): -0.08 (0.13) p=0.44</li> </ul> <p><b>Asthma control</b>  <i>Activity limitation past 4 weeks.</i> Significant within-group reduction in all year groups (YGs)</p> <ul style="list-style-type: none"> <li>• Days/4w mean diff (SE) YG1: -0.70 (0.36), p&lt;0.006; YG2: -0.62 (0.34), p&lt;0.0001; YG3: -1.12 (0.37) p&lt;0.0001</li> </ul> <p><i>Night-time symptoms past 4 weeks.</i> Significant within-group reduction in all year groups (YGs)</p> <ul style="list-style-type: none"> <li>• Nights/4w mean diff (SE) YG1: -0.99 (0.29), p&lt;0.006; YG2: -0.68 (0.29), p&lt;0.0001; YG3: -0.43 (0.40) p=0.005</li> </ul>	<p>Significant reduction in school absenteeism in one of the three-year groups.  <b>Illustrated as no effect but hatched to indicate inconsistency</b></p> <p>Significant reduction in asthma symptoms in all year groups after intervention  <b>Illustrated as consistently positive effect</b></p>
<p><b>Marsland, 2019<sup>29</sup></b>  RCT, FU: 4 m  USA, Urban minority  12 schools: 104 children  Age: 8-14 (mean: 10.6)</p> <p>Intervention: I Can Cope (ICC) and Open Airway for Schools (OAS)</p> <p><b>RoB: High</b></p>	<p><b>Intervention characteristics</b>  ICC: Life-stress theory  <sup>x</sup> based on evidence-based guideline  ICC: Developed with HCP and school nurse  <sup>x</sup> tailored to culture/beliefs</p> <p><b>Outer setting</b>  ICC: Parental attended session + received letter/call  OAS: Based on US guideline  <sup>x</sup> assessment of asthma care  <sup>x</sup> coordination with HCP</p> <p><b>Inner setting</b>  ICC: Teachers involved in development and coordination  Delivered during school hours</p>	<p><b>School absenteeism</b>  Not measured</p> <p><b>Asthma control</b>  <i>Validated asthma control rated by child.</i> Significant between-group difference in mean score post-intervention:  CHSDA-C Mean (SD): ICC:1.2 (2.0) vs C:2.6 (2.3), p&lt;0.05; OAS: 1.4 (2.1) vs C: 2.6 (2.3), p&lt;0.05  <i>Asthma control rated by parents.</i> No significant between-group difference in mean score post-intervention  <ul style="list-style-type: none"> <li>• CHSA Mean (SD) I: 1.2 (1.3) vs C: 1.7 (2.2) p=NS; OAS: 1.4 (2.1) vs 1.7 (2.2)</li> </ul> </p>	<p>Significant reduction in ED, hospitalisations and unscheduled GP visits in all year groups after intervention  <b>Illustrated as consistently positive effect</b></p> <p>Children reported asthma prioritised due to the age of the children. Significant reduction in asthma control in intervention groups  <b>Illustrated as positive but inconsistent (Hatched)</b></p>

	<p><b>Individual characteristics</b> Management self-management score</p> <p><b>Process</b> Fidelity: implemented as planned ICC: Games and interactive activities, OAS: Games and stories</p>		
		<p><b>Urgent healthcare services</b> Not reported</p>	
<p><b>Simoneau, 2020<sup>35</sup></b> Non-randomised study FU: 12 m USA, Urban minority 15 schools; 251 children Intervention: Easy Breathing for Schools  <b>RoB: High</b></p>	<p><b>Intervention characteristics</b> Based on opinion from nurse, parents and HCPs</p> <p><b>Outer setting</b> Parent attended session at school Communication with child HCP</p> <p><b>Inner setting</b> School nurse delivered intervention</p> <p><b>Individual characteristics</b> Inhaler technique delivered and assessed</p> <p><b>Process</b> <sup>x</sup> Fidelity: only 25% implemented 3 core elements</p>	<p><b>*School absenteeism</b> <i>Days lost from school:</i> Significantly lower between-group risk of: • Days absent: adjRR=0.75 (95%CI 0.67 to 0.85) p&lt;0.001</p>	<p>Adjusted for sex, ethnicity, age, and school year. 25% fewer absences in intervention group. <b>Illustrated as positive effect</b></p>
		<p><b>Asthma control</b> Not reported</p>	
		<p><b>Urgent healthcare services</b> Not reported</p>	
<p><b>Spencer, 2000<sup>17</sup></b> Uncontrolled study FU: 6 m USA. 40 schools: 369 children, Age: 6-13 yrs  Intervention: Open Airway for School  <b>RoB: High</b></p>	<p><b>Intervention characteristics</b> (None)</p> <p><b>Outer setting</b> Parent attended session at school</p> <p><b>Inner setting</b> (None)</p> <p><b>Individual characteristics</b> Management of asthma symptoms</p> <p><b>Process</b> (None)</p>	<p><b>School absenteeism</b> <i>Parent-reported absences.</i> No significant within-group difference • % with ≥1 absence/6m: Pre: 53% vs post: 53%, p=NS <i>School days missed (nurse-reported)</i> Significant within-group reduction: • Mean days/6m. Pre: 5.50 vs post: 3.73. (p&lt;0.001)</p>	<p>Significant effect of intervention on missed school days, but not proportion with an absence. <b>Illustrated as positive effect but hatched to illustrate inconsistency</b></p>
		<p><b>*Asthma control</b> <i>Asthma symptoms. Significant within group difference improvement</i> • Mean score: Pre: 25.9 vs post: 23.9 (p&lt;0.001)</p>	<p>Significant reduction in non-validated symptom score <b>Illustrated as positive effect</b></p>
		<p><b>Urgent healthcare services</b> <i>Parent-reported events</i> Significant within-group difference in: • % with ≥1 ED visit/6m: Pre: 33% vs post: 18%, p&lt;0.001 • % with ≥1 hospitalisation: Pre: 14% vs post: 7%, p=0.002 <i>Event (nurse-reported)</i> Significant within-group difference in: • Number of ED visits (Mean): Pre: 0.71 vs post: 0.18, p&lt;0.001 • Number of hospitalisations (Mean): Pre: 0.14 vs post:0.04, p&lt;0.013</p>	<p>Significant reduction in ED visits and hospitalisation after intervention <b>Illustrated as consistently positive effect</b></p>

<p><b>Suwannakeeree, 2016<sup>33</sup></b>  Uncontrolled study  FU:6 m  Thailand, Urban  1 school: 29 children  Age: 6-12 (extracted sub-analysis)</p> <p>Intervention: Asthma Friendly School Initiative</p> <p><b>RoB: High</b></p>	<p><b>Intervention characteristics</b>  Based on US guideline  Individually tailored to each child</p> <p><b>Outer setting</b>  Parents attended sessions at school  Medication provided to all participants  Sent spirometry results + other information to HCP</p> <p><b>Inner setting</b>  Teachers were trained asthma management plan  Delivered during school hours</p> <p><b>Individual characteristics</b>  Asthma management behaviour</p> <p><b>Process</b>  <sup>x</sup> fun interactive activity</p>	<p><b>School absenteeism</b>  <i>School absences.</i> Significant within-group difference</p> <ul style="list-style-type: none"> <li>• % (n) with <math>\geq 1</math> absence/6m: Pre: 48% (14) vs post: 17% (5) <math>p=0.004</math></li> </ul>	<p>Significant reduction in missed school after intervention</p> <p><b>Illustrated as positive effect</b></p>
		<p><b>*Asthma control</b>  <i>Symptoms.</i> Significant within-group increase in proportion with:</p> <ul style="list-style-type: none"> <li>• Day symptoms <math>\leq 2</math>/wk % (n): Pre: 48% (14) vs post: 90% (26), <math>p&lt;0.001</math></li> <li>• No night symptom % (n): Pre: 59% (17) vs post: 83% (24), <math>p = 0.020</math></li> </ul> <p><i>SABA use:</i> No significant within-group difference in proportion using</p> <ul style="list-style-type: none"> <li>• SABA <math>\leq 2</math>/wk % (n): Pre: 100% (29) vs post: 90% (26) <math>p=0.25</math></li> </ul>	<p>Significant reduction in asthma symptoms but no significant effect on bronchodilator use after intervention</p> <p><b>Illustrated as positive effect but hatched to show inconsistency</b></p>
		<p><b>*Urgent healthcare services</b>  <i>ED visits.</i> Significant within-group reduction n proportion with:</p> <ul style="list-style-type: none"> <li>• <math>\geq 1</math> ED visit % (n): Pre: 59% (17) vs post: 21% (6), <math>p=0.002</math></li> </ul>	<p>Significant reduction in ED visit after intervention</p> <p><b>Illustrated as positive effect</b></p>
<p><b>Szeffler, 2019<sup>30</sup></b>  Non-randomised study, FU: 12m  USA, minority  463 children, Age: 5-14 (89.7% between 6-12)</p> <p>Intervention: Building Bridges</p> <p><b>RoB: High</b></p>	<p><b>Intervention characteristics</b>  Based on NAEP guideline  School staff and nurse involved in development  Tailored to culture/beliefs</p> <p><b>Outer setting</b>  Parental attended session  85% participant had medical insurance  Letter to HCP</p> <p><b>Inner setting</b>  School nurses delivered intervention  Delivered during school hours</p> <p><b>Individual characteristics</b>  Inhaler technique score</p> <p><b>Process</b>  Fidelity: implemented as planned  Interactive session</p>	<p><b>School absenteeism*</b>  <i>School days missed.</i> Significant between-group reduction in absenteeism</p> <ul style="list-style-type: none"> <li>• Mean % school days missed: I: 9% vs C: 12% <math>p&lt;0.001</math>.</li> </ul>	<p>Significant reduction in absenteeism in intervention group</p> <p><b>Illustrated as positive effect</b></p>
		<p><b>Asthma control</b>  <i>Validated control test:</i> Significant within-group increase in ACT:</p> <ul style="list-style-type: none"> <li>• ACT Mean (SD): Pre: 19.5 (0.2) vs post: 21.1 (0.2), <math>p&lt;0.01</math></li> </ul> <p><i>Proportion poorly controlled:</i> Significant within-group reduction in proportion of children below the ACT threshold for good control</p> <ul style="list-style-type: none"> <li>• % with ACT score <math>\leq 19</math>: Pre: 43% vs post: 29%, <math>p &lt;0.01</math></li> </ul>	<p>Significant reduction in asthma control after intervention</p> <p><b>Illustrated as positive effect</b></p>
		<p><b>Urgent healthcare services</b>  Not reported</p>	
<p>Citation design, size, risk of bias, and intervention</p>	<p>CIFR domains</p>	<p>Reported outcomes (* indicate primary outcome if stated)</p>	<p>Researchers' interpretation for Harvest plot</p>

STUDIES WITH OVERALL NO EFFECT			
<p><b>McGhan, 2010<sup>20</sup></b>  cRCT FU: 12m  Canada, Majority  34 schools: 266  children, Age: 6-13  (8.6)</p> <p>Intervention: Roaring  Adventures of Puff</p> <p><b>RoB: Low</b></p>	<p><b>Intervention characteristics</b>  Social cognitive theory  Based on Canadian guideline</p> <p><b>Outer setting</b>  Parents attended session at school  Letter + communication with HCP</p> <p><b>Inner setting</b>  Session for teachers</p> <p><b>Individual characteristics</b>  Medication use and management behaviour</p> <p><b>Process</b>  Puppetry, games, videos, role-play, etc</p>	<p><b>School absenteeism</b>  School days missed. No significant between-group difference in</p> <ul style="list-style-type: none"> <li>Missed school days/yr (Mean): I: 4.0 vs C: 2.5 (NS)</li> </ul>	<p>No significant effect of intervention on missed school days  <b>Illustrated as no effect</b></p>
		<p><b>Asthma control</b>  Not reported</p>	
		<p><b>Urgent healthcare services</b>  No significant between group difference in mean of:</p> <ul style="list-style-type: none"> <li>Unscheduled visit (Mean): I: 1.2 vs C: 0.7 (NS)</li> <li>ED visits (Mean): I: 0.2 vs C: 0.07 (NS)</li> </ul>	<p>No significant effect of intervention on unscheduled visits and ED visits.  <b>Illustrated as consistently no effect</b></p>
<p><b>Praena-Crespo, 2017<sup>32</sup></b>  cRCT FU: 6 months  Spain  97 schools:381 children  Age: 10-12yrs  Intervention: Asthma,  Sport and Health  programme</p> <p><b>RoB: Low</b></p>	<p><b>Intervention characteristics</b>  <sup>X</sup> Evidence-based (used expert consensus)  Developed jointly with teachers and HCP  Tailored to Spanish children</p> <p><b>Outer setting</b>  <sup>X</sup> Parental involvement  Universal Health Coverage  Coordination with HCPs using forms</p> <p><b>Inner setting</b>  PE teachers delivered intervention  Delivered during PE period</p> <p><b>Individual characteristics</b>  Newcastle asthma knowledge questionnaire</p> <p><b>Process</b>  Implemented as planned  Video and slides presentation</p>	<p><b>School absenteeism</b>  <i>School attendance from Education authority.</i>  "The intervention programme decreases absenteeism, without reaching significance"</p>	<p>No data provided: authors stated no significant between group difference  <b>Illustrated as no effect</b></p>
		<p><b>Asthma control</b>  <i>Validated asthma control questionnaire</i> No significant between-group difference in:</p> <ul style="list-style-type: none"> <li>CAN score Mean (95%CI): I: 11.25 (9.93 to 12.57) vs C: 10.61 (9.43 to 11.78), p =NS</li> </ul>	<p>No significant difference between control and intervention.  <b>Illustrated as no effect</b></p>
		<p><b>Urgent healthcare services</b>  Not reported</p>	
<p><b>Bartholomew, 2006<sup>18</sup></b>  cRCT FU: 12m  USA, Urban minority,  60 schools: 946  children, Age: 6-10yrs  (Grade 1-4)</p>	<p><b>Intervention characteristics</b>  Social cognitive theory  Based on NAEPP  Tailored to language, health literacy</p> <p><b>Outer setting</b>  Parents mailed action plans, video</p>	<p><b>School absenteeism</b>  <i>Missed school in days</i><sup>1</sup> Overall rates of absenteeism declined but here were no between-group differences in the frequency of absences over time<sup>1</sup></p>	<p>No between-group data provided: Authors state no significant between-group difference  <b>Illustrated as no effect</b></p>
		<p><b>Asthma control</b>  <i>Validated Usherwood Symptom Questionnaire.</i> <sup>1</sup>Symptoms declined</p>	<p>No between-group data provided: Authors state no significant</p>



<p>Intervention: Partners in School Asthma Management program</p> <p><b>RoB: Unclear</b></p>	<p>Tailored letters and video to HCP</p> <p><b>Inner setting</b> School action committee</p> <p><b>Individual characteristics</b> Self-efficacy assessed</p> <p><b>Process</b> Interactive computer program</p>	<p>significantly over time, but there were no between-group differences on symptom level or rate of decline'</p>	<p>between-group difference <b>Illustrated as no effect</b></p>
	<p><b>Urgent use of healthcare services</b> <i>Hospitalisations/ED.</i> "Increasing over time but there was no between-group difference in the level or rate of increase of hospitalisations at post-test by group."</p>	<p>No data provided: Authors state no significant between-group difference <b>Illustrated as no effect</b></p>	
<p><b>Clark, 2010<sup>23</sup></b> cRCT, FU: 12m USA. Urban, minority 19 schools: 1292 children, Age: 10-13 (mean: 11.6) Intervention: tailored Open Airway for School (OAS) and tailored OAS + peer component (OAS+) <b>RoB: Unclear</b></p>	<p><b>Intervention characteristics</b> OAS+: Children involvement Adapted to minority in urban setting</p> <p><b>Outer setting</b> Take home assignments and material for parents</p> <p><b>Inner setting</b> <sup>x</sup> School staff delivered/received intervention Delivered during school hours</p> <p><b>Individual characteristics</b> Asthma self-regulation and management scale</p> <p><b>Process</b> OAS+: Games, role-play, artistic activities</p>	<p><b>School absenteeism</b> Not reported</p>	
	<p><b>*Asthma control</b> <i>Symptoms score</i> No significant differences between either group and control in mean frequency of day symptoms. • Odds of a fall in day-time symptoms OAS: OR = 1.1 (p&gt; 0.5) OAS+: OR = 1.3 (p=0.3). No data provided for control group</p>	<p>No significant difference between intervention A and B with control groups for symptoms. <b>Illustrated as no effect</b></p>	
	<p><b>Urgent healthcare services</b> Not reported</p>		
<p><b>Gerald, 2006<sup>24</sup></b> cRCT FU:12m USA, Urban minority 54 schools: 736 children, Age: 6-10 yrs Intervention: tailored Open Airway for School + educational programme for school community <b>RoB: Unclear</b></p>	<p><b>Intervention characteristics</b> Included written personalised asthma action plan Tailored asthma plan individually to each child</p> <p><b>Outer setting</b> Parent attended session at school All children received asthma medication Coordination care with school nurse and HCP</p> <p><b>Inner setting</b> Session for school faculty and staff Delivered during physical education period</p> <p><b>Individual characteristics</b> Knowledge score</p> <p><b>Process</b> <sup>x</sup>Fidelity: program shortened, not as planned</p>	<p><b>*School absenteeism</b> <i>Number of all-cause absences.</i> No significant between-group difference Number of absences Mean (SD) I: 3.88 (3.5) vs C: 3.21 (3.2), p=NS</p>	<p>No significant effect of intervention on school absenteeism <b>Illustrated as no effect</b></p>
	<p><b>Asthma control</b> Not reported</p>		
	<p><b>Urgent healthcare services</b> <i>Number of ED and hospital events.</i> No significant between group difference: • ER visits Median (SD): I: 0.09 (0.28) vs C: 0.10 (0.31), NS • Hospitalisations (median (SD): I: 0.04 (0.19) vs C: 0.02 (0.14), NS</p>	<p>No significant effect of intervention on ER visit and hospitalization. <b>Illustrated as consistently no effect</b></p>	
<p><b>Horner, 2016<sup>25</sup></b> cRCT, FU:12m</p>	<p><b>Intervention characteristics</b> Bruhn's theoretical Model</p>	<p><b>School absenteeism</b> Not reported</p>	

<p>USA, Rural minority 33 schools: 168 children, Age: 7-11 yrs Intervention: Asthma Plan for Kids [Only the school-based group extracted for this review]</p> <p><b>RoB: unclear</b></p>	<p>Based on US guideline Parents involved in development Tailored to families in rural areas <b>Outer setting</b> Group presentation and booklets for parents 92% of children were insured <sup>x</sup> Coordination care with HCP <b>Inner setting</b> <sup>x</sup> school involvement Delivered during lunch time <b>Individual characteristics</b> Asthma management score <b>Process</b> Fidelity: measured Vignettes + problem solving</p>	<p><b>Asthma control</b> (School-based intervention only) <i>Asthma symptoms</i> No significant-between group difference: • Severity of chronic asthma scale Mean (SD) : I: 3.38 (0.69) vs C: 3.79 (1.34), NS</p>	<p>No significant effect of intervention on asthma control <b>Illustrated as no effect</b></p>
<p><b>McCann, 2006<sup>26</sup></b> cRCT FU : 12 m UK 24 schools: 219 children, Age: 7-9 yrs Intervention: Nurse-led</p> <p><b>RoB: Unclear</b></p>	<p><b>Intervention characteristics</b> Based on UK guideline Developed with school staff Tailored to local evidence <b>Outer setting [None]</b> <b>Inner setting</b> Session for teachers <b>Individual characteristics</b> Asthma knowledge + self-confidence + self-esteem <b>Process</b> Role play</p>	<p><b>*School absenteeism</b> <i>School days missed.</i> 'After adjusting for social deprivation, no effect of the intervention was found.' • Within intervention group: Mean days/yr (SD) Pre: 7.0 (7.4) vs post 6.8 (6.1) [No control group data provided]</p>	<p>No data provided: authors state no significant effect of intervention on school absenteeism <b>Illustrated as no effect</b></p>
<p><b>McGhan, 2003<sup>19</sup></b> cRCT FU: Canada, Majority 18 schools: 162 children, Age: 5-13  Intervention: Roaring Adventures of Puff</p> <p><b>RoB: Unclear</b></p>	<p><b>Intervention characteristics</b> Social cognitive theory Based on Canadian guideline <b>Outer setting</b> Parents attended session at school Letter + communication with HCP <b>Inner setting</b> Session for teachers <b>Individual characteristics</b> Self-efficacy and management behaviour</p>	<p><b>School absenteeism</b> <i>School absences.</i> No significant between-group difference in: % (n) with <math>\geq 1</math> absence/12m: I: 39% vs C: 47% (p=0.07)</p>	<p>No significant effect of intervention on missed school days <b>Illustrated as no effect</b></p>
		<p><b>Asthma control</b> Reported symptoms. Mixed findings: Only one significant between-group difference in proportion of children in last 2w with: • Waking with symptoms: I: 45 % vs C: 39% (p&gt;0.1) • Coughing (mod/severe): I: 25% vs C: 28% (p&gt;0.1) • Tight chest (mod/severe): I: 11% vs C: 11% (p&gt;0.1) • Wheezing (mod/severe): I: 15% vs C: 14% (p&gt;0.1)</p>	<p>No significant difference of intervention for all measurement on asthma control except for limitation in kind of play. <b>Illustrated as no effect but hatched to indicate inconsistent</b></p>

	<p><b>Process</b> Puppetry, games, role-play, model building etc</p>	<ul style="list-style-type: none"> <li>• Shortness of breath (mod/severe): I: 15% vs C: 11% (p&gt;0.1)</li> <li>• Limited kind of play: I: 29% vs C: 31% (p&lt;0.01)</li> <li>• Limited amount of play: I: 59% vs C: 58% (p&gt;0.1)</li> </ul>	
		<p><b>Urgent healthcare services</b> Urgent events: No significant between group difference in:</p> <ul style="list-style-type: none"> <li>• % with ≥1 ED visit/12m: I:12%, vs C: 10% (p &gt; 0.1)</li> <li>• % with ≥1 unscheduled visit/12m: I: 34% vs C: 37% (p &gt;0.1)</li> </ul>	No significant effect of intervention in ED visits and unscheduled visits. <b>Illustrated as consistently no effect</b>
<p><b>Perry, 2018<sup>31</sup></b> cRCT FU: 6 m USA, Rural minority 19 schools: 363 children, Age: 7-14 (mean:9.6)</p> <p>Intervention: Telemedicine asthma education</p> <p><b>RoB: Unclear</b></p>	<p><b>Intervention characteristics</b> Based on NAEPP guideline Tailored to individual and rural population</p> <p><b>Outer setting</b> Parents attended session Letter to HCP 3 monthly</p> <p><b>Inner setting</b> Educational session for school nurse <sup>x</sup> Delivered outside of school hours</p> <p><b>Individual characteristics</b> Asthma knowledge and self-efficacy</p> <p><b>Process</b> Fidelity: Implemented as planned</p>	<p><b>School absenteeism</b> Not reported</p>	
		<p><b>*Asthma control</b> <i>Symptom free days.</i> No significant between-group difference in Symptom free days in last 2w Mean (SD): I: 8.8 (5.1) vs C: 9.4 (5.1), p=0.55</p>	No significant effect of intervention on asthma control <b>Illustrated as no effect</b>
		<p><b>Urgent healthcare services</b> Not reported</p>	
<p><b>Persaud, 1996<sup>27</sup></b> RCT FU: 20wks USA, Urban minority 10 schools: 36 children Age: 8-12</p> <p>Intervention: Asthma Self-Management</p> <p><b>RoB: High</b></p>	<p><b>Intervention characteristics</b> Based on US guideline School nurses involved in development Tailored to urban disadvantaged population</p> <p><b>Outer setting</b> <sup>x</sup> parental involvement</p> <p>Practice accepted insured and non-insured Letter to HCP</p> <p><b>Inner setting</b> Feedback and interview with school staff Delivered during school hours</p> <p><b>Individual characteristics</b> Asthma knowledge and children asthma attitude</p> <p><b>Process</b> Role-play</p>	<p><b>School absenteeism</b> <i>School days missed.</i> No significant between group difference in: Days absent/20w mean (SD) I:6.4 (4.6) vs C: 7.6 (5.3), p= NS</p>	No significant effect of intervention on school absenteeism <b>Illustrated as no effect</b>
		<p><b>Asthma control</b> Not reported</p>	
		<p><b>Urgent healthcare services</b> <i>ED visits.</i> No significant between-group difference in:</p> <ul style="list-style-type: none"> <li>• ED visits/20w. Adj mean (SD): I: 0.27 (0.57) vs C: 1.0 (1.2), p=NS</li> </ul> <p>Significant between-group difference in proportion of children with ED visits I: 22% vs C: 50%, p&lt;0.05</p>	Adjusted mean was prioritised over proportion in measurement for the outcome. No effect of intervention on ED visits <b>Illustrated as no effect</b>

<b>Velsor-Friedrich, 2005<sup>28</sup></b> Non-randomised study FU: 12 m USA, Urban, minority 4 schools: 52 children Age: 8-13 (Mean:10.8)  Intervention: Open Airway for School  <b>RoB: High</b>	<b>Intervention characteristics</b> Orem's Self-Care deficit theory Based on US guideline Individually tailored by school nurse <b>Outer setting</b> × parental involvement Coordination with school-based clinic physician <b>Inner setting</b> Delivered during school hours <b>Individual characteristics</b> Measured care abilities and self-care practices <b>Process</b> Group discussion, stories, games, role-play	<b>School absenteeism</b> <i>School days missed.</i> No significant between group difference in: Days absent/yr mean (SD): I: 9.0 vs C: 14.4, p=NS	No significant effect of intervention on missed school days <b>Illustrated as no effect</b>
		<b>Asthma control</b> <i>Days with symptoms.</i> No significant between-group difference in: • % with ≥1 day of symptoms in past 2w: I: 50% vs C: 54%, p=NS	No significant effect of intervention on asthma control <b>Illustrated as no effect</b>
		<b>Urgent healthcare services</b> <i>Urgent doctor visits.</i> No significant between-group difference in: % with ≥1 day of symptoms in past 2w: I: 14% vs C: post:20% , p=NS	No significant effect of intervention on urgent care visits <b>Illustrated as no effect</b>

\* indicates primary outcome of the study

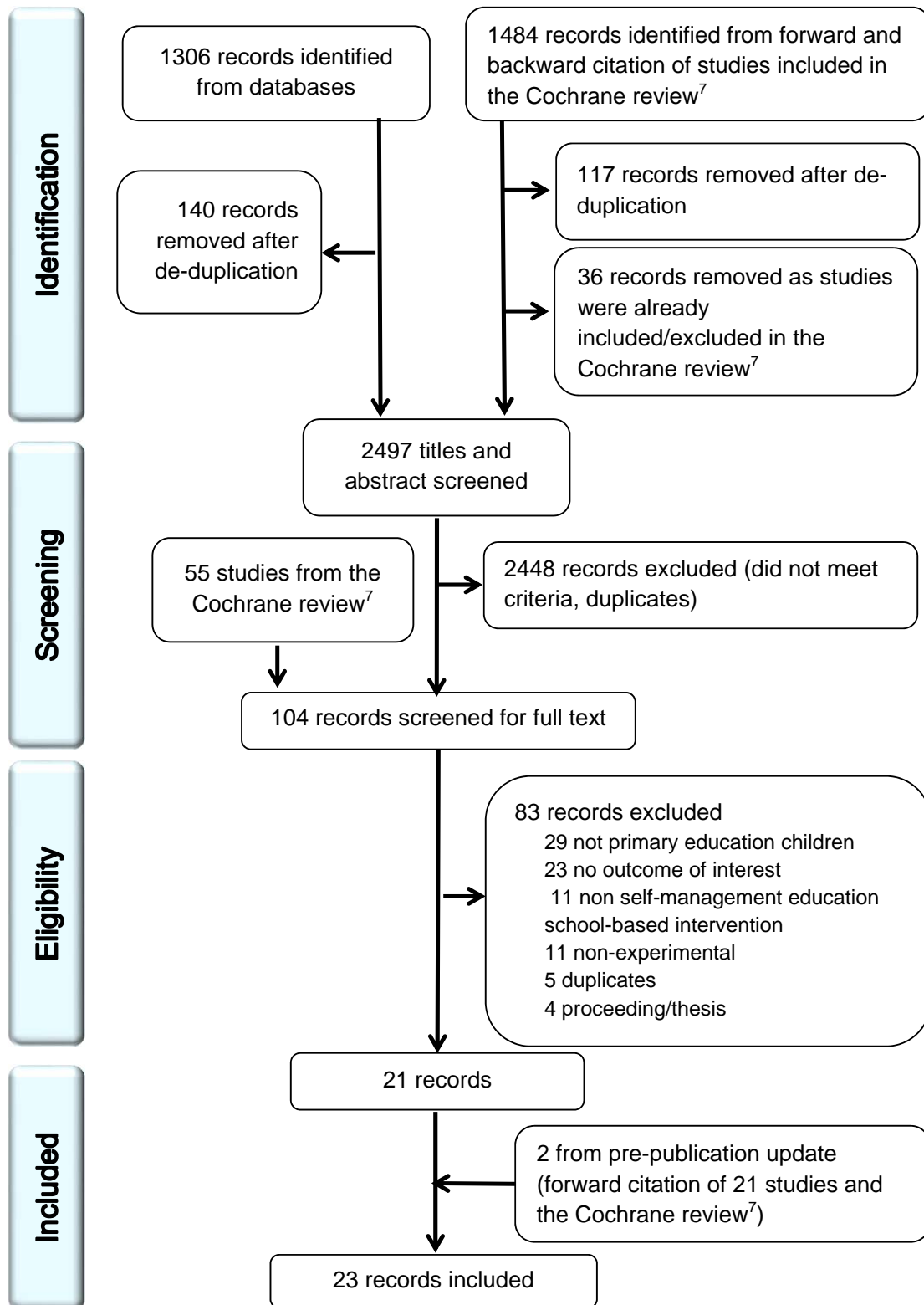
Abbreviations: adjOR=adjusted Odds Ratio, adjRR=adjusted Risk Ratio, ACT= Asthma Control Test, ACQ= Asthma Control Questionnaire, C= Control, CAN= *Control Asma en Niños*  
 CHSA =Children's Health Survey for Asthma (parent version) and CHSA-C (child version). cRCT = cluster Randomised Controlled Trial, CI= Confidence Interval, ED= Emergency  
 Department, FU= Follow up, HCP= HealthCare Professional, RCT = Randomised Controlled Trial, I=Intervention, RoB = Risk of Bias, RR=Risk Ratio, MCID: Minimal Clinically  
 Importance Difference, NAEPP= National Asthma Education and Prevention Programme, NS=Not Significant, SABA= Short Acting Beta Antagonist, SE= Standard Error, SD= Standard  
 Deviation, m=month, PE= Physical Education, PBL=Problem Based Learning, vs=versus, UK = United Kingdom, USA/US =United States of America, w= week, yr=year

Table 3: Summary matrix comparing 12 sub-domains of CFIR in overall positive or no effect studies

<b>Studies with overall positive effect</b>															
CFIR domains and subdomains		Cicutt o 2005	Cicutt o 2013	Clar k 2004	Clark, 2005	Isik 2020	Levy 2006	Magza men 2008	Marsland 2019		Simone au, 2020	Spencer 2000	Suwan nakere e 2016	Szetler 2019	Total with this domain
									ICC	OAS					
Intervention characteristics	Theory-driven	✓	✓		✓	✓			✓						5
	Evidence- based	✓	✓		✓	✓	✓			✓			✓	✓	8
	Stakeholder involvement	✓	✓			✓		✓	✓		✓			✓	7
	Tailored	✓	✓	✓	✓	✓		✓					✓	✓	8
Outer setting	Substantial parental involvement	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓	10
	Minimal parental involvement					✓		✓		✓					3
	Access to asthma care	✓	✓				✓						✓	✓	5
	Coordination with child's health provider	✓	✓				✓				✓		✓	✓	6
Inner setting	School participation		✓	✓	✓		✓		✓		✓		✓	✓	8
	Done during school hours	✓	✓			✓		✓		✓			✓	✓	7
Individual characteristics	Measurement of knowledge, skill or practice	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	12
Process	Fidelity	✓	✓			✓				✓				✓	5
	Child satisfaction	✓	✓		✓	✓		✓	✓	✓				✓	8
Total sub-domains met in individual study (range is in final column)		11	12	4	7	9	6	6	8	6	5	2	8	11	2-12

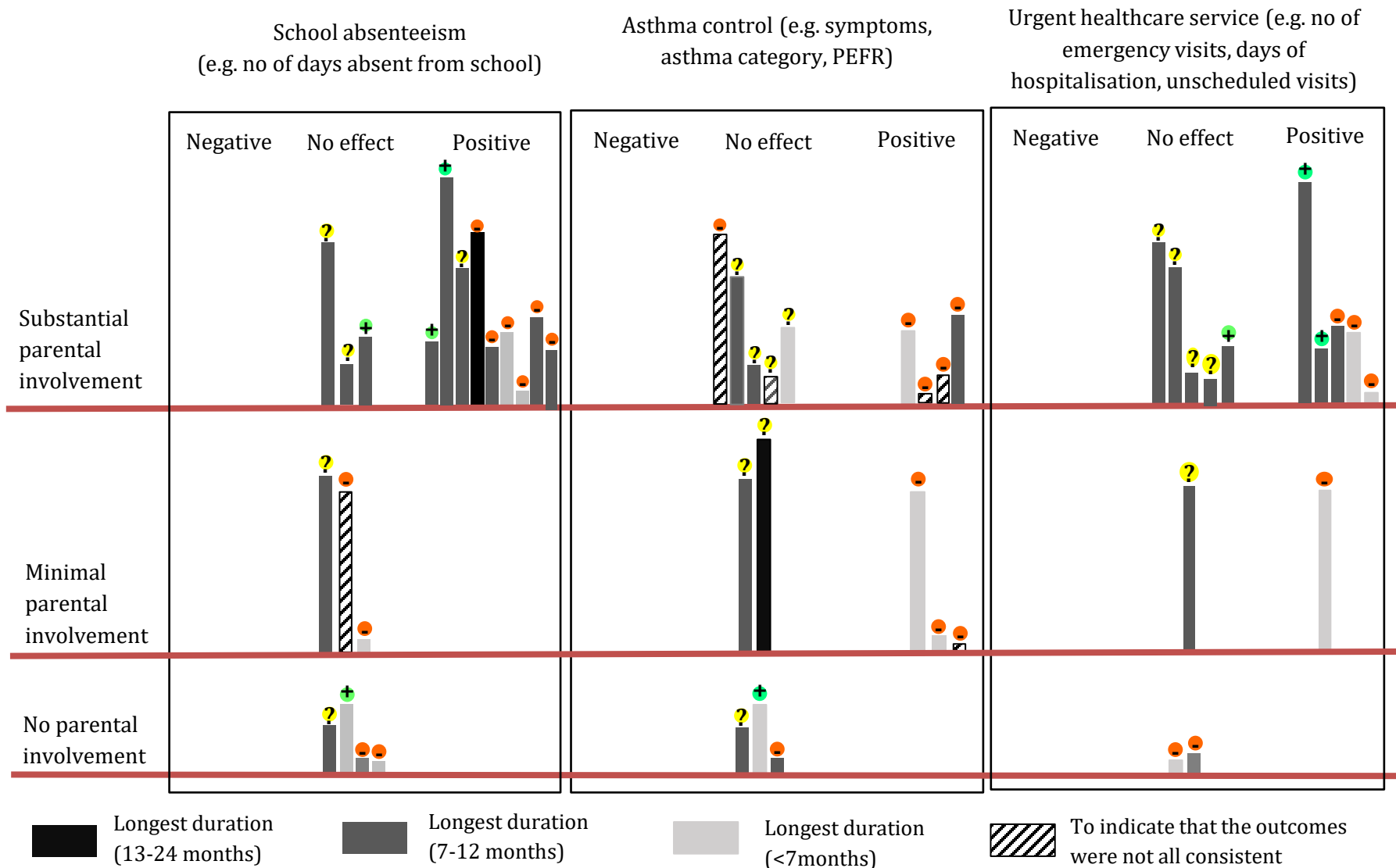
Studies with overall no effect														
CFIR domains and subdomains		Bartholomew 2006	Clark 2010		Gerald 2006	Horne 2016	McCaunn 2000	McGhan 2003	McGhan 2010	Praena-Crespo 2016	Perry 2018	Persaud 1996	Velsor-Friedrich 2005	Total with this domain
			OAS	OAS plus										
Intervention characteristics	Theory-based	✓				✓		✓	✓				✓	5
	Evidence-based	✓			✓	✓	✓	✓	✓		✓	✓	✓	9
	Stakeholder involvement			✓		✓	✓			✓		✓		5
	Tailored	✓	✓		✓	✓	✓			✓	✓	✓	✓	9
Outer setting	Substantial parental involvement				✓	✓		✓	✓		✓			5
	Minimal parental involvement	✓	✓											2
	Access to asthma care				✓	✓				✓		✓		4
	Coordination with child's health provider	✓			✓			✓	✓	✓	✓	✓	✓	8
Inner setting	School participation	✓			✓		✓	✓	✓	✓	✓	✓		8
	Done during school hours		✓		✓	✓				✓		✓	✓	6
Individual characteristics	Measurement of knowledge/skills/behaviour	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	11
Process	Fidelity					✓				✓	✓			3
	Child satisfaction	✓		✓		✓	✓	✓	✓	✓		✓	✓	9
Total sub-domains met in individual study (range is in final column)		8	4	6	8	10	6	7	7	9	7	9	7	4-11





**Figure 1: PRISMA diagram of selection process**





**Figure 2: Harvest plot illustrating the effectiveness on school absenteeism, asthma control and urgent healthcare services across parental involvement for school-based self-management asthma educational intervention**