

# Interventions to Modify Health Care Provider Adherence to Asthma Guidelines: A Systematic Review

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## KEY WORDS

asthma, systematic review, guidelines

## ABBREVIATIONS

CI—confidence interval

ED—emergency department

ICS—inhaled corticosteroids

OR—odds ratio

RCT—randomized controlled trial

SOE—strength of evidence

Dr Okelo developed the protocol, completed data collection and data synthesis, drafted the manuscript, and critically reviewed the manuscript; Dr Butz, Ms Sharma, Drs Diette, Pitts, and King, Ms Linn, Ms Reuben, and Dr Chelladurai developed the protocol, completed data collection and data synthesis, and critically reviewed the manuscript; Dr Robinson developed the protocol, completed data collection and data synthesis, drafted the manuscript, and critically reviewed the manuscript; and all authors approved the final manuscript as submitted.

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## abstract



**BACKGROUND AND OBJECTIVE:** Health care provider adherence to asthma guidelines is poor. The objective of this study was to assess the effect of interventions to improve health care providers' adherence to asthma guidelines on health care process and clinical outcomes.

**METHODS:** Data sources included Medline, Embase, Cochrane CENTRAL Register of Controlled Trials, Cumulative Index to Nursing and Allied Health Literature, Educational Resources Information Center, PsycINFO, and Research and Development Resource Base in Continuing Medical Education up to July 2012. Paired investigators independently assessed study eligibility. Investigators abstracted data sequentially and independently graded the evidence.

**RESULTS:** Sixty-eight eligible studies were classified by intervention: decision support, organizational change, feedback and audit, clinical pharmacy support, education only, quality improvement/pay-for-performance, multicomponent, and information only. Half were randomized trials ( $n = 35$ ). There was moderate evidence for increased prescriptions of controller medications for decision support, feedback and audit, and clinical pharmacy support and low-grade evidence for organizational change and multicomponent interventions. Moderate evidence supports the use of decision support and clinical pharmacy interventions to increase provision of patient self-education/asthma action plans. Moderate evidence supports use of decision support tools to reduce emergency department visits, and low-grade evidence suggests there is no benefit for this outcome with organizational change, education only, and quality improvement/pay-for-performance.

**CONCLUSIONS:** Decision support tools, feedback and audit, and clinical pharmacy support were most likely to improve provider adherence to asthma guidelines, as measured through health care process outcomes. There is a need to evaluate health care provider-targeted interventions with standardized outcomes. *Pediatrics* 2013;132:517–534

In the United States, an estimated 24.6 million people (8.2%) currently have asthma,<sup>1</sup> resulting in >14 million missed school days every year, and ~679 000 childhood emergency department (ED) visits.<sup>2</sup> Asthma is the third leading cause of pediatric hospitalizations.<sup>2</sup>

A number of guidelines have been published (eg, the National Asthma Education and Prevention Program *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma*, also known as EPR-3<sup>3</sup>), and following guideline treatment recommendations improves clinical outcomes.<sup>4–6</sup> However, health care providers do not routinely follow asthma guideline recommendations,<sup>7,8</sup> resulting in substandard care and poor health outcomes.<sup>9–14</sup> One of the shortcomings of asthma guidelines is the limited extent to which health care providers are provided with tools to follow the recommended care.<sup>15</sup> There have been provider-targeted interventions,<sup>16–21</sup> but most interventions have been patient-focused.<sup>22–25</sup> There is no consensus on the most effective provider-targeted interventions to improve adherence to guidelines.

The objective of our systematic review was to assess whether interventions targeting health care providers improve adherence to asthma care guidelines and subsequently improve outcomes. We considered health care process outcomes, such as patients receiving appropriate treatment, and clinical outcomes, such as hospitalizations.

## METHODS

We followed the Agency for Healthcare Research and Quality *Methods Guide for Effectiveness and Comparative Effectiveness Reviews* (available at [www.effectivehealthcare.ahrq.gov/methods-guide.cfm](http://www.effectivehealthcare.ahrq.gov/methods-guide.cfm)). Our protocol and the full report were subject to review.<sup>26,27</sup>

## Data Sources and Searches

We searched Medline, Embase, the Cochrane Central Register of Controlled Trials, Cumulative Index to Nursing and Allied Health Literature, Educational Resources Information Center, PsycINFO, and Research and Development Resource Base in Continuing Medical Education through July 2012. No limits were imposed based on language or date of publication. We also completed backward citation searching by using Scopus for each eligible article.

## Study Selection

Search results were screened independently by 2 trained investigators. Disagreements about eligibility were resolved through discussion. We included randomized and nonrandomized studies. We excluded studies that were conducted in inpatient or ED settings only. Potentially eligible articles not in English were identified but not included in the data abstraction and synthesis. We selected the most common outcomes used in practice, those relied on by clinicians to guide decision-making, and those endorsed by the National Institutes of Health Workshop on Asthma Outcomes.<sup>28</sup> These critical outcomes are prescription of asthma controller medicines, provision of asthma action plan/self-management education, ED visits/hospitalizations, and missed days of school or work.<sup>29</sup>

## Data Extraction and Quality Assessment

One reviewer completed data abstraction and a second reviewer confirmed accuracy. Reviewers completed risk of bias assessment independently. We resolved disagreements through discussion and, as needed, through consensus among the investigators.

## Risk of Bias Assessment

We used the Cochrane Collaboration's tool for assessing risk of bias.<sup>30</sup> For pre-post studies, we added relevant

criteria from the Cochrane Effective Practice and Organization of Care checklist.<sup>31</sup> Specifically, the questions ask if the intervention was likely to affect data collection and if the intervention was independent of other changes.

## Data Synthesis and Analysis

Heterogeneity in the studies, including the measures of outcomes, population included, and specifics of the interventions, precluded quantitative synthesis. Qualitative synthesis was based on these categories of interventions:

1. decision support interventions are health information technology—and/or paper-based interventions designed to support/facilitate health care provider decision-making;
2. organizational change interventions are designed to change the way in which an organization provides care (eg, having an asthma “champion”);
3. feedback and audit interventions provide performance data to health care providers about their quality of care;
4. clinical pharmacy support interventions target pharmacists' delivery of care;
5. education only interventions are focused on educating health care providers about the content of guidelines;
6. quality improvement/pay-for-performance interventions are focused on quality improvement initiatives or pay-for-performance;
7. multicomponent interventions use more than 1 type of intervention, with no intervention clearly the predominant intervention;
8. information-only interventions provide only information to health care providers about guideline recommendations (eg, provide a pocket guide to guidelines).

For studies that used >1 intervention, we determined the predominant intervention. Studies in which this intervention was unclear were discussed among team members to reach consensus. Some studies used multicomponent interventions with no predominant intervention.

We chose magnitudes of effect felt to be clinically meaningful. Magnitude of effect was considered as small (<10% change or difference), moderate (10%–30% change or difference), and large (>30% change or difference).

We graded the strength of evidence (SOE) for each outcome by using the *Methods Guide for Conducting Comparative Effectiveness Reviews*.<sup>32</sup> We

considered 4 domains: risk of bias, directness, consistency, and precision. Our judgments were first based on the ability to make a conclusion (if not able to make a conclusion, then “insufficient” was assigned) and then on the confidence in the conclusion (classified as low, moderate, or high with increasing certainty). Investigators graded the evidence, and this was reviewed by the lead author. Any disagreements were discussed with the full team.

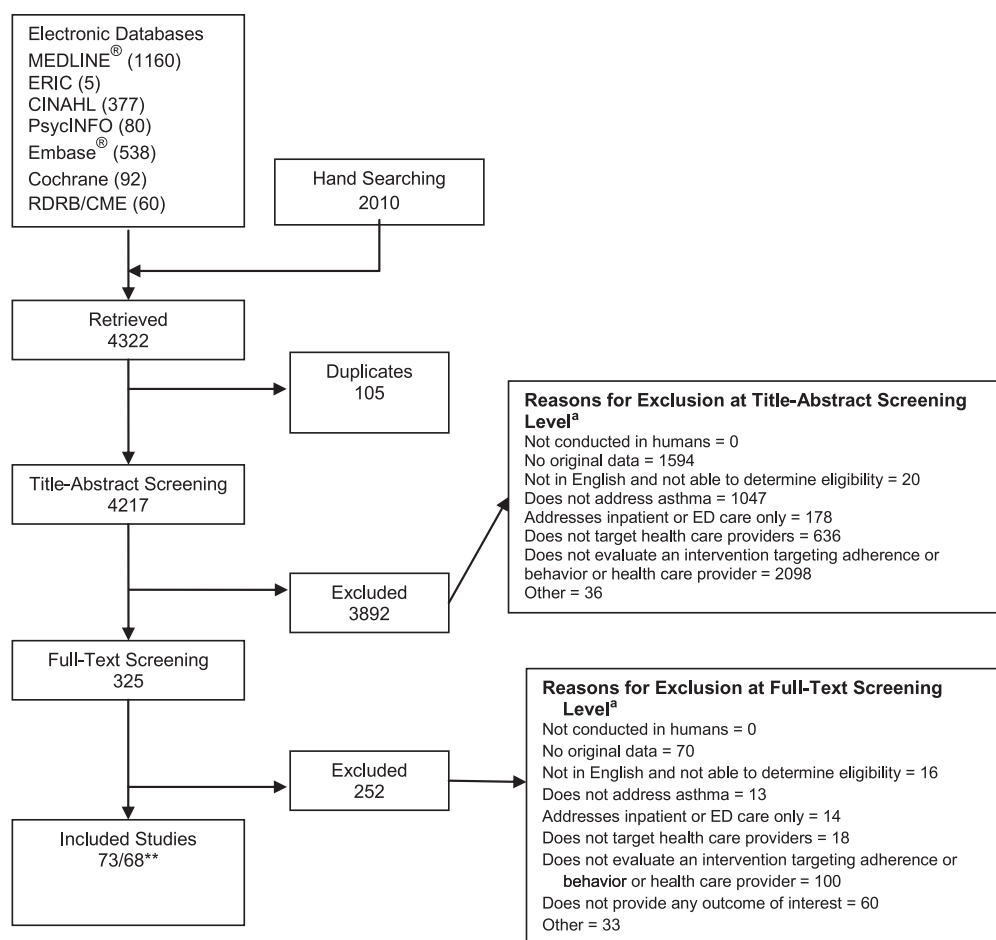
For pediatric health care providers, it is pertinent to know if asthma interventions have included children because these patients often have different natural history, developmental considerations, environmental exposures, advocacy

concerns as minors, and phenotypes than adults. In terms of provider behavior, there is no distinction in guidelines regarding asthma diagnosis and management. Thus, for this summary, we considered studies of all providers but have noted those described as being conducted in a pediatric population.

## RESULTS

### Results of Literature Searches

We identified 4217 unique citations of which 68 studies were eligible (Fig 1). We present the evidence addressing health care process outcomes (Table 1) and clinical outcomes (Table 2). Supplemental Tables provide summaries



**FIGURE 1**

Summary of search (number of articles). ERIC, Educational Resources Information Center; RDRB/CME, Research and Development Resource Base in Continuing Medical Education. \* Total exceeds the number in the exclusion box because reviewers did not need to agree on reason for exclusion. \*\* Three distinct pairs of articles described a single intervention or cohort. For the purposes of this review, each pair was counted as a single study, yielding 68 studies reported in 73 articles.

**TABLE 1** Characteristics of Studies Addressing Health Care Process Outcomes

Intervention	Author, y	Patient Population	Study Design	Type of Provider	No. of Providers	No. of Patients	Health Care Process Outcomes		
							Prescription for Controller Medicines	Self-management Education/Asthma Action Plan	Outcomes
Clinical pharmacy support	De Vries, 2010 <sup>34</sup>	Pediatrics	Nonrandomized pre-post	Arm A: general practitioner, general practitioner, pharmacist; Arm C: general practitioner, pharmacist, pediatrician Pharmacist	9	Arm A (control): 3527; Arm B (feedback): 1447	↑		N/A
	Armour, 2007 <sup>35</sup>	Adults	RCT	Arm A (control): 25; Arm B (PACP): 32		Arm A (control): 186; Arm B (PACP): 165	↑		↑
	Saini, 2004 <sup>35</sup>	Not specified	Pre-post	Arm A: general practitioner, pharmacist; Arm B: pharmacist; Arm C: pharmacist Pediatrician	Arm A (control 1): 13; Arm B (control 2): 12; Arm C (education): NR	Arm A (control 1): 22; Arm B (control 2): 28; Arm C (education): 52	↑		N/A
	Bell, 2010 <sup>47</sup>	Pediatrics	RCT	Pediatrician	NR	Arm A (UP control): 5192; Arm B (UP intervention): 5040; Arm C (SP control): 3843; Arm D (UP control): 5375	↑		∅
Decision Support	Cloutier, 2005 <sup>39</sup>	Pediatrics	Pre-post	Nurse, nurse practitioner, pediatrician, physician assistant, primary health care pediatric residents, medical students	151	3748	↑		N/A
	Fairall, 2010 <sup>49</sup>	Pediatrics	RCT	Nurse	148	Arm B (intervention): 1000	↑		N/A
	Halterman, 2006 <sup>81</sup>	Pediatrics	RCT	Nurse practitioner, pediatrician, physician	NR	Arm A (control): 124; Arm B (intervention): 122	N/A		↑
	Lesho, 2005 <sup>38</sup>	Pediatrics	Pre-post	Primary health care	NR	330	∅		↑
	Rance, 2011 <sup>41</sup>	Pediatrics	Pre-post	Nurse practitioner, pediatrician	4	41	↑		N/A
	Shapiro, 2011 <sup>42</sup>	Pediatrics	Pre-post	Nurse, physician	25	Arm B (SBHC): 200; Arm C (NYGHP): 197	↑		N/A
	Shiffman, 2000 <sup>46</sup>	Pediatrics	Pre-post	Pediatrician	11	Arm A (sole physician arm; patient arm, pre): 91; Arm B (patient arm): 74	∅		N/A
	To, 2008 <sup>65</sup>	Mixed (2–55 y)	Pre-post	Primary health care	NR	1408	N/A		↑
	Cho, 2010 <sup>45</sup>	Adults	Pre-post	Allergist, general practitioner, physician	377	2042	↑		N/A
	Eccles M, 2002 <sup>45</sup>	Adults	RCT	General practitioner	NR	Arm A (angina): 4851; Arm B (asthma): 4960	∅		∅
Cloutier, 2002 <sup>40</sup>	Not specified	Pre-post	Nurse, nurse practitioner, other, pediatrician, physician, physician assistant advanced practice nurses, family practice	172	860	↑		N/A	

TABLE 1 Continued

Intervention	Author, y	Patient Population	Study Design	Type of Provider	No. of Providers	No. of Patients	Health Care Process Outcomes	
							Prescription for Controller Medicines	Self-management Education/Asthma Action Plan
	Davis, 2010 <sup>48</sup>	Not specified	Pre-post	Physician family medicine residents	NR	180	↑	N/A
	Horswell, 2008 <sup>36</sup>	Not specified	Pre-post	Physician	NR	NR	↑	↑
	Kattan, 2006 <sup>5</sup>	Not specified	RCT	Nurse practitioner, physician assistant, primary health care	Arm A (standard practice): NR; Arm B (decision support): 435	Arm A (standard practice): 466; Arm B (decision support): 471	↑	N/A
	Martens, 2007 <sup>44</sup>	Not specified	RCT	General practitioner	Arm A (Control): 54; Arm B (Guidelines and involved in development): 53	Arm A: 24; 160; Arm B: 35; 748	∅	N/A
	McCowan, 2001 <sup>82</sup>	Not specified	RCT	General practitioner	NR	Arm A (control): 330; Arm B (decision support): 147	N/A	∅
	Mitchell, 2005 <sup>37</sup>	Not specified	RCT	General practitioner	NR	NR	∅	N/A
	Newton, 2010 <sup>84</sup>	Not specified	Pre-post	Nurse, physician practice managers, other staff	270	NR	N/A	↑
	Ruoff, 2002 <sup>19</sup>	Not specified	Pre-post	Family physicians	Arm A: 17; Arm B: 17	Arm A: 122; Arm B: 122	N/A	↑
	Ragazzi, 2010 <sup>83</sup>	Not specified	Pre-post	Nurse, pediatrician	26-28	NR	N/A	↑
	Davis, 2004 <sup>37</sup>	Pediatrics	Pre-post	Primary health care	20	NR	↑	N/A
	Blackstien-Hirsch, 2000 <sup>38</sup>	Pediatrics	Pre-post	Physician	59	195	∅	N/A
	Shah, 2011 <sup>50</sup>	Pediatrics	RCT	General practitioner	150	Arm A (control): 107; Arm B (PACE): 110	↑	↑
	Brown R, 2004 <sup>18</sup>	Pediatrics	RCT	Pediatrician	Arm A (Control): 11; Arm B (Education): 12	Arm A (control): 122; Arm B (education): 157	∅	∅
	Clark, 1998 <sup>52</sup>	Pediatrics	RCT	Pediatrician, physician	Arm A (control): 37; Arm B (education): 37	637	↑	↑
	Stergachis, 2002 <sup>53</sup>	Pediatrics	RCT	Pharmacist	Arm A (control): NR; Arm B (education): 35	Arm A (control): 177; Arm B (education): 153	∅	N/A
	Sulaiman, 2010 <sup>87</sup>	Pediatrics	RCT	General practitioner	Arm A (control): 18; Arm B (education and guidelines): 18; Arm C (guidelines): 15	Arm A (control): 121; Arm B (education and guidelines): 156; Arm C (guidelines): 134	N/A	∅
	Premaratne, 1999 <sup>54</sup>	Mixed (15-50 y)	RCT	Nurse practice nurses	NR	Arm A (control): 14; 410; Arm B (education): 9900	∅	N/A
	Holton, 2011 <sup>86</sup>	Adults	RCT	General practitioner	Arm A (control): 45; Arm B (spirometry training): 127	Arm A (control): 157; Arm B (spirometry training): 240	N/A	∅
	Smeete, 1999 <sup>51</sup>	Adults	RCT	General practitioner	Arm A (control): 17; Arm B (education): 17	Arm A (control): 223; Arm B (education): 210	∅	N/A
	Cowie, 2001 <sup>56</sup>	Not specified	Pre-post	NR	NR	Arm A (basic education): NR; Arm B (intermediate education): NR; Arm C (intensive education): NR	∅	N/A

TABLE 1 Continued

Intervention	Author, y	Patient Population	Study Design	Type of Provider	No. of Providers	No. of Patients	Health Care Process Outcomes		
							Prescription for Controller Medicines	Self-management Education/ Asthma Action Plan	Outcomes
Feedback and audit	Mahi-Tarighat, 2004 <sup>55</sup>	Not specified	Pre-post	General practitioner	50	49	Ø	Ø	N/A
	Schneider A., 2008 <sup>67</sup>	Mixed	RCT	General practitioner	96	Arm A (traditional quality circle): NR; Arm B (benchmark quality circle): NR; Arm C (combined arms): 256	Ø	Ø	↑
	Suh, 2001 <sup>65</sup>	Mixed (4–55 y)	Pre-post	NR	NR	Arm A (intermittent asthma): 566; Arm B (persistent asthma): 1050	↑	Ø	N/A
	Sondergaard, 2002 <sup>69</sup>	Mixed (6–45 y)	RCT	General practitioner	Arm A (control): 141; Arm B (individual patient count data feedback): 77; Arm C (aggregate data feedback): 74	6437	Ø	Ø	N/A
	Veninga, 1999 <sup>59</sup>	Adults	RCT	General practitioner	Arm A (Netherlands): 181; Arm B (Sweden): 204; Arm C (Norway): 199; Arm D (Slovakia): 81	NR	↑	Ø	N/A
	Feder, 1995 <sup>60</sup>	Adults	RCT	General practitioner	NR	Arm A (diabetes education): NR; Arm B (education, reminders and audit): NR	↑	Ø	↑
	Veninga, 2000 <sup>61</sup>	Adults	RCT	General practitioner	Arm A (UTI): 91; Arm B (education and feedback): 90	Arm A (UTI): NR; Arm B (education and feedback): NR	↑	Ø	N/A
	Baker, 2003 <sup>66</sup>	Not specified	RCT	General practitioner	Arm A (guidelines only): 27; Arm B (guidelines with audit criteria): 27; Arm C (guidelines with audit criteria and feedback): 27	Arm A (guidelines only): 483; Arm B (guidelines with audit criteria): 510; Arm C (guidelines with audit criteria and feedback): 489	↑	Ø	Ø
	Coleman, 2003 <sup>65</sup>	Not specified	Pre-post	Pharmacist prescriber	NR	Arm A (patient specific information: prescribers with patients on "high dose"): 510; Arm B (patient-specific information: prescribers with patients on "low dose"): 135	Ø	Ø	↑
	Richman, 2000 <sup>64</sup>	Not specified	Pre-post	Pediatrician	29	228	No statistical testing of results for this outcome	↑	↑
Herborg, 2001 <sup>68</sup>	Not specified	Non-RCT	General practitioner, other, pharmacist, pharmacy assistant	Arm A (control): 64; Arm B (TOM): 75	NR	↑	Ø	N/A	

TABLE 1 Continued

Intervention	Author, y	Patient Population	Study Design	Type of Provider	No. of Providers	No. of Patients	Health Care Process Outcomes
							Prescription for Controller Medicines Self-management Education/Asthma Action Plan
	Hoskins, 1997 <sup>62</sup>	Not specified	Pre-post	General practitioner	91	Before intervention: 782; Education and feedback intervention: 669	Unable to discriminate what component of multifaceted intervention was effective N/A
Information only	Bryce, 1995 <sup>71</sup>	Pediatrics	RCT	General practitioner, nurse	NR	Arm A (control): 1563; Arm B (reminders and tools): 1585	∅
	Martens, 2006 <sup>70</sup>	Not specified	RCT	General practitioner	Arm A (control): 54; Arm B (guidelines and involved in development): 53; Arm C (guidelines only): 26	NR	↓
Multi-component	Hagmolen, 2008 <sup>72</sup>	Pediatrics	RCT	General practitioner	Arm A (guidelines only): 34; Arm B (education and guidelines): 34; Arm C (education and guidelines and individualized treatment advice): 38	Arm A (guidelines only): 98; Arm B (education and guidelines): 133; Arm C (education and guidelines and individualized treatment advice): 131	↑
	Frankowski, 2006 <sup>88</sup>	Pediatrics	Pre-post	Nurse, pediatrician, primary health care	NR	Education and feedback: 150	N/A
	Lob, 2011 <sup>78</sup>	Pediatrics	Pre-post	Physician, nurse practitioner	NR	Longitudinal evaluation group, patient-level interview: 761 Cross-sectional random sample, clinic-level chart review, time 1: 680; Cross-sectional random sample, clinic-level chart review, time 2: 680; Cross-sectional random sample, clinic-level chart review, time 3: 680	↓
	Cloutier, 2012 <sup>75</sup>	Adults	RCT	Nurse practitioner, pediatrician, physician assistant	Arm A (control): 44; Arm B (physician-directed interventions): 44	NR	∅
	Daniels, 2005 <sup>73</sup>	Not specified	RCT	General practitioner, internist, nurse practitioner, pediatrician, physician, physician assistant staff	163	Arm A (control): 136 079; Arm B (education): 90 555	∅

TABLE 1 Continued

Intervention	Author, y	Patient Population	Study Design	Type of Provider	No. of Providers	No. of Patients	Health Care Process Outcomes		
							Prescription for Controller Medicines	Self-management Education/ Asthma Action Plan	
	Lundborg, 1999 <sup>74</sup>	Not specified	RCT	General practitioner	Arm A (control): 104; Arm B (education and feedback): 100	Arm A (control): 1333; Arm B (education and feedback): 1121	∅	N/A	N/A
	Yawn, 2008 <sup>77</sup>	Not specified	Pre-post	Nurse practitioner, physician, physician assistant	Education and feedback: 211	Education and feedback: 840	↑	↑	↑
	Bender, 2011 <sup>76</sup>	Not specified	Pre-post	Nurse, physician, physician assistant medical assistants, practice managers, office staff	372	15 508	↑	↑	↑
Organizational change	Finkelstein, 2005 <sup>79</sup>	Pediatrics	RCT	Pediatric medical provider	228	Arm A (control): 1531; Arm B (PLE intervention): 2003; Arm C (planned care intervention): 1635	∅	∅	N/A
	Glasgow, 2003 <sup>89</sup>	Pediatrics	RCT	General practitioner	Arm A (control): 12; Arm B (intervention): 12	Arm A (control): 73; Arm B (intervention): 101	N/A	↑	↑
	Patel, 2004 <sup>90</sup>	Mixed (4–55 y)	Pre-post	Physicians, nurses	NR	451	N/A	↑	N/A
	Thyne, 2007 <sup>90</sup>	Not specified	Pre-post	“Pediatric medical providers,” “urgent care clinicians”	NR	Arm A (time 1, 2002–2003): NR; Arm B (time 2, 2003–2004): NR; Arm C (time 3, 2004–2005): NR	↑	↑	N/A
Quality improvement	Fox, 2007 <sup>92</sup>	Pediatrics	Pre-post	Nurse, nurse practitioner, physician caregivers, administrative staff	NR	Chart review sample: 280; Interview sample: 405	N/A	↑	↑
	Homer, 2005 <sup>91</sup>	Pediatrics	RCT	Nurse, physician front office staff	NR	Arm A (control): 337; Arm B (learning collaborative): 294	N/A	∅	∅
	Mangione-Smith, 2005 <sup>93</sup>	Not specified	Pre-post	“Health care providers”	NR	Arm A (control): 126; Arm B (learning collaborative): 385	N/A	↑	↑

NR, not reported; NYGHP, New York Children's Health Project; PACE, Physician Asthma Care Program; PLE, Peer Leader Education; SBHC, South Bronx Health Center; SP, suburban practice; TOM, therapeutic outcomes monitoring; UP, urban practice; UTI, urinary tract infection. ∅, Statistically significant increase in outcome of interest. ↓, Statistically significant decrease in outcome of interest. ∅, Difference between intervention and control groups or between pre- and postintervention not statistically significant.



**TABLE 2** Characteristics of Studies Addressing Clinical Outcomes

Intervention	Author, y	Patient Population	Study Design	Type of Provider	No. of Providers	No. of Patients	Clinical Outcomes	
							ED Visits/ Hospitalization	Missed Days of School/Work
Clinical pharmacy support	Weinberger, 2002 <sup>94</sup>	Adults	RCT	Pharmacist	NR	Arm A (control): 165; Arm B (peak flow meter monitoring control group): 233	∅	N/A
	Lesho, 2005 <sup>38</sup>	Pediatrics	Pre-post	Primary health care	NR	330	↓	N/A
	Shiffman, 2000 <sup>16</sup>	Pediatrics	Pre-post	Pediatrician	11	Arm A (sole physician arm; patient arm, pre): 91; Arm B (patient arm): 74	↓	N/A
	To, 2008 <sup>85</sup>	Mixed (2–55 y)	Pre-post	Primary health care	NR	1408	↓	↓
	Cloutier, 2009 <sup>86</sup>	Not specified	Pre-post	Pediatrician	NR	3298	↓	N/A
	Horswell, 2006 <sup>56</sup>	Not specified	Pre-post	Physician	NR	NR	↓	N/A
	Kattan, 2006 <sup>5</sup>	Not specified	RCT	Nurse practitioner, physician assistant, primary health care	Arm A (standard practice): NR; Arm B (decision support): 471	Arm A (standard practice): 466; Arm B (decision support): 471	↓	∅
	McCowan, 2001 <sup>82</sup>	Not specified	RCT	General practitioner	NR	Arm A (control): 330; Arm B (decision support): 147	∅	N/A
	Mitchell, 2005 <sup>37</sup>	Not specified	RCT	General practitioner	270	NR	↓	N/A
	Newton, 2010 <sup>84</sup>	Not specified	Pre-post	Nurse, physician practice managers, other staff	NR	NR	↓	N/A
Education only	Renzi, 2006 <sup>95</sup>	Not specified	RCT	Primary health care	NR	NR	↓	N/A
	Blackstien-Hirsch, 2000 <sup>58</sup>	Pediatrics	Pre-post	Physician	59	195	∅	N/A
	Brown, 2004 <sup>18</sup>	Pediatrics	RCT	Pediatrician	Arm A (control): 11; Arm B (education): 12	Arm A (control): 122; Arm B (education): 157	↓ <sup>a</sup>	∅
	Clark, 1998 <sup>52</sup>	Pediatrics	RCT	Pediatrician, physician	Arm A (control): 37; Arm B (education): 37	637	∅	N/A
	Stergachis, 2002 <sup>53</sup>	Pediatrics	RCT	Pharmacist	Arm A (control): NR; Arm B (education): 35	Arm A (control): 177; Arm B (education): 153	∅	∅
	Sulaiman, 2010 <sup>87</sup>	Pediatrics	RCT	General practitioner	Arm A (control): 18; Arm B (education and guidelines): 15; Arm C (guidelines): 15	Arm A (control): 121; Arm B (education and guidelines): 156; Arm C (guidelines): 134	∅	N/A
	Cabana, 2006 <sup>17</sup>	Pediatrics	RCT	Primary health care	Arm A (control): 43; Arm B (PACE): 51	Arm A (control): 452; Arm B (PACE): 418	∅	N/A
	Shah, 2011 <sup>50</sup>	Pediatrics	RCT	General practitioner	150	Arm A (control): 107; Arm B (PACE): 110	N/A	∅
	Holton, 2011 <sup>88</sup>	Adults	RCT	General practitioner	Arm A (control): 45; Arm B (spirometry training): 127	Arm A (control): 157; Arm B (spirometry training): 240	N/A	∅
	Cowie, 2001 <sup>56</sup>	Not specified	Pre-post	NR	NR	Arm A (basic education): NR; Arm (intermediate education): NR; Arm C (intensive education): NR	∅	∅

**TABLE 2** Continued

Intervention	Author, y	Patient Population	Study Design	Type of Provider	No. of Providers	No. of Patients	Clinical Outcomes	
							ED Visits/ Hospitalization	Missed Days of School/Work
Feedback and audit	Schneider, 2008 <sup>67</sup>	Mixed	RCT	General practitioner	96	Arm A (traditional quality circle): NR; Arm B (benchmark quality circle): NR; Arm C (combined arms): 256	∅	N/A
	Richman, 2000 <sup>64</sup>	Not specified	Pre-post	Pediatrician	29	228	∅	∅
Information only	Bryce, 1995 <sup>71</sup>	Pediatrics	RCT	General practitioner, nurse	NR	Arm A (control): 1563; Arm B (reminders and tools): 1585	∅	N/A
Multicomponent	Lob, 2011 <sup>78</sup>	Pediatrics	Pre-post	Physician, nurse practitioner	NR	Longitudinal evaluation group, patient-level interview: 761; Cross-sectional random sample, clinic-level chart review, time 1: 680; Cross-sectional random sample, clinic-level chart review, time 2: 680; Cross-sectional random sample, clinic-level chart review, time 3: 680	↓	↓
Organizational change	Finkelstein, 2005 <sup>79</sup>	Pediatrics	RCT	Pediatric medical provider	228	Arm A (control): 1531; Arm B (PLE intervention): 2003; Arm C (planned care intervention): 1635	∅	N/A
	Glasgow, 2003 <sup>89</sup>	Pediatrics	RCT	General practitioner	Arm A (control): 12; Arm B (intervention): 12	Arm A (control): 73; Arm B (intervention): 101	∅	∅
	Patel, 2004 <sup>90</sup>	Mixed (4–55 y)	Pre-post	Physicians, nurses	NR	451	↓	N/A
	Thyne, 2007 <sup>80</sup>	Not specified	Pre-post	“Pediatric medical providers,” “urgent care clinicians”	NR	Arm A (time 1, 2002–2003): NR; Arm B (time 2, 2003–2004): NR; Arm C (time 3, 2004–2005): NR	↓ <sup>b</sup>	N/A
Quality improvement	Homer, 2005 <sup>91</sup>	Pediatrics	RCT	Nurse, physician front office staff	NR	Arm A (control): 337; Arm B (learning collaborative): 294	∅	N/A
	Mangione-Smith R., 2005 <sup>93</sup>	Not specified	Pre-post	“Health care providers”	NR	Arm A (control): 126; Arm B (learning collaborative): 385	∅	∅

NR, not reported; PAQE, Physician Asthma Care Education; PLE, Peer Leader Education. †, Statistically significant increase in outcome of interest. ‡, Statistically significant decrease in outcome of interest. ∅, Difference between intervention and control groups, or between pre- and post-intervention not statistically significant.

<sup>a</sup> Reduction in ED visit for subgroup of low-income participants only but reduction in annual rate of hospitalization for entire group.

<sup>b</sup> Reduction in ED visit but P value not reported in study.

of the evidence by outcome. Twenty-five of the 68 studies were conducted in pediatric-only populations. The tables indicate if the patient population included children only, adults only, a mixture of children and adults, or if the patient population is unknown.

## Outcome: Prescription of Controller Medicines

### Clinical Pharmacy Support

We identified 3 studies.<sup>33–35</sup> In a randomized controlled trial (RCT), pharmacists trained in risk assessment, medication adherence, and spirometry reported increased dispensation of asthma controller medicines (odds ratio [OR]: 3.80; 95% confidence interval [CI]: 1.40–10.32;  $P = .01$ ).<sup>33</sup> In 2 non-RCTs,<sup>34,35</sup> clinical pharmacy support increased controller medication prescribing by 20%<sup>35</sup> and 6%<sup>34</sup> ( $P < .05$  for both studies). In the controlled pre-post study, the intervention was a specialized asthma service provided by community pharmacies: patient appointments, assessment and intervention of patient medication needs, and goal-setting with the patient.<sup>35</sup> In the latter study, pharmacists were encouraged to meet with local practitioners to discuss pediatric asthma care guidelines.<sup>34</sup>

SOE: moderate.

### Decision Support

Fifteen studies were identified that included the provision of asthma guidelines in a more accessible format (eg, “pocket” versions),<sup>36–38</sup> use of a specific algorithm, pathway, or flow sheet,<sup>37–40</sup> a structured template for taking a history,<sup>41,42</sup> a reminder system to raise awareness about the patient’s asthma status,<sup>5,43,44</sup> and computer systems.<sup>36,43–48</sup> Ten of the studies reported significantly increased prescribing of asthma controller medicines,<sup>5,36,39–43,47–49</sup> from 2% to 34%, and 5 reported no statistically significant effect.<sup>37,38,44–46</sup>

SOE: moderate.

### Education Only

The 10 education-only interventions we identified<sup>18,50–58</sup> included small-group asthma education programs,<sup>51</sup> structured training,<sup>58</sup> seminars,<sup>52</sup> and grand rounds.<sup>58</sup> Certain interventions also emphasized more general skills, such as training in communication.<sup>50,52</sup> The studies reported increased prescribing of 3.5% to 50.3%, although statistically significant increases were reported only in 3 of the studies.

SOE: low.

### Feedback and Audit

We identified 11 studies; most assessed a multifaceted intervention combined with provider education,<sup>59–65</sup> prioritized review criteria for audit,<sup>66</sup> benchmarking (comparison with peers or other practices),<sup>66,67</sup> or pharmacy monitoring of fill data and feedback.<sup>68,69</sup>

Increased prescribing of asthma controller medicines was reported for RCTs using (1) targeted key guideline messages (eg, “use inhaled corticosteroids [ICS] promptly”; 5%–12% increase,  $P = .05$ ),<sup>59</sup> (2) prioritized guideline review criteria on a card,<sup>66</sup> (3) prompts for annual review of asthma management,<sup>60</sup> or (4) individualized feedback on prescribing and decision strategies.<sup>61</sup> The 2 RCTs reporting no effect on prescribing of asthma controller medications involved mailed feedback of prescribing data<sup>69</sup> and a trial of performance feedback (a “benchmark” group, whose prescribing behavior was compared with a performance benchmark or with other prescribers, versus a traditional or individual feedback group, which did not receive comparison with other prescribers).<sup>67</sup> The observed effects between 3 groups (guidelines alone, prioritized guideline review criteria, and review criteria plus feedback on actual prescribing behavior) was a 15.9% increase in controller prescribing in the review criteria plus feedback group, compared with an 11%

increase in the review criteria only and no change (0%) in the guideline only group.<sup>66</sup> A positive but nonsignificant 2.7% difference (95% CI: –14.4 to 19.7) was noted in the proportion of patients in practices with asthma “prophylaxis” compared with practices provided with diabetes guidelines.<sup>60</sup>

Three of 5 pre-post studies reported increased prescribing of controller medications (52%–104%): change in prescribing over time (52%), a 104.4% in patients with intermittent asthma but a decrease by 10.8% in patients with persistent asthma.

SOE: moderate.

### Information Only

Two RCTs were assessed information only.<sup>70,71</sup> One study, which randomized patients to have asthma management information and treatment guidelines inserted into their medical records for provider use, reported no benefit.<sup>71</sup> The second study randomly selected providers to participate in developing local asthma guidelines mailed to providers in both intervention and comparison groups.<sup>70</sup> Intervention providers wrote 8 fewer prescriptions per 1000 patients ( $P < .01$ ).

SOE: insufficient.

### Multicomponent

We identified 7 studies of multicomponent interventions.<sup>72–78</sup> All interventions included information, education, and at least 2 of the following: organizational change, decision support, and feedback and audit. Two of the 3 pre-post studies reported 25% to 49% increases in prescribing rates.<sup>76,77</sup> Three of the 4 RCTs reported no statistically significant effects.

SOE: low.

### Organizational Change

The 2 studies of organizational change focused on pediatric providers.<sup>79,80</sup> An

RCT assessed the use of an asthma nurse educator,<sup>79</sup> and the pre-post study evaluated use of a community health worker.<sup>80</sup> The RCT reported no significant increase in prescriptions for ICS or asthma controller medications (4%–16%).<sup>79</sup> In the pre-post study, investigators observed a 12% increase in ICS prescriptions (no *P* value reported).<sup>80</sup>

SOE: low.

#### *Quality Improvement and Pay-for-Performance*

No studies were identified.

SOE: insufficient.

#### **Outcome: Self-Management Education and Asthma Action Plans**

##### *Clinical Pharmacy Support*

We identified 1 RCT in which patients of pharmacists in the Pharmacy Asthma Care Program had increased asthma action plan possession (40.4%; 95% CI: 31.9–48.9; *P* < .001); however, there are no data for the control group.<sup>53</sup>

SOE: moderate.

##### *Decision Support*

We identified 10 studies<sup>19,36,38,45,47,81–85</sup> that included computerized support,<sup>36,45,47,82,84</sup> a flow sheet/algorithm,<sup>19,85</sup> and/or the provision of guidelines.<sup>38</sup> Two of the 3 studies focused on pediatricians.<sup>81,85</sup> Seven studies reported statistically significant increase in the provision of patient education/asthma action plans of 14% to 84% (all reported as statistically significant).<sup>19,36,38,81,83–85</sup> Three of the 4 RCTs reported no significant difference.<sup>45,47,82</sup>

SOE: moderate.

##### *Education Only*

Of the 5 RCTs of education-only interventions,<sup>18,50,52,86,87</sup> 1 focused on pediatricians and used small-group asthma education programs, structured training, and interactive seminars. Two

studies increased use of asthma action plans by 10% (*P* = .03)<sup>52</sup> and 15% (*P* = .046).<sup>50</sup> The other 3 studies reported no increase.<sup>18,86,87</sup>

SOE: low.

##### *Feedback and Audit*

Five studies evaluated feedback and audit.<sup>60,63,64,66,67</sup> Significant increases in provision of self-management education/asthma action plans (1%–40%) were reported in 4 studies.<sup>60,63,64,67</sup>

For peak flow meter use, one study reported a 3.6% decrease, while a second study reported a minimal increase of 0.7% (95% CI: –15.2 to 16.7) after practices received asthma guidelines.<sup>60</sup> A moderate increase was noted for inhaler technique, 12.9% (95% CI: 1.9 to 23.9),<sup>51</sup> and a small increase in change of asthma action plan use (7.6%) in a benchmarking feedback group.<sup>67</sup>

SOE: low.

##### *Information Only*

No studies were identified.

SOE: insufficient.

##### *Multicomponent*

Of the 6 studies we reviewed,<sup>73,75–78,88</sup> most included an educational component but also included (1) training in communication techniques with provision of a spirometer and training in use of the spirometer<sup>76</sup>; (2) laminated posters of guidelines and medications with feedback on asthma action plan use and monthly calls from an intervention team to troubleshoot communication problems<sup>88</sup>; (3) asthma kits (peak flow meters, spacers, educational materials) and systems-level changes (flow sheets and standing medication orders)<sup>73</sup>; (4) systematic use of a patient questionnaire and an asthma management algorithm<sup>77</sup>; (5) an asthma coordinator and feedback on performance as part of continuous quality improvement efforts; or (6) an

educational toolbox with seminars, teleconferences, mini fellowships, opinion leader visits, clinician-specific feedback, and pay for performance.<sup>75</sup> The pre-post studies reported increases in the provision of action plans (27%–46%).<sup>76–78,88</sup> Both RCTs reported nonsignificant increases in patient education/asthma action plans (7% in 1 study; relative risk = 1.82 in the other study).<sup>73,75</sup>

SOE: low.

##### *Organizational Change*

We identified 2 studies.<sup>89,90</sup> A pre-post study (instituting a registry to track asthma patients and an asthma case manager) reported a 10% increase in patient education (*P* < .001) and a 14% increase in asthma action plan dispensations (*P* < .001).<sup>90</sup> In the RCT (a restructured clinical protocol for how asthma patients are cared for during ambulatory care encounters; “3+ visit plan”), there was a 10% increase in the provision of asthma education (*P* = .01).<sup>89</sup>

SOE: low.

##### *Quality Improvement and Pay-for-Performance*

Three studies, each including pediatric health care providers, were identified.<sup>91–93</sup> Two studies assessed participation in a Breakthrough Series Collaborative,<sup>91,93</sup> and 1 study assessed a combination of continuous quality improvement and the addition of a community health worker.<sup>92</sup> One of these studies showed a difference of 33% in the intervention arm.<sup>93</sup> Two of the 3 studies showed a 28% to 32% increase in the proportion of patients who had received an asthma action plan.<sup>92,93</sup> These 2 studies enrolled practices that had already joined a quality improvement initiative<sup>93</sup> or were part of a demonstration project.<sup>92</sup>

The RCT showed no significant effect, with a 3% lower rate for the intervention

versus control group.<sup>91</sup> However, there were decreases in participation and in outcome reporting over time. In the controlled pre-post study, documented self-management education increased by 21%.<sup>93</sup>

SOE: low.

## Outcome: ED Visits/Hospitalizations

### Clinical Pharmacy Support

In an RCT, pharmacists were provided with patient specific clinical data, training about asthma management, patient educational materials, resource guides, and pragmatic strategies.<sup>94</sup> Patients of intervention pharmacists were more likely to have a reduction in ED visits/hospitalizations compared with patients seen by pharmacists who received peak flowmeter instruction only (OR: 2.16; 95% CI: 1.76–2.63) but not compared with patients of the usual care control group (OR 1.08; 95% CI: 0.93–1.25).<sup>94</sup>

SOE: insufficient.

### Decision Support

For the 10 studies addressing this outcome,<sup>5,36–38,46,82,84,85,95,96</sup> decision support interventions included computer systems,<sup>36,46,82,84</sup> checklists,<sup>95</sup> supplemental feedback protocols,<sup>5</sup> and structured pathways/algorithms.<sup>37,96</sup> Several studies included children.<sup>5,37,46,85,96</sup>

Nine studies reported a reduction in ED visits or hospitalizations<sup>5,36–38,46,84,85,95,96</sup> (5%–60%) among pre-post studies (all statistically significant) and 1% to 7% among the RCTs.<sup>5,37,95</sup>

SOE: moderate.

### Education Only

We identified 7 studies<sup>17,18,52,53,56,58,87</sup> involving interactive seminars, structured training, and medical grand rounds. One study reported statistically significant reduction in ED visits (only in a subgroup of low-income participants;  $-1.23$  visits per year,

$P = .001$ ) and in the overall annual hospitalization rate.<sup>18</sup>

SOE: low.

### Feedback and Audit

We identified 2 studies: (1) an RCT of a traditional quality circle intervention of provider feedback on individual performance and the aggregate performance of the provider group was compared with a benchmark quality circle intervention (feedback on providers' individual performance was explicitly compared with a performance benchmark)<sup>67</sup>; and (2) a pre-post study comparing individual providers' practice patterns with their peers plus providing asthma education to office staff.<sup>64</sup> Patients in the benchmark quality circle had a 6.7-point decrease in ED visits, although patients in the traditional quality circle intervention had a 12.2-point decrease ( $P = .064$ ).<sup>67</sup>

No significant change in ED visits (1% decrease) or hospitalizations (2% decrease) was reported in the pre-post study.<sup>64</sup>

SOE: insufficient.

### Information Only

The 1 study identified randomized patients to have information about asthma guidelines inserted in their medical records for provider use; each provider thus managed patients in both intervention and control arms simultaneously.<sup>71</sup> No differences in rates of ED visits or hospitalizations were observed between intervention and control arms of the study.

SOE: insufficient.

### Multicomponent

One study included quality improvement, decision support, organizational change, and feedback-and-audit.<sup>78</sup> This study reported a 69% reduction in ED visits and hospitalizations. However, 44% of the patient sample was lost to

follow-up, and significant heterogeneity in results was seen across participating sites.

SOE: insufficient.

### Organizational Change

We identified 4 studies,<sup>79,80,89,90</sup> which included restructured asthma care visits,<sup>89</sup> supplemental trained personnel, and provider education.<sup>79,80,90</sup> Three studies focused on pediatric providers.<sup>79,80,89</sup>

Only 1 of 4 studies, a pre-post study, reported a significant reduction in ED visits: a 41% reduction in ED visits and 54% reduction in hospitalizations ( $P < .001$  for both).<sup>90</sup> The other pre-post study reported a 4% reduction in hospitalizations (no  $P$  value reported).<sup>80</sup> The 2 RCTs reported 1% ( $P > .05$ )<sup>79</sup> and 7% ( $P = .06$ )<sup>89</sup> reductions.

SOE: low.

### Quality Improvement and Pay-for-Performance

One RCT<sup>91</sup> and 1 controlled pre-post study<sup>93</sup> evaluated a Breakthrough Series Collaborative quality improvement strategy among pediatric providers in community health centers. Neither study showed a significant reduction in either outcome. However, in the RCT, when analyses were limited to the 9 practices that attended all 3 learning sessions, significant reductions in ED visits were reported.<sup>91</sup>

SOE: low.

## Outcome: Missed Days of Work/School

### Clinical Pharmacy Support

No studies identified.

SOE: insufficient.

### Decision Support

An RCT reported no reduction in missed school (0.05 days;  $P = .4$ ) after mailing patient-specific asthma morbidity information to their health care provider.<sup>5</sup>

A pre-post study reported a 49% reduction ( $P < .001$ ) in school absenteeism and a 51% reduction in the odds of missed work (OR: 0.49; 95% CI: 0.34–0.71) after using an asthma care map, a treatment flowchart, program standards, management flowchart, and action plan.<sup>85</sup> Both studies were conducted in a pediatric population.

SOE: insufficient.

#### *Education Only*

Five studies evaluated the effect of provider education on missed school or missed work.<sup>18,50,53,56,86</sup> Three RCTs used structured training, seminars, and workshops for health care providers to examine the effects on missed school. They reported small but statistically nonsignificant reductions in missed school (0.6–4 days). To evaluate the impact on missed work, 2 RCTs<sup>50,86</sup> and 1 pre-post study<sup>56</sup> provided workshops and training in how to perform spirometry, and 1 study compared asthma program development with a nurse educator program to continuing education. All studies reported small, statistically nonsignificant reductions in missed school or work.

SOE: insufficient.

#### *Feedback and Audit*

We identified 1 pre-post study that provided asthma education to office staff and observed an 11% reduction in school days missed and a 0% reduction in parent workdays missed.<sup>64</sup>

SOE: insufficient.

#### *Information Only*

No studies were reviewed.

SOE: insufficient.

#### *Multicomponent*

One study implemented decision support, organizational change, and feedback and audit. This study found significant reductions in missed days of school (53%) and work (72%). However,

44% of the patient sample was lost to follow-up, and significant heterogeneity in results was reported.<sup>78</sup>

SOE: insufficient.

#### *Organizational Change*

One RCT of organizational change based on restructuring the clinical protocol for patient care during ambulatory care encounters (“3+ visit plan”)<sup>89</sup> did not reduce missed school days (OR: 0.8; 95% CI: 0.5–1.2;  $P = .3$ ).

SOE: low.

#### *Quality Improvement and Pay-for-Performance*

One controlled pre-post study reported that patients of providers participating in the Breakthrough Series Collaborative quality improvement strategy showed no significant reduction in the mean number of school days or parental workdays missed.<sup>93</sup>

SOE: insufficient.

## **DISCUSSION**

Of the 68 studies we identified, a minority of studies focused on pediatric health care providers or involved children (14 studies assessing clinical outcomes; 24 studies assessing health care process outcomes). We acknowledge that there are a number of ways in which providing care for children is different from providing care for adults: (1) physiology; (2) disease presentation, natural history, and morbidity; (3) the need to consider congenital, genetic, and developmental issues; and (4) support structure, including that children are minors so parents are a necessary element to any medical decision-making process. However, there are a few reasons that findings of provider-targeted asthma interventions should be applicable across the health care provider spectrum: (1) asthma guideline recommendations generally do not distinguish different

types of providers; (2) a number of provider behaviors in asthma care are universal (eg, assessing asthma control/severity; prescribing controller medications for persistent asthma; providing self-management education); (3) the goals for patient outcomes are the same (eg, reducing acute care visits for exacerbations; limiting missed school/work); and (4) the mainstay treatment options are the same (eg, inhaled steroids and short-acting bronchodilators). Therefore, for pediatricians, as with other providers, it is reasonable that the decision to choose and implement a given intervention to improve their adherence to asthma guidelines be based on (1) the data on the effectiveness of the intervention, (2) the feasibility of implementing the intervention within their own practice setting, and (3) the sustainability of the intervention. There is always a need for pediatric-focused studies, but we believe that the findings of our review may provide lessons for all providers.

Decision support, feedback/audit, and education only were the most common interventions and were tested for each of the outcomes we evaluated. Conversely, organizational change, clinical pharmacy support, quality improvement/pay-for-performance, information only, and multicomponent strategies were less consistently tested (see Table 3). Evidence suggests that some of the interventions are not effective in achieving specific outcomes: education to increase prescribing of asthma controller medications or to reduce ED visits/hospitalizations; organizational change to reduce ED visits/hospitalizations or to reduce missed days of school/work; and quality improvement to reduce ED visits/hospitalizations. Notably, these findings were limited by having only a few studies, typically nonrandomized, on which to draw conclusions. Most of the studies used a pre-post design, which more often reported a beneficial effect than the RCTs.

**TABLE 3** Summary of SOE for Interventions Designed to Modify Clinician Adherence to Asthma Guidelines

Intervention	Outcome: Prescription of Controller Medications	Outcome: Self-management Education/Asthma Action Plans	Outcome: ED Visits/Hospitalizations	Outcome: Missed Days of Work/School
Clinical pharmacy support	Benefit within 3 studies with moderate magnitude of effect; SOE moderate	Benefit in 1 study with moderate magnitude of effect; SOE moderate	Unable to make a conclusion based on 1 study with imprecise results; SOE insufficient	No studies; SOE insufficient
Decision support	Benefit with large magnitude of effect; SOE moderate	Studies consistently favor intervention with large magnitude of effect; SOE moderate	Benefit with moderate magnitude of effect (larger in pre-post studies); SOE moderate	Unable to conclude due to inconsistent results; SOE insufficient
Education only	No benefit; SOE low	Small to moderate increases in a minority of studies; SOE low	No benefit; inconsistent results (reductions and increases); low SOE	No conclusion due to inconsistent and imprecise estimates of effect in 5 studies; SOE insufficient
Feedback and audit	Benefit with moderate magnitude of effect; SOE moderate	Benefit with low magnitude of effect; SOE low	No conclusion could be made due to conflicting results in few studies; SOE insufficient	No conclusion due to inconsistent results in 1 included study; SOE insufficient
Information only	Unable to make conclusion; SOE insufficient	No studies; SOE insufficient	Unable to make conclusion; no difference seen, but study quality was low; SOE insufficient	No studies; SOE insufficient
Multicomponent interventions	Benefit with moderate magnitude of effect; SOE low	Benefit, with moderate magnitude of effect (larger in observational studies); SOE low	Unable to make conclusion; although the 1 study reported a large reduction, the study quality was low; insufficient SOE	No conclusion; 1 study reported a large reduction, but study quality was low; SOE insufficient
Organizational change	Benefit with small magnitude of effect; SOE low	Two studies show benefit with moderate magnitude of effect; SOE low	No benefit with range of magnitudes of effect; SOE low	No benefit (for missed school days); SOE low
Quality improvement and pay-for-performance	No studies; SOE insufficient	Observational studies showed benefit, but the RCT did not; benefit with moderate magnitude of effect; SOE low	No benefit; SOE low	Unable to draw conclusions; 1 study (with high risk of bias) reported a nonsignificant reduction in schooldays missed; SOE insufficient

There was much more evaluation of the health care process than the clinical outcomes; most common was the prescribing of asthma controller medications, and least common was missed days of work/school. Three interventions were not assessed in terms of missed days of work/school. There was insufficient evidence to comment on the effectiveness of many of the interventions, particularly for missed school or workdays.

Heterogeneity, such as variation in personnel delivering and length of intervention, made it challenging to draw conclusions. Future studies should thus include standardization of outcome measures, more information about the dose and frequency of the intervention, improved description of the study populations, and more use of RCTs to

isolate the effectiveness of each intervention. The interventions may also need to more comprehensively meet the needs of health care providers to deliver asthma care (ie, help providers complete multiple elements of providing asthma care, eg, prescribe controller medications and provide asthma action plans).

### CONCLUSIONS

We found more information about the effect of interventions on health care process outcomes than for clinical outcomes. There is low to moderate evidence to support the use of decision support, feedback and audit, and clinical pharmacy support to improve the adherence of health care providers to asthma guidelines and to improve

clinical outcomes. There is a need to further evaluate health care provider-targeted interventions with a focus on standardized measures of outcomes and more rigorous study designs.

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