Comparative Effectiveness Review
Number 95

Effective Health Care Program

Interventions To Modify Health Care Provider Adherence to Asthma Guidelines

Executive Summary

Background

Asthma is a respiratory disease characterized by variable and recurring symptoms, airflow obstruction, bronchial hyper-responsiveness, and inflammation of the airways. In the U.S., an estimated 24.6 million people (8.2 percent) currently have asthma.[1] Students with asthma miss more than 14 million school days every year due to illness. In 2005, there were approximately 679,000 emergency room visits in the U.S. due to asthma in children under 15 years of age.[2] Currently, asthma is the third leading cause of hospitalization among children in this age group.[2] Furthermore, certain U.S. population subgroups have higher prevalence rates of asthma in comparison with the national average: children (9.6 percent), poor children (13.5 percent), non-Hispanic African American children (17.0 percent), women (9.7 percent), and poor adults (10.6 percent).[1]

A number of asthma guidelines have been published internationally (e.g., the National Asthma Education and Prevention Program "Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma" is also known as EPR-3,[3] a guideline based on a systematic review of published evidence and expert opinion). Following asthma guideline treatment recommendations improves clinical outcomes in a variety of pediatric populations, including high-risk populations, such as inner-city, poor,

Effective Health Care Program

The Effective Health Care Program was initiated in 2005 to provide valid evidence about the comparative effectiveness of different medical interventions. The object is to help consumers, health care providers, and others in making informed choices among treatment alternatives. Through its Comparative Effectiveness Reviews, the program supports systematic appraisals of existing scientific evidence regarding treatments for high-priority health conditions. It also promotes and generates new scientific evidence by identifying gaps in existing scientific evidence and supporting new research. The program puts special emphasis on translating findings into a variety of useful formats for different stakeholders, including consumers.

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and/or African American populations.[4-6] The available evidence suggests that most people with asthma can be symptom-free if they receive appropriate medical care, use inhaled corticosteroids when prescribed, and modify their environment to reduce or eliminate exposure to allergens and irritants.

Despite the evidence of improved outcomes associated with adherence to guidelines, their long-term existence (>20 years) and widespread availability, health care providers do not routinely follow asthma guideline recommendations.[7,8] In one study, only 34.2 percent of patients reported receiving a written asthma action plan, while only 68.1 percent had been taught the appropriate response to symptoms of an asthma attack.[8] In the same study, only about one-third of children or adults were using long-term asthma controller medicine such as inhaled corticosteroids. Health care providers do not appropriately assess asthma control in most children,[9-12] resulting in substandard care. Minority children are up to half as likely as Caucasian children to receive inhaled steroids.[13] The significance of these studies is that suboptimal outcomes persist, such as twofold higher rates of emergency room visits for African American children compared with their Caucasian counterparts.[14]

With the lack of adherence to guideline recommendations, attention has been focused on why best practices are not followed (i.e., adhered to) by health care providers. In 1999, Cabana et al.[15] proposed a theoretical framework to understand why physicians do not adhere to guidelines, citing lack of awareness, disagreement with the guidelines recommendations, doubts about the effectiveness of the guidelines recommendations, lack of confidence in being able to carry out the best practice, inability to overcome the inertia of previous practice behaviors, and external barriers (e.g., time constraints during a visit, lack of user-friendly guidelines, patient preferences). There is a growing understanding that one of the shortcomings of asthma guidelines is the limited extent to which health care providers are provided with the tools and resources necessary to follow the recommended care.[16] There is a lack of interventions developed specifically to address the barriers outlined by Cabana et al. Awareness of asthma guidelines may have improved over time,[17,18] but certain barriers outlined by Cabana et al. would likely not be overcome as a result of increased exposure to asthma guidelines (e.g., the inability of health care providers to overcome practice inertia and external barriers).[19] Therefore, learning what strategies are available to overcome these barriers and improve adherence to asthma guidelines would be beneficial.

Most interventions targeting improvement of asthma care and outcomes have been patient-focused,[20-23] but there have also been provider-targeted interventions to improve adherence to guidelines (e.g., educational seminars, prompts, etc.).[24-29] However, there is no consensus on the most effective provider-targeted interventions that improve adherence to guidelines.

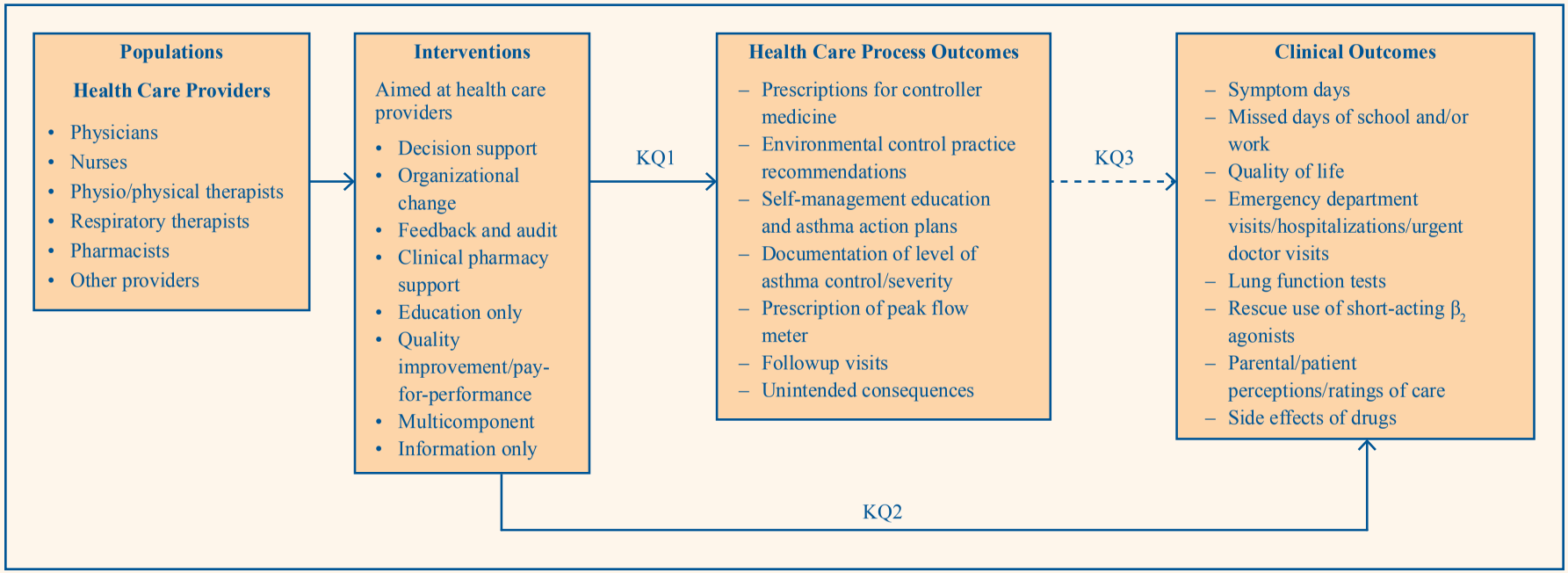
Scope and Key Questions

The objective of our systematic review was to assess whether interventions targeting health care providers improve adherence to asthma guideline recommendations for asthma care and if these interventions subsequently improve clinical outcomes for patients. We also sought to determine whether any observed changes in asthma care processes directly improve clinical outcomes. Successful interventions were those in which statistically significant improvements in a given outcome (e.g., prescriptions for controller medications) were observed. Ultimately results of this report will inform health care providers and policymakers regarding successful interventions or components of specific interventions that may be translated into clinical practice with the goal to improve health care provider adherence to asthma guidelines for their patients. It is important to note that the scope of this project does not include assessments of cost for implementation of the interventions reviewed. Therefore, users of this report will have to seek supplemental information to understand the complete implications of these interventions to patients, physicians, and organizations. This report has provided an organized systematic review of provider-focused interventions to improve asthma care and outcomes. Therefore, this report should provide a context in which to organize different types of interventions, their relative impact on a variety of outcomes, and considerations for what and how future studies should be planned. Our specific Key Questions (KQs) are listed below and are displayed graphically in Figure A.

KQ1: In the care of pediatric or adult patients with asthma, what is the evidence that interventions designed to improve health care provider adherence to guidelines impact health care process outcomes (e.g., receiving appropriate treatment)?

KQ2: In the care of pediatric or adult patients with asthma, what is the evidence that interventions designed to improve health care provider adherence to guidelines impact clinical

Figure A. Analytic framework for guidelines on the care of adults and children with asthma



KQ = Key Question

outcomes (e.g., hospitalizations, patient-reported outcomes such as symptom control)?

KQ3: In the care of pediatric or adult patients with asthma, what is the evidence that interventions designed to improve health care provider adherence to guidelines impact health care process outcomes that then affect clinical outcomes?

Methods

Literature Search Strategy

We searched the following databases for primary studies: MEDLINE®, Embase®, and the Cochrane Central Register of Controlled Trials, Cumulative Index to Nursing and Allied Health Literature (CINAHL®), Educational Resources Information Center (ERIC℠), PsycINFO®, and Research and Development Resource Base in Continuing Medical Education (RDRB/CME) through July 2012. We developed a search strategy for MEDLINE, accessed via PubMed®, based on an analysis of the medical subject headings (MeSH), terms, and text words of eligible articles identified a priori (Appendix B). This strategy was translated for use in the other electronic sources. No limits were imposed based on language or date of publication. Searches were conducted in July 2012. We also completed backward citation searching using Scopus for each included article.

Study Selection

Title and abstracts were screened independently by two trained investigators, and were excluded if both investigators agreed that the article met one or more of the exclusion criteria (see inclusion and exclusion criteria listed in Table A and the Abstract Review Form in Appendix C). Differences between investigators regarding abstract eligibility were resolved through consensus.

Citations promoted on the basis of title and abstract screen underwent another independent paired-reviewer screen using the full-text article (Appendix C, Article Review Form). Differences regarding article inclusion were resolved through consensus.

Data Abstraction and Data Management

We used DistillerSR (Evidence Partners, 2010) to manage the screening process. DistillerSR is a Web-based database management program that manages all levels of the review process. We uploaded to the system all citations identified by our search.

We created standardized forms for data extraction (Appendix C) and pilot tested the forms prior to the beginning the process of data extraction. We used Access (Microsoft, Redmond, WA) for the data abstraction process. Reviewers extracted information on general study characteristics, study participants, eligibility criteria, interventions, and the outcomes. One reviewer completed data abstraction and the second reviewer confirmed the first reviewer's data abstraction for completeness and accuracy. Reviewers completed risk of bias assessment independently. Reviewer pairs included personnel with both clinical and methodological expertise. We resolved differences between reviewer pairs through consensus among the larger group of investigators.

Risk of Bias Assessment

We used the Cochrane Collaboration's tool for assessing the risk of bias of controlled studies. Two reviewers independently assessed the included studies according to the guidelines in Chapter 8 of the Cochrane Handbook for Systematic Reviews of Interventions[30] using the following criteria: sequence generation and allocation concealment (selection bias), blinding of health care providers, investigators, and outcome assessors (detection bias), incomplete outcome data (attrition bias), selective outcome reporting (reporting bias), and other sources of bias. We report judgments for each criterion as "Low risk of bias," "High risk of bias," or "Unclear risk of bias (information is insufficient to assess)."

For pre-post studies, we added the two relevant criteria from the Cochrane Effective Practice and Organization of Care (EPOC) data collections checklists.[31]

Data Synthesis

For each KQ, we created a detailed set of evidence tables containing all information abstracted from eligible studies. We grouped the information for each KQ by intervention(s) being assessed:

1. Decision support interventions are health information technology- and/or paper-based-interventions designed to support/facilitate health care provider treatment decisionmaking (e.g., classify asthma severity);
2. Organizational change interventions are designed to change the way in which an organization provides asthma care (e.g., having an asthma "champion");

Table A. Study inclusion and exclusion criteria

PICOTS Framework	Inclusion	Exclusion
Populations	Participants: human subjects. Health care providers: physicians, nurses, physiotherapists/physical therapists, respiratory therapists, pharmacists, and other health care providers treating children or adults with asthma.	• Animal models/simulations.
Intervention	Interventions to improve adherence to guidelines including decision support (health information technology and paper-based), organizational change, feedback and audit, clinical pharmacy support, education only, quality improvement/pay-for-performance, multicomponent, information only.	Studies that do not: • Assess an intervention. • Address adherence to asthma guidelines. • Target health care providers.
Comparisons of interest	Usual care, as defined in each eligible study, and comparisons between interventions.	Studies lacking a comparison.
Outcomes	**Health care process outcomes:** – Prescriptions for controller medicine – Environmental control practice recommendations – Self-management education and asthma action plans – Documentation of level of asthma control/ severity – Prescription of peak flow meter – Followup visits – Unintended consequences **Clinical outcomes:** – Symptom days – Missed days of school and/or work – Quality of life – Emergency department visits/hospitalizations/ urgent doctor visits – Lung function tests – Rescue use of short-acting β_2 agonists – Parental/patient perceptions/ratings of care – Side effects of drugs The outcomes were nondirectional; that is, all outcomes were considered whether they were beneficial or caused potential harms or unintended consequences.	Studies that do not report an outcome of interest (e.g., studies reporting acceptability of intervention only).
Type of Study	Randomized and quasi-randomized controlled trials and cross-over studies. Nonrandomized studies with comparison groups including nonrandomized controlled trial or crossover studies, controlled pre-post studies, historically controlled studies, cohort studies, case-control studies, and cross-sectional studies. Nonrandomized studies without a separate comparison group, including interrupted-time-series, noncontrolled and pre-post studies.	We excluded meeting abstracts, studies with no original data (e.g., reviews, editorials, comments, and letters) and noncomparative studies.
Timing and Setting	Studies of any duration followup that occurred in an outpatient setting employing healthcare providers were eligible for inclusion.	We excluded studies exclusively addressing inpatient or emergency department settings or guidelines.

3. Feedback and audit interventions are based upon providing performance data to health care providers about their quality of asthma care;
4. Clinical pharmacy service support: interventions targeting pharmacists' delivery of asthma care;
5. Education-only interventions are focused on educating health care providers about the content of asthma clinical practice guidelines;
6. Quality improvement/pay-for-performance interventions are focused on quality improvement initiatives or pay-for-performance as the primary intervention;
7. Multicomponent interventions use more than one type of intervention; and
8. Information-only interventions are designed only to provide information to health care providers about asthma guideline recommendations (e.g., provide a pocket guide to asthma guidelines).

Studies implementing combinations of interventions were categorized by the predominant intervention. Studies using multiple interventions in which no single intervention could be characterized as predominant were grouped into a separate category.

Based on input from key informants and public comment, the following outcomes were abstracted.

The health care process outcomes included:

- Prescriptions for controller medicine
- Environmental control practice recommendations
- Self-management education and asthma action plans
- Documentation of level of asthma control/severity
- Prescription of peak flow meter
- Followup visits
- Unintended consequences

The clinical outcomes, assessed in patients, included:

- Symptom days
- Missed days of school and/or work
- Quality of life
- Emergency department (ED) visits/hospitalizations/urgent doctor visits
- Lung function tests
- Rescue use of short-acting β_2 agonists
- Parental/patient perceptions/ratings of care
- Side effects of drugs

To answer Key Question 3, we sought to identify studies providing evidence on the link between changes in health care provider behavior (health care process outcomes) to changes in clinical outcomes. Ideally, relevant studies suitably answering Key Question 3 would measure both health care process and clinical outcomes, as well as measure the strength of association between the changes in health care process to the change in clinical outcomes observed in a given study.

To focus our synthesis, we selected outcomes we considered the most commonly used in practice; those relied upon by clinicians to guide decisionmaking; and those endorsed by the NIH Workshop on Asthma Outcomes.[32] These critical outcomes identified were prescription of asthma controller medicines, provision of asthma action plan/self-management education, ED visits/hospitalizations, and missed days of school or work.[33] Data abstracted for all outcomes can be found in Appendix E.

We conducted a qualitative synthesis of the evidence. The heterogeneity of the studies, related to measures of outcomes, population included, and specifics of the interventions, precluded quantitative synthesis.

In the absence of national qualitative standards to determine magnitude of effect in clinical asthma studies, we chose magnitudes of effect by group consensus among the investigators that were felt to be clinically meaningful changes. Magnitude of effect for studies addressing each outcome was described as small (less than 10 percent change or difference), moderate (10–30 percent change or difference), and large (over 30 percent change or difference). These judgments were made by one reviewer and checked by another, with disagreements discussed with the full team.

Strength of the Body of Evidence

Two reviewers graded the strength of evidence for each outcome for each of the Key Questions using the grading scheme recommended by the "Methods Guide for Effectiveness and Comparative Effectiveness Reviews."[34] In assigning evidence grades we considered four domains: risk of bias, directness, consistency, and precision. We classified evidence into four basic categories: (1) "high" grade (indicating high confidence that the evidence reflects the true effect, and further research is very unlikely to change our confidence in the estimate of the effect); (2) "moderate" grade (indicating moderate confidence

that the evidence reflects the true effect, and further research may change our confidence in the estimate of the effect and may change the estimate); (3) "low" grade (indicating low confidence that the evidence reflects the true effect, and further research is likely to change our confidence in the estimate of the effect and is likely to change the estimate); and (4) "insufficient" grade (evidence is unavailable or does not permit a conclusion). 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). The author of the section first graded the evidence and this was reviewed by the principal investigator. Any disagreements were discussed with the full team.

Applicability

An applicability statement was created in order to help different key stakeholders understand what key implications to take away from this document, to inform future relevant activities. Applicability was assessed separately for the different outcomes of benefit and harm for the entire body of evidence guided by the PICOTS framework as recommended in the "Methods Guide for Effectiveness and Comparative Effectiveness Reviews."[34] We considered factors that may limit applicability of the findings (e.g., a study conducted in a non-U.S. health care setting, providers not common to the U.S. health care system).

Results

Results of Literature Searches

We identified 4,217 unique citations. We excluded 3,892 citations during the abstract screening. During full-text article screening, we excluded an additional 249 articles that did not meet one or more of the inclusion criteria. Seventy-three articles were eligible for inclusion and 68 addressed 1 of the 4 critical outcomes (prescription of asthma controller medicines, provision of asthma action plan/self-management education, ED visits/ hospitalizations, and missed days of school or work) and are thus included in the narrative of the report.

Organization of Results

The results are organized according to each KQ, the four critical outcomes, and each type of intervention. For each KQ, a description and summary of the key findings from each type of intervention are presented, along with a table summarizing the strength of evidence.

Results by Key Questions

KQ1: In the care of pediatric or adult patients with asthma, what is the evidence that interventions designed to improve health care provider adherence to guidelines impact health care process outcomes (prescription of controller medications; providing asthma education/asthma action plans)?

Outcome: Prescription of Controller Medicines

Decision support. Fifteen studies of decision support interventions evaluated the effects on prescription of asthma controller medications: six RCTs[5,35-39] and nine pre-post studies.[40-48] The types of decision support interventions varied, including the provision of asthma guidelines in a more accessible format (e.g., "pocket" versions),[37,44,46] use of a specific algorithm, pathway or flow sheet,[37,45-47] a structured template for taking a history,[40,41] or a reminder system to raise awareness of the health care provider about the patient's asthma status.[5,36,42] The decision support interventions were often combined with other strategies, including education,[35,37-39,42,47,49,50] reminders,[36,39-41,44] feedback,[5,44] and/or organizational change.[43] Computer-based interventions served to guide the health care provider through a guideline-consistent assessment and/or treatment approach.[36,38,39,42,44,48,51]

Ten studies reported that a decision support intervention significantly increased prescribing of asthma controller medicines by health care providers,[5,35,39-42,44,45,47,48] while the remaining studies did not.[36-38,43,46] Eight of the studies in which increased prescribing was observed used a pre-post study design, while three of the five RCTs observed no benefit from decision support interventions.[36-38] The increase in prescribing of asthma controller medicines ranged from 2 percent to 34 percent in the pre-post design studies and ranged from 2 percent to17 percent in RCTs. The absolute difference in effect observed between control and interventions arms of the RCT studies was generally less than 10 percent. In summary, moderate evidence supports the use of decision support interventions to increase prescribing of asthma controller medications.

Organizational change. Two studies[52,53] examined the impact of organizational change on the prescribing of asthma controller medications by health care providers. One study was an RCT,[52] while the other used a pre-post

study design.[53] Both studies focused the intervention on pediatric health care providers. Both studies utilized additional personnel to facilitate organizational change, as well as education for the participating health care providers. One study used an asthma nurse educator,[52] while the pre-post study used a community health worker.[53] The RCT found that neither the peer-led education arm nor the planned care intervention (utilizing an asthma nurse educator) arms resulted in a significantly higher proportion of prescriptions for inhaled steroids or asthma controller medications compared with the control arm of the study.[52] Notably, prescribing increased in all arms of the study, including the control arm. The improvement in prescribing any type of controller medication ranged from 8 to16 percent among all patients with asthma and 4 to 11 percent among asthma patients with persistent asthma In the pre-post study, investigators observed a 12 percent increase (absolute change from 44 percent to 56 percent) in prescriptions for inhaled steroids among all asthma patients (no p-value reported).[53] Low strength of evidence supports the effectiveness of organizational change in increasing the prescribing of asthma controller medicines.

Feedback and audit. We identified six RCTs,[54-59] four pre-post studies,[60-63] and one nonrandomized controlled study[64] evaluating the effect of feedback and audit interventions on the prescription of controller medications. Most feedback and audit interventions were part of a multifaceted intervention combined with provider education,[54,57,59-63] prioritized review criteria for audit,[56] benchmarking or comparison with peers or other practices[56,58] or pharmacy monitoring of fill data and feedback.[64]

Of the six RCTs,[54-59] four demonstrated positive effects from the intervention.[54,56,57,59] Increased prescribing of asthma controller medicines was reported for audit and feedback interventions using targeted key guideline messages about the inflammatory nature of asthma (such as, "use inhaled corticosteroids promptly") (5 percent to 12 percent increase from baseline, p=0.05),[54] prioritized guideline review criteria on single card,[56] medical record prompts for annual review of asthma management with guideline prompts,[57] and individualized feedback on prescribing and decision strategies.[59] The two RCTs reporting no effect on prescribing of asthma controller medications involved feedback of prescribing data[55] and a trial of performance feedback.[58] Of the studies using a pre-post or nonrandomized controlled design, two studies reported an increase in prescribing of controller medicines.[62,64] The increase reported in these studies ranged from 52 to 104 percent.[62,64] The magnitude of effect for feedback and audit support on the prescription of controller medications is moderate. The positive effect sizes, measured as an increase in patients on inhaled corticosteroids from baseline to outcome and between intervention and control groups, ranged from a low (0.12) to a moderate (0.66) effect size.[54] A significant increase in the change of percentage of patients treated with inhaled steroid from baseline to 12 months post intervention between three groups (guidelines alone, prioritized guideline review criteria and review criteria plus feedback on actual prescribing behavior) was noted as a positive increase of 15.9 percent in controller prescribing in the review criteria plus feedback group as compared with an increase of 11 percent in the review criteria only and no change (0 percent) in the guideline only group.[56] A positive but nonsignificant difference (2.7 percent difference in proportion of patients) was noted in the proportions of patients in practice with asthma "prophylaxis" after one year as compared with practices provided with diabetes guidelines (Difference in asthma prophylaxis: 2.7 [95% CI: -14.4 to19.7]).[57]

Two RCTs reported no effect on prescribing asthma controller medications, based on low hazard ratios of 0.77 (95% CI: 0.59, 1.01) and 1.08 (95% CI: 0.90, 1.3).One study used a mailed prescriber feedback intervention.[55] In the other study, there was no difference in percentage of patients prescribed medication consistent with guidelines (3.2 to 8 percent, p=0.19) between a "benchmark" group (their prescribing behavior was compared with a performance benchmark or with other prescribers) versus a traditional or individual feedback group (who did not receive comparison with other prescribers).[58] Of the five pre-post design studies, only three reported an increase in prescribing controller medications, ranging from 52 percent to 104 percent; change in prescribing over time (52 percent change over 6 months), increase of 104.4 percent in patients with intermittent asthma but a decrease of ICS by 10.8 percent in patients with persistent asthma. The strength of the evidence of feedback and audit support on the prescription of asthma controller medications is moderate with several caveats. Factors that lessen the confidence in the results include inconsistent definitions of controller medication prescribing behavior (controller only, controller + rescue medication, and prophylaxis asthma medication), wide variation in feedback and audit intervention protocols, use of varying clinical asthma and GP guidelines over a long period (1990–2007), inconsistent followup periods ranging from 3-12 months, and inconsistent control in the analysis for asthma severity. The strength of the evidence in support of feedback/audit interventions to increase prescribing of controller medicines by health care providers is moderate.

Clinical pharmacy support. Three studies—one RCT,[65] one nonrandomized study[66] and a controlled pre-post study[67]—evaluated the effect of clinical pharmacy support on the prescription of asthma controller medications. In the RCT, pharmacists trained in risk assessment, medication adherence, and spirometry reported increases in the dispensation of asthma controller medicines (odds ratio: 3.80 [95% CI: 1.40, 10.32]; p=0.01).[65] In the two non-RCTs, increases in controller medication prescribing of 20 percent[67] and 6 percent[66] were observed (p<0.05 for both studies). In the controlled pre-post study, the intervention was a specialized asthma service provided by community pharmacies; components included seeing patients by appointment, assessment and intervention in responses to patient medication needs, and goal-setting with the patient.[67] In the latter study, pharmacists were encouraged to hold meetings with local general practitioners to discuss guidelines for the care of children with asthma.[66] The strength of the evidence of clinical pharmacy support on the prescription of asthma controller medications is moderate because of consistent and precise results, though the risk of bias was high. The one RCT evaluating the effect of clinical pharmacy support on the prescription of asthma controller medications versus rescue medication for children, indicated a large shift from the use of rescue medication only to rescue medication plus controller medication (OR 3.80 [95% CI: 1.40, 10.32], p=0.01).[65] The evidence from this study is of high quality due to its large sample size (n=50 pharmacies and n=351/396 patients completing study), blinding of pharmacists and high rates of followup (intervention: 86 percent and control: 91 percent). Still, it is the only RCT evaluating a pharmacy intervention. The two non-RCTs reported moderate effect size defined as change in percentage of patients prescribed controller medication between pre and post intervention periods (6 percent to 21 percent);[66,67] however, the studies either lacked a large sample size and/or reported inconsistent description of controller medication use ("no inhaled corticosteroid use while on long-acting betamimetics"[74] or ideal profile was reliever + preventer + symptom controller medication).[66]

In summary, the strength of the evidence is moderate for an effect of clinical pharmacy support on the prescription of asthma controller medications with a moderate increase in prescribing of controller medications.

Education only. Ten studies of education alone as an intervention examined prescribing asthma controller medication as an outcome. Six were RCTs[26,68-72] and four were pre-post designs.[73-76] Nearly all of the studies targeted primary care physicians (GPs, FPs, pediatricians) or nurses. One study recruited pharmacists.[71] The education interventions were varied and included small group asthma education programs,[69] structured training,[76] seminars (including interactive),[70] and grand rounds.[76] Besides delivering specific asthma content, certain interventions also emphasized more general skills, such as training in communication.[68,70] The findings from all studies were consistently in the positive direction, reporting increases in controller medicines prescribing from 3.5 percent to 50.3 percent, though statistically significant differences were reported in only three of the studies. Provider education does not appear to increase the prescription of asthma controller medications. However, our confidence in this conclusion is low (low strength of evidence).

Quality improvement and pay-for-performance. No studies examined the effect of quality improvement strategies on prescription of asthma controller medications. Therefore, there is insufficient evidence for this outcome.

Multicomponent. Seven studies evaluated the impact of multicomponent interventions.[77-83] All interventions included *information, education,* and at least two of the following; *organizational change, decision support,* and *feedback and audit.* Four[78-80,83] were cluster-randomized controlled trials (randomizing primary care practices) and three[77,81,82] were pre-post studies with no comparison group. Only two of the pre-post studies[77,81] and one of the three RCTs[78] found an impact of their multicomponent intervention on rates of inhaled corticosteroid prescriptions. The two pre-post studies found large positive effects on ICS prescribing rates (25 percent to 49 percent increases). Among the four experimental studies, three found effects in a positive direction, but only one reached statistical significance, and the magnitude of effect was small (0.1 puff per day per patient between groups). In summary, there is low strength of evidence supporting the effectiveness of multicomponent interventions to increase prescribing of controller medications for asthma.

Information only. Two RCTs[84,85] evaluated the provision of information to health care providers (without an accompanying educational intervention) on rates of controller medication prescribing. One study, which randomized patients to have asthma management information and treatment guidelines inserted into their medical records for provider use, reported no benefit.[85] The second study[84] included providers randomly selected to participate in developing local asthma guidelines, which were then mailed to providers in both intervention and comparison groups. This study reported a negative effect on controller medication prescribing, with providers in the intervention group writing 8 fewer prescriptions

per 1,000 patients than those in the comparison group ($p<0.01$). This is the only unintended consequence that we identified. In summary, because of inconsistent results between only two studies, there is insufficient evidence to evaluate the effect of information alone on rates of controller medication prescribing in asthma.

Outcome: Self-Management Education and Asthma Action Plans

Decision support. Ten studies evaluated the impact of decision support interventions on the provision of patient education/asthma action plans.[27,38,39,43,44,46,49,86-88] Four of the studies were RCTs,[38,39,87,88] while the remainder employed a pre-post study design.[49,27,43,44,46,86] The interventions included computerized support,[38,39,43,44,88] a flow sheet/algorithm,[27,86] and/or the provision of guidelines.[46] These studies all focused on primary care settings and involved general practitioners,[38] pediatricians,[49,87] or family practitioners.[27]

Seven of these studies reported a positive effect of decision support on the provision of patient education/asthma action plans.[27,43,44,46,49,86,87] The increase in self-management education/use of asthma action plans ranged from 14 percent to 84 percent (all reported as statistically significant). Of the four RCTs, only one showed a positive impact from decision support intervention.[87] In summary, moderate evidence supports the use of decision support interventions to increase the provision of asthma education/asthma action plans by health care providers.

Organizational change. Two studies examined how organizational change influenced the provision of patient self-management education and/or asthma action plans; one used an RCT design[89] and the other a pre-post design.[90] In the pre-post study, the investigators[90] instituted a registry to track asthma patients and an asthma case manager, while in the RCT[89] the investigators restructured the clinical protocol for how asthma patients are cared for during ambulatory care encounters ("3+ visit plan"). In general, the effect of organizational changes to increase self-management education/asthma action plan use by health care providers was small. Investigators in the pre-post study observed a 10 percent increase in documentation of patient education ($p<0.001$) and a 14 percent increase in documentation of home asthma action plan dispensations ($p<0.001$), while in the RCT, there was a 10 percent increase in asthma education ($p=0.01$). In summary, low strength of evidence supports the use of organizational change as a method to increase the provision of self-management education/asthma action plan by health care providers.

Feedback and audit. Five studies—three RCTs[56-58] and two pre-post studies[61,63]—evaluated the effect of feedback and audit interventions on the provision of self-management education and asthma action plans by health care providers. Statistically significant increases in provision of self-management education/asthma action plans ranging from 1 to 40 percent were reported in four of the five studies.[57,58,61,63] The magnitude of effect for feedback and audit support to increase the provision of self-management education/asthma action plans is low based on a range of negative to low differences in proportions for practices recording peak flow meter use after a feedback/audit intervention. A negative change for peak flow meter use was noted in the guideline review criteria plus feedback group (decrease 3.6 percent)[56] and a minimal increase of 0.7 difference in proportion (95% CI: -15.2, 16.7) after practices received asthma guidelines.[57] A moderate increase was noted for inhaler technique—12.9 (95% CI: 1.9, 23.9)[57]—and a small increase in change of asthma action plan use (7.6 percent) in a benchmarking feedback group.[58] In summary, the strength of evidence is low for support of the use of feedback and audit interventions to increase the provision of self-management education/asthma action plans by health care providers.

Clinical pharmacy support. We identified one RCT[65] evaluating the effect of clinical pharmacy support on self-management education/asthma action plan use by health care providers. Patients receiving care by pharmacists enrolled in the Pharmacy Asthma Care Program had increased asthma action plan possession (mean change from baseline: 40.4 percent [95% CI: 31.9, 48.9; $p=0.001$]), however there are no comparison data for the control group.[65] In summary, the strength of the evidence is moderate in support of the use of clinical pharmacy interventions to increase self-management education/asthma action plan use by health care providers.

Education only. There were five RCTs of education-only interventions[26,68,70,91,92] that reported provision of a written asthma action plan as an outcome. Most targeted general practitioners and one focused on pediatricians. The educational strategies included small group asthma education programs, structured training, and interactive seminars. Two studies showed increased use of asthma action plans of 10 percent ($p=0.03$)[70] and 15 percent ($p=0.046$).[68] The other three studies[26,91,92] reported no benefit from their educational intervention on the provision of asthma action plans.

In summary, low strength of evidence suggests that educational interventions can increase use of asthma action plans by health care providers.

Quality improvement and pay-for-performance. Three studies examined the effect of quality improvement strategies on receipt of asthma action plans.[93-95] The design of the studies included an RCT,[95] a pre-post study,[93] and a controlled, pre-post study.[94] All three studies involved pediatric health care providers, including nurses, nurse practitioners, and physicians. Two studies assessed participation in a Breakthrough Series collaborative,[94,95] and one study assessed a combination of continuous quality improvement and the addition of a community health worker.[93]

Overall, the results are inconsistent, with a -3 to 33 percent change in the proportion of patients provided an asthma action plan. Two of the three studies,[93,94] both pre-post studies, showed a 19 to 33 percent improvement in the proportion of patients who had received an asthma action plan. One of these studies,[94] the controlled pre-post study, showed a 19 percent increase by survey and a difference of difference of 33 percent by medical record review in the intervention arm. The second study[93] showed a 28.2 percent increase in the proportion of patients who had received an asthma action plan. These two nonrandomized studies that demonstrated a beneficial effect enrolled practices that had already joined a quality improvement initiative[94] or were part of a demonstration project.[93]

The third study[95]—an RCT—showed no effect, with a 1 percent increase in the intervention group and 4 percent increase in the control group for a -3 percent difference of difference.[95] However, there was some evidence of poor adherence to the quality improvement intervention in the RCT, with decreases in participation in the learning sessions and in outcome reporting over time.[95]

One controlled pre-post study examined the effect of a quality improvement initiative on asthma self-management education in addition to asthma action plans.[94] In this study, documented self-management education increased by 21 percent, although there was no definition of what constituted self-management education and how it was documented.

In summary, there is low strength of evidence that quality improvement leads to moderate increases in the provision of self-management education/asthma action plans in select populations of health care providers, based on two observational studies and one negative RCT with evidence of suboptimal engagement by participants.

Multicomponent. Six studies[77,79,81-83,96] examined the impact of multimodal interventions on rates at which providers created asthma action plans for their patients. Two studies[79,83] were cluster-randomized trials of primary care practices, while the remaining four studies[77,81,82,96] were pre-post studies. The interventions varied in their content, but most included an educational component. Other elements of these interventions included: (1) training in communication techniques, provision of a spirometer and training in use of the spirometer;[77] (2) laminated posters of asthma guidelines and medications, feedback on asthma action plan use, and monthly calls from an intervention team to troubleshoot communication problems;[96] (3) asthma kits (peak flow meters, spacers, educational materials) and systems-level changes (flow sheets and standing medication orders);[79] (4) systematic use of a patient questionnaire and an asthma management algorithm;[81] (5) an asthma coordinator and feedback on performance as part of continuous quality improvement efforts; and (6) an educational toolbox, seminars, teleconferences, mini fellowships, opinion leader visits, clinician-specific feedback, and pay for performance.[83] All four pre-post studies reported a large and statistically significant positive impact on asthma action plans over time (ranging from 27 percent to 46 percent of providers, median 42 percent). Both RCTs reported changes in the provision of patient education/asthma action plans in a positive direction, (one reporting an increase among 7 percent of providers, the other reporting RR=1.82) but neither result achieved statistical significance. Based on the use of weak study designs among studies observing an intervention effect, combined with the inconsistency of results among studies, there is low evidence to support the effectiveness of multicomponent interventions in increasing the provision of patient education/asthma action plans.

Information only. No studies examined the impact of information provision alone on self-management education or asthma action plans. Therefore, there is insufficient information to assess the effect of information-only strategies on self-management education/asthma action plan use by health care providers.

KQ2: In the care of pediatric or adult patients with asthma, what is the evidence that interventions designed to improve health care provider adherence to guidelines impact clinical outcomes (ED visits/hospitalizations; missed days of school/work)?

Outcome: Emergency Department Visits/Hospitalizations

Decision support. Ten studies examined the effect of decision support interventions on patient use of emergency department (ED) visits or hospitalizations for asthma.[5,37,43,44,46,50,51,86,88,97] The decision support interventions included computer systems,[43,44,51,88] checklists,[97] supplemental feedback protocols,[5] and structured pathways/algorithms.[37,50] These interventions were combined with educational interventions, organizational changes, and/or reminders. Of the 10 studies evaluating the effect of decision support on ED visits/hospitalizations, 4 were RCTs,[5,37,88,97] while the others were pre-post studies.[43,44,46,50,51,86] The populations in these studies were a mix of adult[43,44,46,86,88,97] and pediatric patients.[5,37,50,51,86]

Nine studies reported a reduction in ED visits or hospitalizations[5,37,43,44,46,50,51,86,97] ranging from 5 percent to 60 percent (all statistically significant) among the studies using a pre-post study design. Among the RCTs reporting a difference, the difference between intervention and control arms ranged from 1 percent to 7 percent.[5,37,97] The one study reporting no difference was an RCT.[88]

In summary, there is moderate evidence that decision support interventions targeting health care provider adherence to guidelines reduce ED visits/hospitalizations.

Organizational change. Four studies evaluating organizational change measured the impact on patient ED visits and/or hospitalizations.[52,53,89,90] Two of these were RCTs,[52,89] while the other two were pre-post studies.[53,90] Three of the studies were focused on pediatric health care providers.[52,53,89] One of the studies restructured asthma care visits,[89] while the remaining three studies utilized supplemental trained personnel as part of the intervention.[52,53,90] Three of the studies also incorporated an educational component provided to health care providers.[52,53,90]

Two studies reported reductions in ED visits and/or hospitalizations. The first study reported 41 percent reduction in ED visits and 54 percent reduction in hospitalizations (p-value <0.001 for both outcomes).[90] The second study reported a 4 percent reduction in hospitalizations (no p-value reported).[53] The two RCTs did not report statistically significant reductions in ED visits/hospitalizations (1 percent, $p>0.05$[52] and 7 percent, $p=0.06$[89]) compared with the control arms in the study. In summary, organizational change does not reduce ED visits/hospitalizations. The strength of evidence for this conclusion is low.

Feedback and audit. We identified one RCT[58] and one pre-post study[63] that evaluated the effect of health care provider feedback and audit on ED visits and hospitalizations of patients. The interventions were: (1) a traditional quality circle (TQC) intervention, in which providers were given feedback on their individual performance and the aggregate performance of group providers, compared with a benchmark quality circle (BQC) intervention, in which feedback on providers' individual performance was explicitly compared with a performance benchmark,[58] and (2) an intervention comparing individual primary care provider's guideline practice patterns with their peers plus providing asthma education to office staff.[63] Clinicians in both studies were primary care practitioners. Patients whose providers participated in a benchmark quality circle (BQC) and received prescribing feedback with comparison with other providers had a 6.7 point decrease in ED visits (from 17.6 percent at baseline to 10.9 percent 12 months post intervention), but this decrease was smaller than that seen among patients whose provider participated in a traditional quality circle (TQC) (19.7 percent at baseline to 6.1 percent or a 12.2 point decrease; $p=0.064$).[58]

No change in ED visits (baseline: 82 percent, 6 months: 81 percent) or hospitalizations (baseline: 96 percent, 6 months: 94 percent) was reported in the pre-post study.[63] No conclusions could be made because of conflicting results among a small number of studies. The strength of the evidence is insufficient to determine the effect of feedback and audit interventions on ED visits/hospitalizations.

Clinical pharmacy support. We identified one RCT[98] evaluating the effect of clinical pharmacy support on the number of ED visits and hospitalizations in patients with asthma. In this RCT, patients seen by pharmacists provided with patient specific clinical data, training about asthma management, patient educational materials, resource guides, and pragmatic strategies were more likely to have a reduction in ED visits/hospitalizations at 12 months compared with patients seen by pharmacists who received peak flow meter (PFM) instruction only (odds ratio 2.16 [95% CI: 1.76 to 2.63]). However, patients in the clinical pharmacy support intervention group did not experience a decline in ED visits/hospitalizations

compared with patients of the usual care control group (odds ratio 1.08 [95% CI: 0.93 to 1.25]).[98] In summary, we are unable to make a conclusion regarding the benefit of clinical pharmacy support on ED visits and hospitalizations. The strength of evidence was insufficient.

Education only. There were seven studies, five RCTs[25,26,70,71,92] and two pre-post studies,[74,76] that examined the impact of health care provider education on ED visits and/or hospitalizations. The educational interventions included interactive seminars, structured training, and medical grand rounds. The effects reported were inconsistent. One of the studies did not find a statistically significant effect for the intervention group overall, but did report statistically significant findings in a subgroup of low income participants (-1.23 visits per year, p=0.001).[26] For hospitalization, one study reported statistically significant reduction in the annual rate,[26] while the other five studies reported no reduction on the rates of hospitalization. Overall, education only interventions do not reduce asthma ED visits and/or hospitalizations. The strength of evidence for this conclusion is low.

Quality improvement and pay-for-performance. One RCT[95] examined the effect of quality improvement on ED visits and hospitalizations and one controlled pre-post study evaluated the effect on the combined number of ED visits and hospitalizations.[94] Both studies evaluated a Breakthrough Series collaborative quality improvement strategy. These studies focused on pediatric health care providers working in community health center settings. The patients were primarily African American or Hispanic.

Neither study showed a statistically significant reduction in any outcome, with a 5 percent reduction in ED visits,[95] a 2 percent reduction in hospitalizations,[95] and an increase of 0.3 combined ED visits and hospitalizations[94] reported in the quality improvement arms.

However, there was some evidence of poor adherence to the quality improvement intervention in the RCT, with decreases in participation in the learning sessions and in outcome reporting over time.[95] When analyses were limited to the nine practices that attended all three learning sessions, they report that there was a significant reduction in ED visits.

There is low strength of evidence to suggest that quality improvement does not significantly reduce ED visits/hospitalizations based on one controlled pre-post study and one RCT with evidence of suboptimal engagement by participants.

Multicomponent. One study[82] evaluated the impact of a multicomponent intervention in pediatric clinics on rates of ED visits and hospitalizations. This study implemented an intervention that included elements of quality improvement, decision support, organizational change, and feedback-and-audit. Among a longitudinal cohort of patients, this study found large and statistically significant reductions in rates of ED visits and hospitalizations (69 percent reductions for both outcomes). However, 44 percent of the patient sample was lost to followup, and significant heterogeneity in results was seen across participating clinical sites.

The strength of evidence is insufficient to determine the effect of multicomponent interventions on ED visits and/or hospitalizations.

Information only. Only one RCT study[85] examined the impact of information provision on rates of ED visits and hospitalizations for asthma. This study 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. This study found no differences in rates of either ED visits or hospitalizations between study groups. In summary, based on a single study with a high risk of bias, there is insufficient evidence to determine the effect of information-only interventions on ED visits/hospitalizations.

Outcome: Missed Days of Work/School

Decision support. There were two studies that examined the impact of decision support interventions on missed work or school. One study used an RCT design,[5] while the other used a pre-post design.[86] Both studies involved children, although one study[86] also included adult patients. The RCT study[5] reported no significant reduction in missed school (0.05 school days; p=0.4) in their study of mailing patient-specific asthma morbidity information to their health care provider. The pre-post design study[86] reported a 49 percent reduction (p<0.001) in school absenteeism and a 51 percent reduction in the odds of missed work (odds ratio: 0.49 [95% CI: 0.34, 0.71]) among the patient populations in a study that utilized a combination of an asthma care map, a treatment flow chart, program standards, management flow chart, and action plan.

In summary, there is insufficient evidence for the effect of decision support on the number of missed days due to inconsistent results from two studies.

Organizational change. One RCT of organizational change based on restructuring the clinical protocol for asthma patient care during ambulatory care encounters ("3+ visit plan"), evaluated the impact on missed school days.[89] More specifically, at 12 months, the percentage

of children who missed no school was 52 percent in the intervention group and 45 percent in the control group (odds ratio 0.8 [95% CI: 0.5 to 1.2]; p=0.3). In summary, organizational change does not reduce missed school days from asthma. The strength of evidence for this conclusion is low.

Feedback and audit. We identified one pre-post study[63] that evaluated the impact of feedback and audit on days of missed work/school. This study provided asthma education to office staff and observed an 11 percent reduction in school days missed (percent reporting no school absences due to asthma in past 6 months: baseline: 49 percent; 6 months: 38 percent). The magnitude of the effect is low (11 percent reduction in school days missed). There was 0 percent reduction in parent work days missed due to child's asthma. In summary, there is insufficient evidence to evaluate the effect of feedback/audit interventions on the number of missed days of school or work.

Clinical pharmacy support. We identified no studies evaluating the effect of clinical pharmacy support on the outcome of missed days of work and school. Therefore, there is insufficient evidence to evaluate the effect of clinical pharmacy support interventions on the number of missed days of school or work.

Education only. There were five studies that evaluated the effect of health care provider education on missed school or missed work as outcomes. There were three RCTs that included missed school days as an outcome.[26,68,71] The interventions targeted GPs, pediatricians, and pharmacists and included structured training, seminars, and workshops. In all three trials there was consistent evidence of small non-statistically-significant reductions in missed school (0.6 days to 4 days).

Two RCTs[68,91] and one pre-post study[74] examined missed work as an outcome. The interventions included workshops and training in how to perform spirometry and one study compared asthma program development with a nurse educator program or continuing education. There were no significant reductions in missed work in any studies (range: 10 percent reduction to a 5 percent increase in missed days of work; p>0.05).

In summary, the study results were inconsistent and had imprecise estimates of the effect of these education interventions. Therefore there is insufficient evidence to evaluate the effect of education-only strategies on the number of missed days of work from asthma.

Quality improvement and pay-for-performance. One controlled pre-post study examined the effect of quality improvement on missed school and missed parental work.[94] This study evaluated health care provider participation in a Breakthrough Series collaborative quality improvement strategy. This study showed no significant reduction in the mean number of school days (0.2 school days; p=0.4) or parental work days (0 work days; p=0.7) missed due to a child's asthma. In summary, with only one study at high risk of bias, there is insufficient evidence to determine the effect of quality improvement interventions on school or work absenteeism.

Multicomponent. One study[82] evaluated the impact of a multicomponent intervention in pediatric clinics on rates of ED visits and hospitalizations. This study implemented an intervention that included elements of quality improvement, decision support, organizational change, and feedback-and-audit. Among a longitudinal cohort of patients, this study found large and statistically significant reductions in rates of missed days of school (53 percent reduction) and work (72 percent reduction). However, 44 percent of the patient sample was lost to follow up, and significant heterogeneity in results was seen across participating clinical sites. Therefore, the strength of evidence is insufficient to determine the effect of multicomponent interventions on missed days of school or work

Information only. No studies examined the impact of information provision alone on missed days of work or school (insufficient strength of evidence).

KQ3: In the care of pediatric or adult patients with asthma, what is the evidence that interventions designed to improve health care provider adherence to guidelines impact health care process outcomes that then affect clinical outcomes?

No studies evaluated how interventions designed to change health care provider adherence to asthma guidelines impacts clinical outcomes.

Discussion

We identified a number of different strategies designed to improve health care provider adherence to asthma guidelines. The studies we reviewed evaluated these strategies either in terms of their impact on health care processes and/or clinical outcomes. We found a large degree of variability in the frequency with which certain interventions were studied and in the frequency with which certain outcomes were evaluated. More specifically, decision support, feedback/audit and education only interventions were the most common and were tested for

each of the critical outcomes we evaluated in this report. Conversely, organizational change, clinical pharmacy support, quality improvement/pay-for-performance, information-only, and multicomponent strategies were less consistently tested for each of the outcomes.

In terms of the outcomes we evaluated, there was much more evaluation of the health care process outcomes than the clinical outcomes. Most common was the evaluation of prescribing of asthma controller medications, which arguably has been a frequently reported problem in the management of asthma in primary care settings. Least common was evaluations of missed days of work/school (we noted three types of interventions in which no data were available to evaluate the impact on missed days of work/school), which has significant implications for patient quality of life.

We identified few RCTs testing these interventions. Most of the interventions were studied using a pre-post design, which more often reported a beneficial effect than the few RCTs we identified. We found that there was insufficient evidence to comment on the effectiveness of many of the interventions on health care process outcomes or clinical outcomes. The inability to draw conclusions due to inadequate evidence was particularly striking for the outcome of missed school or work days, where there was insufficient evidence to evaluate the effect of any of these interventions.

Table B summarizes the strength of evidence in support of eight interventions.

KQ1: In the care of pediatric or adult patients with asthma, what is the evidence that interventions designed to improve health care provider adherence to guidelines impact health care process outcomes (prescription of controller medications; providing asthma education/asthma action plans)?

The key findings are summarized in Table C.

KQ2: In the care of pediatric or adult patients with asthma, what is the evidence that interventions designed to improve health care provider adherence to guidelines impact clinical outcomes (e.g., hospitalizations, patient-reported outcomes such as symptom control)?

The key findings are summarized in Table D.

Future Research

Future health care provider interventions aimed at improving adherence to national asthma guidelines should take a more *active* role in the asthma care process (e.g., provide asthma action plans, patient education, environmental control practices), particularly processes associated with a low risk of harm and those inhibited by specific barriers such as time constraints, poor self-efficiency, and lack of provider awareness. Interventions are needed that address all elements of the asthma care process including prescription for controller medication and peak flow meter, environmental control practice education, self-management education and asthma action plans, documentation of asthma severity, and control and automated scheduling of followup visit within 3 months. This also suggests that systems-level interventions that address barriers external to the health care provider would be an important approach to effecting positive changes in health care provider behavior. In addition to further evaluating interventions for which we found insufficient evidence, there are a variety of study design elements that may be considered to strengthen future research of health care provider-targeted interventions. Such design considerations include: standardization of presentation of data and outcome measures, particularly controller medication adherence; more comprehensive measurement of health care process and clinical outcomes within a given study; more information about the intensity (dose and frequency of the intervention); improved description of the comparator and the intervention populations; and more use of RCT study designs to isolate the effectiveness of each intervention. Cost implications of specific interventions may be associated with reduced use but this was not addressed in this report. Lastly, testing the efficacy of the more potent multifaceted interventions in targeted populations (i.e., adolescents, obese patients, high asthma severity, or high health care utilizers) may lead to identification of novel preventive and therapeutic strategies for high risk patients.

Conclusion

In summary, we found more information about the effectiveness of interventions on improving health care process outcomes than for clinical outcomes. There is a need for further evaluations of how these interventions may improve clinical outcomes for patients with asthma.

There is low to moderate evidence to support the use of decision support tools, feedback and audit, and clinical

Table B. Summary of the strength of evidence in support of eight interventions designed to modify clinician adherence to asthma guidelines

Intervention	Outcome: Prescription of Controller Medications	Outcome: Patient Education/Asthma Action Plans	Outcome: ED Visits/ Hospitalizations	Outcome: Missed Days of Work/ School
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.
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.
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 one included study. SOE insufficient.
Clinical pharmacy support	Benefit within three studies with moderate magnitude of effect. SOE moderate.	Benefit in one study with moderate magnitude of effect. SOE moderate.	Unable to make a conclusion based on one study with imprecise results. SOE insufficient.	No studies. 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 five studies. SOE insufficient.
QI and pay-for-performance	No studies. SOE insufficient.	Observational studies showed benefit, while the RCT did not. Benefit with moderate magnitude of effect. SOE low.	No benefit. Low SOE.	Unable to draw conclusions. One study (with high risk of bias) reported a nonsignificant reduction in school days missed. 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; while the one study reported a large reduction, the study quality was low. Insufficient SOE.	No conclusion; One study reported a large reduction, but study quality was low. SOE insufficient.
Information only	No studies. SOE insufficient.	No studies. SOE insufficient.	Unable to make conclusion; no difference seen, but study quality was low. SOE insufficient.	No studies. SOE insufficient.

ED = emergency department; QI = quality improvement; RCT = randomized controlled trial; SOE = strength of evidence

Table C. Summary of strength of evidence for included studies for KQ1				
Outcomes	**Intervention**	**No. of Studies/ No. of Health Care Providers**	**Strength of Evidence**	**Conclusions**
Prescriptions for controller medications	Decision support	15/1,635 6 RCTs, 9 pre-post	Moderate	Most of the evidence supporting the use of decision support interventions comes from a number of nonrandomized studies consistently showing that decision support interventions can increase health care provider prescriptions for asthma controller medications. The magnitude of effect is large: 2%–34% in pre-post studies; 2%–17% in RCTs.
	Organizational change	2/228 1 RCT, 1 pre-post	Low	Although far fewer studies performed using organizational change (in comparison with decision support or feedback/audit), the findings consistently showed that organizational change can increase health care provider prescriptions for controller medicines. The effect on prescriptions by health care providers is smaller. The magnitude of effect is small. In the RCT: 8%–16% for all asthma patients; 4%–11% for patients with persistent asthma; 4%–9% for inhaled steroids (ICS) for all asthma patients; 13%–19% for ICS for patients with persistent asthma. In the pre-post study: 12% increase in ICS.
	Feedback and audit	11/1,831 6 RCTs, 4 pre-post and 1 nonrandomized controlled	Moderate	These studies consistently showed that feedback/audit interventions effectively increase prescriptions for controller medicines by health care providers. The magnitude of the effect is moderate. Effect size: 0.12–0.66. Increases in prescribing controller medications ranged from 15.9% to 52–104%. Hazard ratio range: 0.77–1.08.
	Clinical pharmacy support	3/91 1 RCT, 1 pre-post, 1 nonrandomized	Moderate	The three studies were consistent in showing that clinical pharmacy support interventions increase asthma controller medication prescribing. The magnitude of the effect is moderate. OR: 3.80 (95% CI: 1.4, 10.32) and percent increase in patients prescribed controller meds pre and post: 6–21%.
	Education only	10/451 6 RCTs, 4 pre-post	Low	The evidence suggests that interventions based only on education of clinicians do not improve prescription of asthma controller medications. The magnitude of effect is small to large in studies (3.5–50.3% increase in prescribing controller medicines).

Table C. Summary of strength of evidence for included studies for KQ1 (continued)				
Outcomes	**Intervention**	**No. of Studies/ No. of Health Care Providers**	**Strength of Evidence**	**Conclusions**
Prescriptions for controller medications (continued)	Quality improvement and pay-for-performance	0	Insufficient	No studies identified.
	Multicomponent interventions	7/>1,141 4 cluster randomized, 3 pre-post	Low	Two pre-post studies and one RCT reported a significant increase in prescribing (25–49% in pre-post studies), while all other effects were null. Overall, the magnitude of effect is small.
	Information only	2/107 1 RCT, 1 quasi-experimental	Insufficient	Due to inconsistency across studies, evidence is insufficient to determine the effect of information alone on prescribing of asthma controller medication.
Patient education/ asthma action plans	Decision support	10/122-124 4RCTs, 6 pre-post	Moderate	A majority of nonrandomized studies consistently favor the use of decision support interventions to improve the provision of self-management education/asthma action plans by health care providers. The magnitude of effect is large: 14%–84%.
	Organizational change	2/24 1 RCT, 1 pre-post	Low	Both studies favor the use of organizational change to increase patient education/asthma action plan use by health care providers. The magnitude of effect is moderate: 10%–14%.
	Feedback and audit	5/336 3 RCTs, 2 pre-post	Low	Despite a number of studies examining feedback/ audit, inconsistent results lead to a low strength of evidence for the use of feedback/audit to improve self-management education/ asthma action plan use. The magnitude of the effect is low. Self-management education: difference in proportions range from low of 0.7 (95% CI: -15.2, 16.7) for peak flow meter use to 12.9 (95% CI: 1.9, 23.9) for inhaler technique education. Asthma Action Plans: Increase of 7.6% in feedback with benchmark as compared with traditional: 4.5%. Asthma Education: Range pre to post 46–133% increase.

Table C. Summary of strength of evidence for included studies for KQ1 (continued)				
Outcomes	**Intervention**	**No. of Studies/ No. of Health Care Providers**	**Strength of Evidence**	**Conclusions**
Patient education/ asthma action plans (continued)	Clinical pharmacy support	1/82 1 RCT	Moderate	The one study demonstrated a positive effect in the use of clinical pharmacy support to improve self-management education/asthma action plan use by health care providers. The magnitude of the effect is moderate. Asthma Action Plans: 40–45% increase from baseline.
	Education only	5/470 5 RCTs	Low	Small increases in asthma self-management education were observed in a minority of studies, resulting in an overall low strength of evidence regarding this outcome. The magnitude of effect is small to moderate: 10%–15%. OR: 1.00; RR: 1.40.
	Quality improvement and pay-for-performance	3/63 practices (providers not reported) 1 RCT, 2 pre-post	Low	Inconsistent results with a -3 to 33% change in the provision of asthma action plans. Both observational studies reported increases of 19–33% while the negative RCT had evidence of suboptimal practice engagement.
	Multicomponent interventions	6/>937 2 RCT, 4 pre-post	Low	Magnitude of effect is moderate. Provision of asthma action plan increased 27%–46% in observational studies. Smaller effect sizes were seen in RCTs (7% of providers and RR: 1.82).
	Information only	0	Insufficient	No studies identified.

CI = confidence interval; OR = odds ratio; RCT = randomized controlled trial; RR = relative risk
Note: If the number of healthcare provider participants was not reported for a particular study, the "NR" value was treated as zero for that particular intervention and outcome category.

Table D. Summary of strength of evidence for included studies for KQ2				
Outcomes	**Intervention**	**No. of Studies/ No. of Health Care Providers**	**Strength of Evidence**	**Conclusions**
ED Visits/ Hospitalizations	Decision support	10/820 4 RCTs, 6 pre-post	Moderate	Nine of 10 studies reported that decision support interventions reduce ED visits/hospitalizations. The magnitude of effect is large in pre-post studies (5%–60%) and small in RCTs (1%–7%).
	Organizational change	4/252 2 RCTs, 2 pre-post	Low	Inconsistent results account for the low strength of evidence for organizational change to reduce ED visits/hospitalizations. Magnitude of effect is large in pre-post studies (41%–54%) and small in RCTs (1%–7%).
	Feedback and audit	2/125 1 RCT, 1 pre-post	Insufficient	No conclusions could be made because of conflicting results and low magnitude of effect.
	Clinical pharmacy support	1/36 1 RCT	Insufficient	No conclusion could be made because of imprecise results from one study.
	Education only	7/343 5 RCTs, 2 pre-post	Low	Overall, due to conflicting results among a number of studies, the low strength of evidence suggests that education only interventions do not reduce asthma ED visits and/or hospitalizations. Magnitude of effect is low. Reductions and increases in ED visits were observed. One study demonstrated significant decreases; in hospitalizations; others showed no change or an increase in hospitalizations (+5 to 10.5%).
	Quality improvement and pay-for-performance	2/56 practices (providers not reported) 1 RCT, 1 pre-post	Low	Two studies found no significant change in ED visits and hospitalizations. The RCT had evidence of suboptimal practice engagement. Magnitude of effect is low. ED visits: 5% reduction. Hospitalizations: 2% reduction.
	Multicomponent	1/17 clinics (providers not reported) 1 cohort	Insufficient	There is insufficient evidence to determine the effect of multicomponent interventions on ED visits/ hospitalizations due to high rates of participant attrition (low study quality) in the single study included.
	Information only	1/13 1 RCT	Insufficient	Based on a single study with a high risk of bias, there is insufficient evidence to determine the effect of information-only interventions on ED visits/hospitalizations.

Table D. Summary of strength of evidence for included studies for KQ2 (continued)				
Outcomes	**Intervention**	**No. of Studies/ No. of Health Care Providers**	**Strength of Evidence**	**Conclusions**
Missed days of work/school	Decision support	2/435 1 RCT, 1 pre-post	Insufficient	There is insufficient evidence to evaluate the effect of decision support interventions on the number of missed days of work/school due to inconsistent results across the two studies analyzed.
	Organizational change	1/24 1 RCT	Low	Organizational change does not reduce missed school days from asthma. The strength of evidence for this conclusion is low.
	Feedback and audit	1/29 1 pre-post	Insufficient	There is insufficient evidence to evaluate the effect of feedback and audit interventions on the number of missed days of work and school from asthma due to inconsistent results and study design.
	Clinical pharmacy support	0	Insufficient	No studies identified.
	Education only	5/1,767 4 RCTs, 1 pre-post	Insufficient	There is insufficient evidence to evaluate the effect of education only strategies on the number of missed days of work/school from asthma due to imprecise estimates and inconsistent results.
	Quality improvement and pay-for-performance	1/13 practices (providers not reported) 1 pre-post	Insufficient	There is insufficient evidence to evaluate the effect of quality improvement/pay-for-performance interventions on the number of missed days of work/school from asthma because of high risk of bias in the single study analyzed.
	Multicomponent	1/17 clinics (providers not reported) 1 cohort	Insufficient	There is insufficient evidence to determine the effect of multicomponent interventions on the number of missed days of work/school from asthma due to risk of bias (high rates of attrition) and inconsistent results across clinical sites.
	Information only	0	Insufficient	No studies identified.

ED = emergency department; RCT = randomized controlled trial

Note: If the number of healthcare provider participants was not reported for a particular study, the "NR" value was treated as zero for that particular intervention and outcome category.

pharmacy support to improve the adherence of health care providers to asthma guidelines, as measured through health care process outcomes, 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, more rigorous study designs and addition of cost measures.

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Full Report

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