

PAEDIATRICS

Effectiveness of paediatric asthma clinical pathways: a narrative systematic review

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Abstract

Objective: To evaluate the effectiveness of clinical pathways (CPs) for paediatric asthma on length of hospital stay, additional visits due to asthma exacerbations, hospital cost, manpower and workload required for implementing CPs. **Methods:** Studies were eligible if they met the following criteria: children (≤ 18 years) with asthma, hospital or emergency department based, and study designs were (1) randomised controlled trial, (2) controlled clinical trial or (3) controlled before and after study. Two reviewers independently screened references, extracted data and assessed the risk of bias. We resolved disagreement by discussion between authors. Due to an insufficient number of studies and the heterogeneity of interventions and outcomes, we conducted a narrative systematic review with forest plots but did not pool results. **Results:** About 3155 relevant articles were identified through a literature search, 628 were duplicates removed, 2037 were excluded based on review of titles and abstracts and 117 were excluded because they did not meet inclusion criteria. Seven studies involving 2600 participants met the inclusion criteria. Using asthma CPs may decrease the length of hospital stay; however, CPs did not appear to reduce additional visits due to asthma exacerbations or reduce hospital costs. No eligible studies were found that quantified the manpower and workload for implementing CPs. **Conclusions:** Current studies suggest CPs may reduce the length of hospital stay, but insufficient evidence is available on total costs or readmissions to justify extensive uptake of asthma CPs in paediatric inpatient care. Higher quality, large randomised controlled trials are required that measure costs and a wider range of outcomes.

Keywords

Asthma, children, clinical pathway, cost, length of stay, systematic review

History

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Introduction

Asthma is defined as the presence of reversible airflow obstruction and at least one other symptom such as wheezing, breathlessness, chest tightness or coughing [1]. It is a common disease in childhood with increasing prevalence over time and represents a significant burden to healthcare systems. The prevalence of asthma increased from 2001 to 2010, and an estimated 25.7 million people worldwide had asthma in 2010 [2]. The monetary costs of asthma are substantial, resulting from both direct medical costs via

routine and emergency healthcare, and the costs of work absences.

Despite the high burden of this chronic disease, the use of asthma management strategies based on clinical guidelines remain below the targets set by the Healthy People 2010 Initiative [3]. National and global guidelines for the management of children with asthma are continually being updated. However, the effectiveness of clinical pathways (CPs) was not clear and variations remain.

CPs are defined as interventions that include multidisciplinary care plans have timeframes or criteria-based progression, and are used by health services to detail essential steps in the care of patients with a specific clinical problem [4]. They attempt to link evidence to practice and optimise clinical outcomes while maximising clinical efficiency. A survey of 9429 admissions conducted between 1998 and 2005 in the UK reported that the percentage of children given bronchodilators exclusively by spacer increased from 7% to 44% and the

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proportion discharged with written asthma plans increased from 24% to 41% [3]. Clinical practice guidelines are common, but it is not clear whether they improve care. In a recent publication, Boluyt et al. [5] assessed controversial paediatric asthma management options using Grading of Recommendations Assessment, Development and Evaluation (GRADE), and found that “most recommendations are weak and based on low-quality evidence for critical outcomes”. Their final recommendations differed from international guidelines: for example, inhaled corticosteroid formulations of extra-fine particles were not considered first-line treatment in children with asthma according to the GRADE assessment [5]. On the other hand, using CPs may avoid these controversies through a clear statement of a structured care plan. We believe that this systematic review can clarify: the effectiveness of paediatric asthma CPs for reducing length of hospital stay, additional visits due to asthma exacerbations, hospital costs, as well as manpower and workload associated with implementation of CPs.

Methods

Design

A systematic review of quantitative studies was performed using the Cochrane Handbook for Systematic Reviews of Interventions [6]. The research question was deconstructed into the discrete categories of population, intervention, comparison and outcomes (PICO) as shown in Table 1. The questions were: what is the effectiveness of CPs (I) for children with asthma (P) compared with usual care (C) on length of hospital stay, additional visits due to asthma exacerbations, hospital costs, manpower and workload associated with the implementation of CPs (O).

Table 1. The research question was deconstructed into discrete categories of population, intervention, comparison and outcomes (PICO).

Key element	Description
Population	Children (age ≤18 years) with acute or chronic asthma. Setting: hospital and emergency department.
Intervention	Clinical pathways (CPs) as a structured multidisciplinary care plan for a well-defined period of time, detailing essential steps and goals in patients with a specific clinical problem based on evidence or international/national guidelines. They allow multidisciplinary professions to document, monitor and evaluate variances and help communication with patients by providing a written summary. The terms included for CPs were “care model”, “care map”, “multidisciplinary care”, “evidence-based care” and “guideline” [4,7,8].
Comparison	Usual care/routine care/traditional care
Outcomes	1. Health resources utilisation: length of hospital stay and additional visits due to asthma exacerbations. 2. Administrative analysis: hospital costs, manpower and workload associated with implementing of CPs.

Search methods

The PICO principles were used to formulate clinical questions that guided the search strategy [9]. We used Medical Subject Headings (MeSH) terms and free-text referring to childhood asthma and CPs in hospital or emergency departments (EDs). These search terms were selected based on previous studies, and through consultation with an experienced medical librarian. We combined keywords related to asthma (such as: “asthma”[MeSH] or asthma*...) and clinical pathway (such as: “clinical protocols”[MeSH] or “practice guideline”[MeSH] or “best practice*” or “professional standard”...) to search the Cochrane library (Cochrane Reviews, Other Reviews, CENTRAL, Economic Evaluations; 1967 to 29th Oct, 2012), MEDLINE (1946 to Week 1 of October, 2012), CINAHL (1981 to Oct, 2012) and EMBASE (1974 to 17th Oct, 2012). Search filters included language (English and Chinese) as well as age (equal or less than 18 years old). The full search strategies used for each electronic database are included in Appendix 1. In addition, the reference lists of retrieved articles and key systematic reviews were scanned for relevant references [10–15]. We contacted the authors via e-mail to obtain the full text and additional data when needed.

Studies selection

Studies were eligible if they met the following criteria: (1) population were children ≤18 years old (mixed-age populations were excluded if a paediatric subgroup analysis was not available) with acute or chronic asthma; (2) the setting were hospital or emergency department (ED) based; and (3) study designs were randomised controlled trial (RCT) comparing CPs with usual care, controlled clinical trial (CCT) or controlled before-and-after study (CBA). Results of searches were reviewed against pre-determined criteria for inclusion. All titles and abstracts were pooled and duplicates deleted. Two reviewers (KC and CC) independently scored each title and abstract identified by the search strategy as definitely, possibly or clearly not meeting inclusion criteria. We retrieved the full text copies of all potentially relevant articles. Any discrepancies were resolved by consensus or involvement of a third reviewer (PPG).

Data extraction and assessment of the risk of bias

After confirming the eligibility of articles, two reviewers independently extracted data and assessed risk of bias. KC and CC extracted the following information from each study using a standardised data extraction sheet in Microsoft Office InfoPath™ 2003 (Appendix 2): source of publication, study design, participants, interventions/comparator details, results (e.g. outcome title, sample size for this outcome, number of missing participants, intention to treat (ITT)/per protocol analysis, number of events, mean at start/end of study, SD of mean at start/end of study, mean change, SD of mean change...), risk of bias (e.g. sequence generation, allocation concealment and blinding) and miscellaneous (e.g. funding source). We contacted the authors via e-mail to verify methods and to obtain additional data if necessary. Any disagreement in the data extraction process was resolved by discussion between authors.

Data synthesis

We synthesised data via RevMan 2012 Software [16]. Due to an insufficient number of studies and the heterogeneity of interventions and outcomes, we conducted a narrative systematic review with forest plots to report the findings. We have presented our findings from individual studies in a summary for easy comparison.

Results

Details on the number of retrieved references, the number of obtained full text papers and the number of included and excluded articles are shown as a PRISMA flowchart [17,18] in Figure 1. We contacted five authors for additional information.

Description of studies

Seven studies – two RCTs with two study arms comparing CPs with usual care [19,20], four CBAs [21–24] and one CCT

[25] – involving a total of 2600 participants met the eligibility and study quality criteria for inclusion. Study characteristics and selected outcomes of RCTs and other studies are summarised in Tables 2 and 3, respectively.

Participants and samples

Four studies reported the mean age and standard deviation [19,21,24,25], one study reported the mean age with range [22], and two studies reported mean age only [20,23]. All studies were conducted in school-age children (5–9 years old). The sample size of included studies ranged from 34 to 377. Power calculations to justify sample sizes were reported in four trials [19–21,24].

In the Cunningham [19] and Johnson [20] studies, the data shown is balanced for race and age characteristics. In the Kwan-Gett [22] study, there were significant differences in ‘sex’ and ‘race’, with more male and more Asian-Americans in the pathway group. However, no significant differences in the length of stay (LOS), rate of readmission to

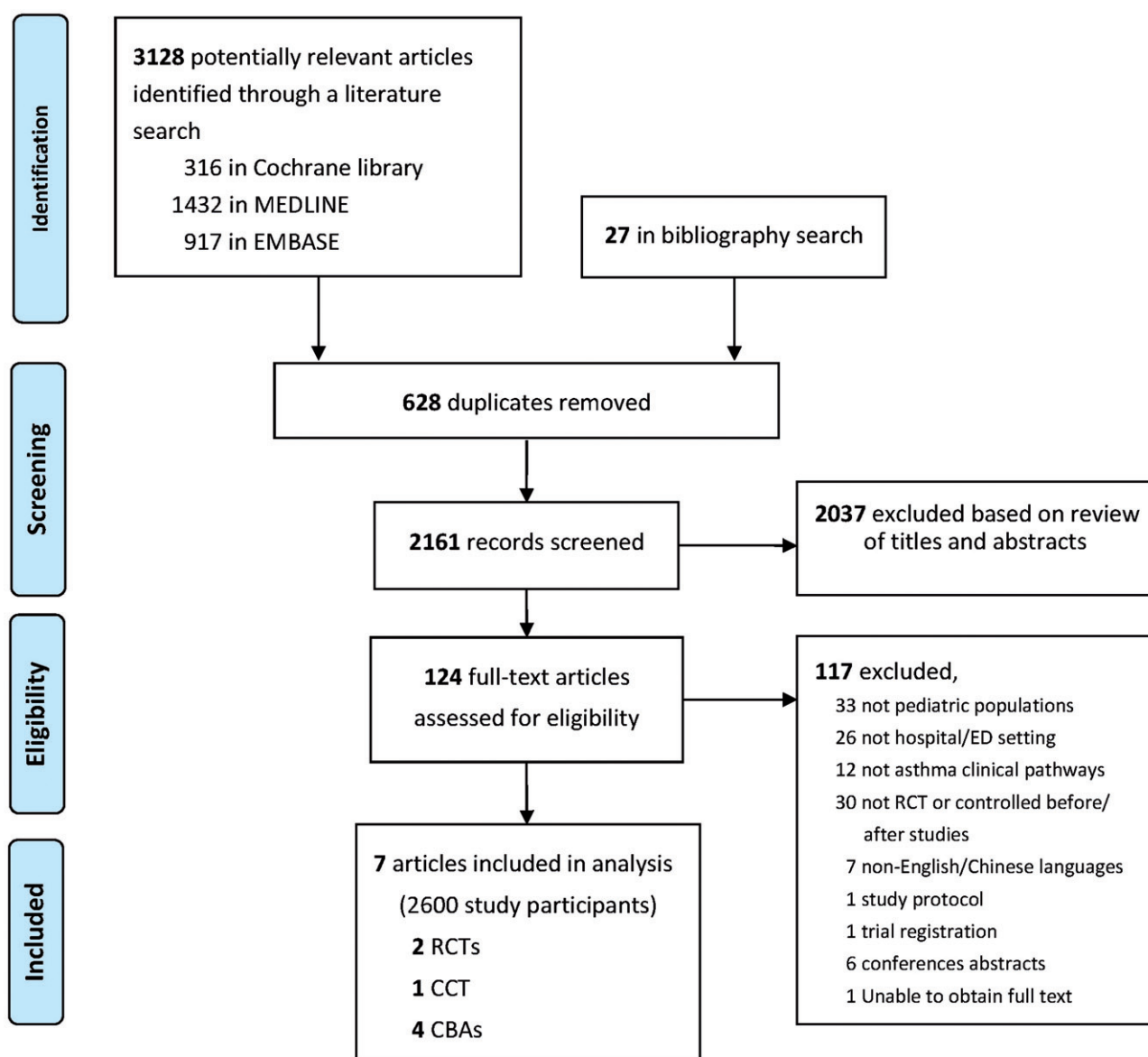


Figure 1. Flow-chart for the number of potential studies identified and included. (RCT, randomised controlled trial; CCT, controlled clinical trial; CBA, controlled before and after study).

Table 2. Study characteristics (RCT, randomised controlled trial).

Source/Design & Date	Setting, country	Study date	No. of participants	Mean age (years)	Intervention and control description	Selected outcomes and results
Cunningham et al. [19]/ Cluster randomised trial	Emergency department (ED), UK	Aug, 2004– Feb, 2005	136	5.7	Intervention: An integrated care pathway (ICP) combining all nursing, medical, clinical observation, and prescribing charts chronologically within a single document. Control: Standard care providing separate documentation for nursing, medical, clinical observation, and prescribing charts.	Intervention versus Control group 1. Discharged home from the ED [h, 95% CI: 2 (1.7–2.3) versus 1.8 (1.6–2.1)]. 2. Discharged from hospital ward [h, 95% CI: 38 (34–42) versus 41 (36–46); $p = 0.4$]. 3. Additional visits (number, %): 16 (12%) versus 19 (17%) (OR 0.6; 95% CI, 0.2–1.5; $p = 0.27$). 4. Clinician workload (1) Mean total number of clinical contacts (ED only) (mean, 95% CI): 6.2 (5.8–6.6) versus 6.4 (5.9–6.9). (2) Mean number of clinical contacts with the patient during the first 12 h, including time in the ER: (1) medical staff: 6 versus 5.5 ($p = 0.04$); (2) nursing staff: 16 versus 14 ($p = 0.002$); all contacts: 22 versus 19 ($p = 0.0004$).
Johnson et al [20]/ Parallel RCT	Hospital, USA	Summer, 1995–1997	55	8.2	Intervention: 1. Nurse-driven protocol for weaning bronchodilators; 2. Peak flow measurement (for children ≤ 5 years) every 4 h, before and after nebulisation; 3. Asthma teaching essential, including spacer and peak flow meter training, beginning the day of admission; 4. Prescriptions for home therapies given to family before discharge; 5. Early contact between attending physical and private medical doctor to establish plan for asthma management and improve coordination of care. Control: 1. Obtaining vital signs before administering each nebulised β -agonist; 2. Nurses did not determine whether patients were ready to be weaned from their medication, but they would notify the house officer if asked to before administering a nebulised β -agonist; 3. Patient received education about the use of an inhaler and spacer, as well as some coordination of post discharge care from case management team.	Intervention versus Control group 1. LOS (the duration of hospitalisation) (h): 40.3 versus 53.7 ($p < 0.01$). 2. Number doses of β -agonist nebulisation therapies (every 2, 3, 4, 6 and 8 h): 4.5, 3.7, 3.5, 1.4 and 0.1 versus 6.5, 5.9, 4.7, 2.2 and 0 ($p = 0.02$, 0.002, 0.04, 0.01 and 0.32), respectively 3. Hospital charge for each patient (US\$): (1) routine (room) charge: \$2407 versus \$3116 ($p < 0.001$); (2) medication charges: \$129 versus \$153 ($p = 0.2$); (3) laboratory charge: \$21 versus \$42 ($p = 0.1$); (4) respiratory therapy charge: \$42 versus \$250 ($p < 0.001$). 4. Adverse events: phone call to care provider because of worsening asthma symptom (count): 1 versus 1; unscheduled clinic visits: 0 versus 2.

Table 3. Study characteristics.

Source/study design	Setting, country	Study date	No. of participants	Mean age (years)	Intervention description	Selected outcomes and results
Clinical controlled trial, CCT						
McDowell et al. [25]/ Nonrandomised, prospective, controlled trial	Hospital, USA	Sep, 1995–Feb, 1996	104	7.3	<i>Intervention:</i> asthma care algorithm (ACA) A unique patient record containing assessment, algorithm cues, and a treatment record was used. <i>Control:</i> Unstructured standard treatment.	<i>Intervention versus Control group</i> 1. LOS (days) (median, SE): 2 (0.1) versus 2.7 (0.2) ($p < 0.001$). 2. Cost per hospitalisation (US\$) (median, SE): \$2550 (144) versus \$3304 (170) ($p < 0.001$). 3. Readmission (%): 3% versus 1% ($p = 0.6$). 4. Aerosolised albuterol doses given (median, SE): 10 (0.7) versus 16 (1.2) ($p < 0.001$). 5. Therapy intensification (number, %): 15% versus 5% ($p = 0.02$).
Controlled before and after studies, CBAs						
Kelly et al. [21]/ Pre- and post-study with a retrospective cohort control group	Hospital, USA	Sep and Dec 1996	34	7.3	<i>Pre-pathway</i> A retrospective cohort control group of non-pathway patients was matched with each pathway patient by age, race, gender, comorbidities, asthma severity score, ICU admission, and time of year admitted. <i>Clinical pathway</i> Based on the paediatric asthma score (PAS) or the peak expiratory flow rates (PEFR), the asthma therapy driven protocol directed nursing and respiratory therapy staff to adjust the dose and frequency of albuterol without a specific order from the physician.	<i>Pre-pathway versus Pathway</i> 1. LOS (days, 95% CI): 2.9 (2.7–3.2) versus 1.5 (1.3–1.7) ($p < 0.001$). 2. Total cost of care (US\$, 95% CI): \$2829 (2496–3162) versus \$1685 (1437–1933; $p < 0.001$). 3. Asthma education completed (number, %): 6 (18%) versus 22 (65%) ($p < 0.001$). 4. Controller medication prescribed (number, %): 18 (53%) versus 30 (88%; $p < 0.01$). 5. Availability of peak flow meter (23% versus 57%, $p < 0.05$) and a spacer device (71% versus 100%, $p < 0.001$) for home use. 6. Readmission to the hospital or ED within 72 h of discharge: 0 versus 0.
Kwan-Gett et al. [22]/ Before and after study	Hospital, USA	Mar, 1994–Feb, 1995	292	6.4	<i>Pre-pathway</i> A retrospective compared similar patients who were admitted to hospital in the year prior to the asthma clinical pathway implementation. <i>Pathway</i> A plan-of-care flowchart provided day-to-day guidance about albuterol and steroid dosage, oximetry monitoring, patient and family education, and criteria for consulting the pulmonologist, clinical nurse specialists and social workers on the monitoring and management of the individual patient after hospitalisation.	<i>Pre-pathway versus Pathway</i> 1. LOS of 1 or 2 days (%): 70% versus 68% ($p = 0.6$). 2. Rate of readmission to the hospital with 14 days of discharge (number, %): 5 (1%) versus 7 (2%; $p = 0.5$). 3. Average total charge (US\$): Per admission: \$2634 versus \$2604; per admission per day: \$1224 versus \$1213 (N.S.). 4. Average total charge (US\$): ED: \$352 versus \$350 (N.S.); laboratory: \$39 versus \$26 ($p = 0.04$); radiology services: \$55 versus \$32 ($p < 0.001$), and respiratory therapy: \$400 versus \$372 (N.S.).
		Mar, 1995–Feb, 1996	297	6.4		

Massie et al. [23]/Pre- and post-study with a 3-cohort control group	ED, Australia	<i>Asthma Best Practice Guidelines (launched in Oct 1999)</i>			<i>Cohort 1 versus Cohort 2 versus Cohort 3</i>	
		1. The focus of implementation included: assessment of asthma severity, nurse assessment of patient improvement, individualised asthma management plan, discharge letter and management plan sent to the general practitioner, and newly diagnosed patients referred for paediatrician follow-up.			1. Rates of re-attendance within 6 months: 22% versus 28% versus 25% (N.S.).	
		2. A multidisciplinary Asthma Special Interest Group convened monthly to discuss asthma care (hospital and community based) with emphasis on the guidelines.			2. Readmission to hospital within 6 months: 11% versus 11% versus 11% (N.S.).	
		Jun and Oct 1999	374	6.1	<i>Cohort 1: before implementation of the guidelines</i>	
		Apr and Aug 2000	363	6	<i>Cohort 2: after implementation</i>	
		Jan and May 2001	377	5.9	<i>Cohort 3: after implementation for 1 year</i>	
Norton et al. [24]/Prospective, before-after, blinded, controlled trial	ED, Canada/	Feb and Mar 2000, Feb and Mar 2001	193	5.1	<i>Pre-pathway</i>	
					Timing and selection of treatment for children in the pre-implementation group were left to the discretion of the doctor.	
		Feb and Mar 2002	74	5.1	<i>Clinical pathway</i>	
					1. Clinical pathway consisted of assessment and order documentation forms and a plan-of-care flow-chart indicating treatment and actions of nurses and doctors over the first 8 h in the ED according to exacerbation severity.	
					2. Clinical care pathway as an operational version of a clinical guideline that designated the timing and sequence of assessments and interventions for patients with specific diagnoses.	
					<i>Pre-pathway versus Pathway</i>	
					1. Rate of hospitalisation: 53/193 (28%) versus 10/74 (14%; $p=0.02$; NNT 7.1).	
					2. Reduction in hospitalisation: 48/103 (47%) versus 8/36 (22%; $p=0.01$).	
					3. Rate of return visit: 8/103 (8%) versus 1/36 (3%; $p=0.3$).	
					4. Rate of administration of oral corticosteroids: 71% versus 92% ($p=0.01$).	
					5. Proportion (%) of patients who received ≥ 1 dose β_2 -agonists in the first hour: 58% versus 73% ($p=0.02$).	
					6. Return to ED within 14 days (%): 14% versus 8% ($p=0.2$).	

ED: emergency department; OR: odds ratio; LOS: length of stay; NNT: number needed to treat; N.S.: no significant difference; CCT, clinical control trials; CBAs, controlled before and after studies.

the hospital within 14 days of discharge, and hospital costs were noted. In the Norton study [24], “age” is balanced between the “pre-pathway” and “clinical pathway” period. Although there are more males in the control group than the CPs group (65% versus 53%), no significant differences in the rate of hospitalisation, rate of return visit and rate of return to ED within 14 days were found. The McDowell study [25] was gender-balanced, but there were more Caucasian participants (40.5% versus 14%, $p = 0.008$) and older children (7.3 versus 5.0, $p = 0.003$) in the intervention versus the control group. The results showed that a significant difference in LOS and cost per hospitalisation, but no significant differences in readmission. No study in the seven included articles stated income and location in the baseline analysis.

Countries and settings

More than half of the studies were conducted in the United States [20–22,25], and the others were in the United Kingdom ($n = 1$) [19], Australia [23] and Canada [24]. Four studies were conducted in a hospital environment [20–22,25] and three in EDs [19,23,24].

Interventions

The CPs included in this systematic review were: an integrated care pathway (ICP) combining all nursing, medical, clinical observation and prescribing charts chronologically within a single document [19], a nurse-driven protocol [20], an asthma care algorithm (ACA) [25], an asthma therapy driven protocol [21], a plan-of-care flowchart [22,24] and asthma best practice guidelines [23]. CPs implemented in the included studies were all developed by the target institutes. Different terminology was used, and there was some variation in the contents of the seven included studies. Detail study characteristics were presented in Tables 2 and 3.

Control arms

In RCTs and CCTs, the control groups all comprised usual/standard care except CPs implementation. In CBAs, the results pre- and post-implementation of asthma CPs were compared (Tables 2 and 3).

Outcomes (effects of interventions)

Due to an insufficient number of studies, and the heterogeneity of interventions and outcomes, we conducted a narrative systematic review with forest plots to report the findings. We present findings from individual studies in a summary of findings for comparison.

Length of stay

The LOS was the most common outcome measure among included studies. Cunningham et al. [19] stated that the mean number of days to discharge from the hospital ward was lower in the study group than in the control group (1.6 versus 1.7 days), but this was not statistically significant ($p = 0.4$). In the Johnson et al. [20] study, the mean LOS was 0.5 day shorter than that of the control group (1.7 versus 2.2 days; $p < 0.01$). McDowell et al. [25] reported that using the “asthma care algorithm” leads to shorter LOS in the intervention compared to the control group (median: 2 versus 2.7 days, $p < 0.001$). Similarly, the results of the Kelly et al. [21] study showed that the LOS was reduced after CPs implementation (pre-pathway 2.9 versus CPs 1.5, days; $p < 0.001$). Taken together, these studies suggest that using paediatric CPs may reduce the LOS. The forest plot is presented in Figure 2.

Additional visits due to asthma exacerbations

In the Cunningham et al. [19] study, the number (%) of additional visits for the study group was 16 (12%), while for the control group it was 19 (17%; OR 0.6; 95% CI 0.2–1.5; $p = 0.3$). In the Johnson et al. [20] study, two participants had worsening asthma symptoms in the control group, compared to none in the study group (OR 0.2, 95% CI 0.01–4.1). Similarly, Norton et al. [24] reported that the proportion of children with asthma that returned to ED within 14 days was reduced after CPs implementation (14% versus 8%; $p = 0.2$). However, McDowell et al. [25] found that 3% of children were readmitted in the study group, compared to 1% in the control group (OR 3, 95% CI 0.29–28; $p = 0.62$). We could not combine the results of additional visits due to asthma exacerbations because of different settings, i.e. ED [19,24] and hospital [20,25] and different definitions of outcome

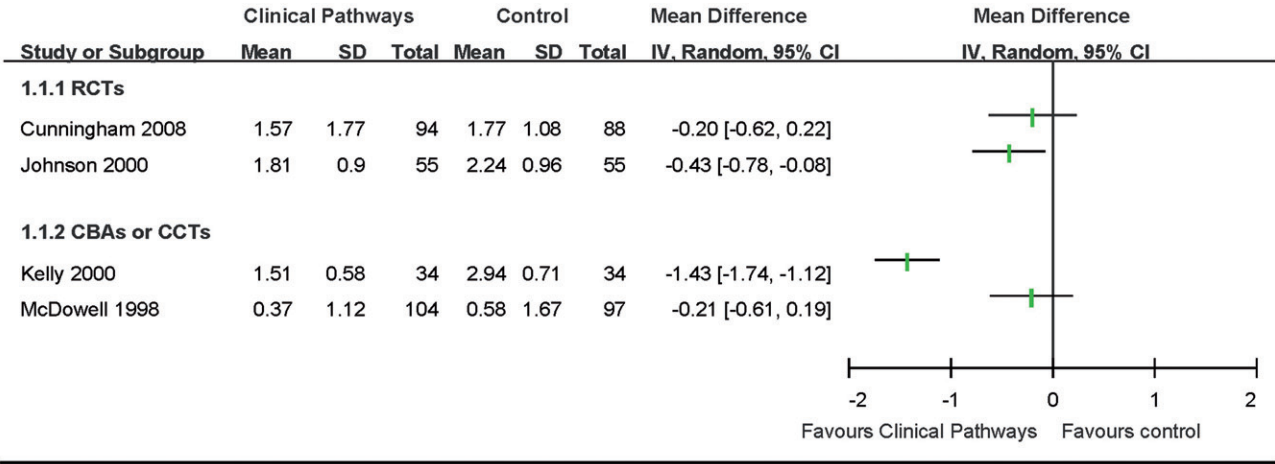


Figure 2. Forest plot of comparison: asthma clinical pathways versus controls, outcome: length of hospital stays (days). (RCTs: randomised controlled trials, CBAs: controlled before and after study, CCTs: controlled clinical trials).

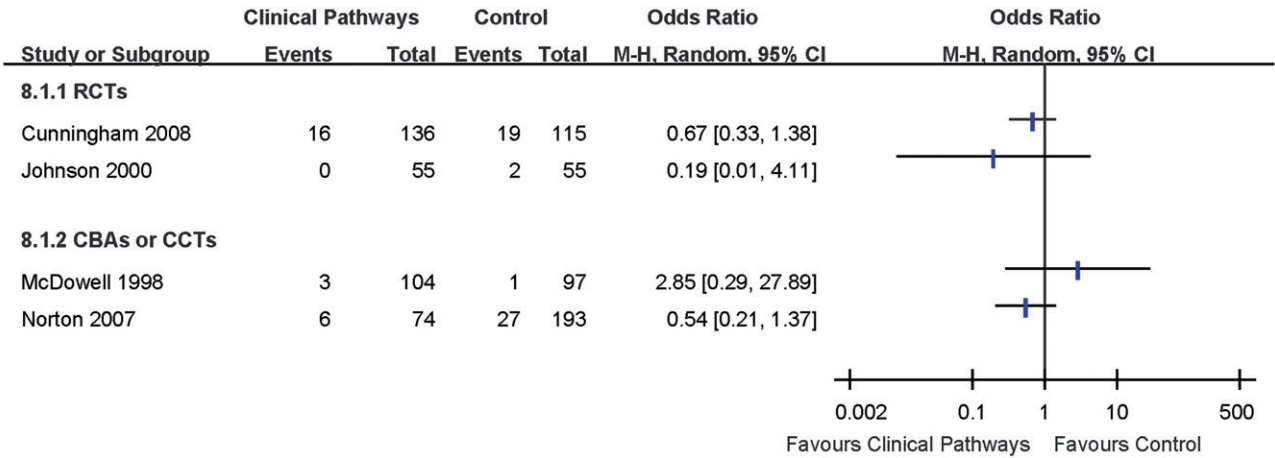


Figure 3. Forest plot of comparison: asthma clinical pathways versus controls, outcome: additional visits due to asthma exacerbations (the outcome variable were defined as additional visits [19]; unscheduled clinic visits for asthma symptoms (no readmission in 14 days) [21]; return to ED within 14 days [24]; and readmissions [25]). (RCTs: randomised controlled trials, CBAs: controlled before and after study, CCTs: controlled clinical trials).

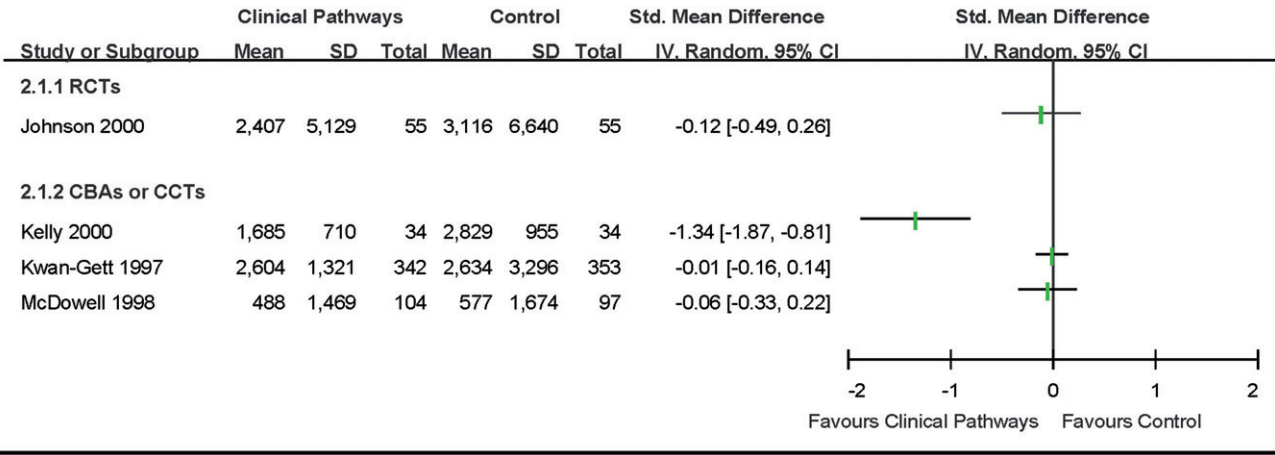


Figure 4. Forest plot of comparison: asthma clinical pathways versus controls, outcome: hospital cost (US\$). (RCTs: randomised controlled trials, CBAs: controlled before and after study, CCTs: controlled clinical trials).

measures. The results are instead summarised as number of events and the forest plot is presented in Figure 3.

Hospital cost (US\$)

Only one RCT, Johnson et al. [20], mentioned the individual hospital charges for each patient; the routine room charges and respiratory therapy charges in the study group were lower than those of the control group ($p < 0.001$). However, differences in the medication and laboratory charges were not significantly different ($p > 0.05$) [20] (Table 2). Similarly, Kwan-Gett et al. [22] found that no significant difference in the average total cost per admission (\$2634 versus \$2604). On the other hand, McDowell et al. [25] demonstrated that the median cost per hospitalisation (US\$) in the study group was \$2550 compared to \$3304 in the control group at ($p < 0.001$); and Kelly et al. [21] found that the total costs of care in the pathway versus pre-pathway study groups were \$1,685 (95% CI 1437–1933) versus \$2829 (95% CI 2496–3162; $p < 0.001$). The trend of the decrease in hospital costs did not favour

clinical pathways except the Kelly et al. study conducted in 1996–1997. The forest plot is presented in Figure 4.

Manpower and workload due to implementing CPs

We found no eligible studies on manpower and workload required for implementation of CPs and therefore we were unable to draw conclusions on this aspect.

Funding

The Johnson et al. [20] study was funded by the Johns Hopkins Miracle Telethon Fund (the Johns Hopkins Children’s Centre). The Massie et al. [23] study was funded by grants from the National Health and Medical Research Council of Australia (NH&MRC grant No. 98/31401) and the Department of Human Services, Victoria. The Norton et al. [24] study was funded by the Divisions of Paediatric Emergency Medicine and Quality Promotion, Children’s and Women’s Health Centre of British Columbia, Canada. Four studies [19,21,22,25] did not declare any sources of funding.

Discussion

The results are relevant to a variety of settings worldwide. The degree of clinical and statistical heterogeneity made a meta-analysis of the extracted outcomes difficult. Despite this limitation, some of our findings should be meaningful for clinicians, hospital managers, and researchers.

Findings to support CPs

Kelly *et al.* [21] reported favourable results for CPs for the outcomes “LOS” and “hospital cost”. The LOS in two hospitals was significantly reduced when a CPs was introduced [20,21]. Two other studies that also measured LOS found no statistically significant differences [19,25]. For the outcome additional visits due to asthma exacerbation, no results from the included studies could prove any benefit from applying CPs to inpatient care for asthmatic children. Three studies showed that CPs did not reduce the cost of asthma care [20,22,25], only Kelly *et al.* [21] showed that CPs can reduce costs. However, our review cannot support the extensive application of asthma CPs for inpatient care. The review exposed that the effect of CPs on patients’ clinical outcomes, like adverse effects or “aerosolised albuterol doses given”, has only been reported by a limited number of studies. McDowell *et al.* [25], Johnson *et al.* [20] and Norton *et al.* [24] showed that the capacity of CPs to reduce the use of aerosolised nebulisers for asthma patients. There are insufficient numbers of homogenous studies to draw firm conclusions at this stage; however, the data reveals that CPs can potentially control the LOS of asthma patients.

Hospital perspective and costs of hospitalisation

In order to provide a replicable framework for local hospital providers considering the effectiveness of CPs as a patient management strategy, we limited the scope of this review to a hospital perspective. Hence, readers need to be aware of the potential biases caused by just looking at hospital costs in an institutional context. There is potential for pathway interventions to result in capacity and/or cost shifting to other sectors of healthcare, i.e. to patients and their families. Moreover, like LOS outcomes, hospital cost data can be misleading and difficult to interpret. The magnitude of cost savings should be assessed in the context of clinically relevant patient outcomes (e.g. mortality).

Heterogeneity of the included studies

We defined CPs as detailed in Table 1. However, in the seven included studies, there was significant variation among the CPs applied by researchers. The CPs included various terms which were not identical in contents. In addition, four studies were conducted in a hospital environment, and three in EDs.

Limitations

Studies were restricted to those published in English and Chinese. In addition, no attempt was made to source unpublished work. Despite these limitations, the authors are confident that all RCTs meeting the inclusion criteria were retrieved. The overall quality of the studies varied. We did not include the ambulatory care paediatric asthma populations in

the review. However, there may be differences between children with asthma that do not use hospital-based services and those that do, and the review does not address the potential effectiveness of clinical pathways for paediatric asthma management in ambulatory settings to prevent hospital use.

In general, there was a lack of high quality research on this study subject. Only two RCTs were included in our review. The favoured experimental methods such as RCTs may be considered beyond the capacity of many clinicians and researchers. We therefore included CCT and CBA for the analysis. These study designs can be useful for internal monitoring but it is difficult to draw meaningful conclusions due to the lack of control and a potentially high risk of bias.

Conclusions

Current studies suggest CPs may reduce the length of hospital stay, but insufficient evidence is available on total hospital costs or readmissions to justify extensive uptake of asthma CPs in paediatric inpatient care. Higher quality, large randomised controlled trials are required that measure costs and a wider range of outcomes.

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Declaration of interest

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Appendix 1. Search strategies.

Cochrane library search ($n = 316$)
<1967 to 29 Oct, 2012>

#1 MeSH descriptor: [Patient Care Planning] explode all trees 1223.
 #2 MeSH descriptor: [Clinical Protocols] this term only 1418.
 #3 (clinical or care) near/2 pathway*:ti,ab,kw (Word variations have been searched) 260.
 #4 MeSH descriptor: [Practice Guideline] explode all trees 10.
 #5 (practice or clinical or planning) near/2 (guideline* or protocol*):ti,ab,kw (Word variations have been searched) 4948.
 #6 MeSH descriptor: [Nursing Process] explode all trees 1745.
 #7 nursing near/2 (plan* or protocol* or assessment*):ti,ab,kw (Word variations have been searched) 761.
 #8 "professional standard" or "professional standards":ti,ab,kw (Word variations have been searched) 18.
 #9 written standard" or "written standards":ti,ab,kw (Word variations have been searched) 2.
 #10 "standard operation procedures":ti,ab,kw (Word variations have been searched) 0.
 #11. MeSH descriptor: [Practice Guidelines as Topic] explode all trees 1427.
 #12 consensus next/1 (statement* or development*):ti,ab,kw (Word variations have been searched) 92.
 #13 best practice*:ti,ab,kw (Word variations have been searched) 4321.
 #14 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 11860.
 #15 MeSH descriptor: [Asthma] explode all trees 8780.
 #16 asthma*:ti,ab,kw (Word variations have been searched) 20310.
 #17 #15 or #16 20310.
 #18 #14 and #17 330.
 Excluded methods Studies, technology assessments and cochrane groups 316

EMBASE search child "limit" ($n = 917$)
<1974 to 17 Oct, 2012>

#1 'patient care planning'/de AND [embase]/lim 1537.
 #2 'clinical pathway'/de AND [embase]/lim 2450.
 #3 'nursing care plan'/de AND [embase]/lim 99.
 #4 'nursing protocol'/de AND [embase]/lim 60.
 #5 'practice guideline'/de AND [embase]/lim 148055.
 #6 'nursing process'/de AND [embase]/lim 50.
 #7 'good clinical practice'/de AND [embase]/lim 6510.
 #8 ((clinical OR care) NEXT/1 pathway*):ab,ti AND [embase]/lim 2926.
 #9 ((practice OR clinical OR planning) NEAR/1 (guideline* OR protocol*)):ab,ti AND [embase]/lim 19285.
 #10 (nursing NEAR/2 (protocol* OR assessment*)):ab,ti AND [embase]/lim 584.
 #11 'professional standard':ab,ti OR 'professional standards':ab,ti AND [embase]/lim 673.
 #12 'written standard':ab,ti OR 'written standards':ab,ti AND [embase]/lim 44.
 #13 'standard operating procedures':ab,ti AND [embase]/lim 937.
 #14 (consensus NEXT/1 (statement* OR development*)):ab,ti AND [embase]/lim 3657.
 #15 'best practice':ab,ti OR 'best practices':ab,ti AND [embase]/lim 7351.
 #16 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 175601.
 #17 'asthma'/exp AND [embase]/lim 134676
 #18 asthma*:ab,ti AND [embase]/lim 113110
 #19 #17 OR #18 150306.
 #20 #16 AND #19 4808.
 #21 #20 AND ([newborn]/lim OR [infant]/lim OR [preschool]/lim OR [school]/lim OR [child]/lim OR [adolescent]/lim) 917.

Ovid MEDLINE(R) search (*n* = 1432)
<1946 to week 1 of Oct 2012>

1 exp Patient Care Planning/(49168)
2 Clinical Protocols/(18394)
3 ((clinical or care) adj2 pathway*).tw. (3338)
4 practice guideline/(17264)
5 ((practice or clinical or planning) adj2 (guideline* or protocol*).tw. (23267)
6 exp Nursing Process/(73520)
7 (nursing adj2 (plan* or protocol* or assessment*).tw. (3378)
8 ("professional standard" or "professional standards").tw. (877)
9 ("written standard" or "written standards").tw. (49)
10 "standard operating procedures".tw. (630)
11 Practice Guidelines as Topic/(70880)
12 (consensus adj1 (statement* or development*).tw. (3753)
13 best practice*.tw. (7744)
14 or/1-13 (240871)
15 exp Asthma/(100234)
16 asthma.tw. (97320)
17 15 or 16 (123036)
18 14 and 17 (3115)
19 limit 18 to ["all infant (birth to 23 months)" or "all child (0 to 18 years)" or "newborn infant (birth to 1 month)" or "infant (1 to 23 months)" or "preschool child (2 to 5 years)" or "child (6 to 12 years)" or "adolescent (13 to 18 years)"] (1432)

CINAHL search (*n* = 463)
<1981 to Oct 2012>

S1 MH Patient Care Plans 4836
S2 MH Nursing Protocols 3396
S3 MH Nursing Process 24928
S4 TI ((clinical or care or critical) N2 pathway*) OR AB ((clinical or care or critical) N2 pathway*) 2587
S5 MH Practice Guidelines 28298
S6 TI ((practice or clinical or planning) N2 (guideline* or protocol*)) OR AB ((practice or clinical or planning) N2 (guideline* or protocol*)) 9839
S7 TI (nursing N2 (plan* or protocol* or assessment*)) OR AB (nursing N2 (plan* or protocol* or assessment*)) 3843
S8 TI ("professional standard" or "professional standards") OR AB ("professional standard" or "professional standards") 421
S9 TI ("written standard" or "written standards") OR AB ("written standard" or "written standards") 26
S10 TI "standard operating procedures" OR AB "standard operating procedures" 121
S11 (MH "Nursing Practice, Evidence-Based+") OR (MH "Nursing Practice, Theory-Based") 9169
S12 TI [consensus N2 (statement* or development*)] OR AB (consensus N2 (statement* or development*)) 1067
S13 TI best practice* OR AB best practice* 7039
S14 S1 or S2 or S3 or S4 or S5 or S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13 80401
S15 (MH "Asthma+") 17260
S16 TI asthma* OR AB asthma* 15801
S17 S15 or S16 19973
S18 S14 and S17 1086
S19 S14 and S17 Narrow by Subject Age birth-18 years, all infant, all child 463

Appendix 2 Data extraction form.

Review Author	
Date of data extraction	

Section 1: Source of Publication

Study ID		(e.g. Cochrane format "SurnameYYYY")
Report ID		(used to distinguish duplicate reports of same study)
Citation		
Author contact		

Section 2: Confirmation of Study Eligibility

Criterion 1	
Criterion 2	
All criteria met?	
If no, reason for exclusion	

Section 3: Study Methods

Study design	
Describe further, or specify if "other"	
Total study duration	

Section 4: Participants

(The information in sections 4, 5, and 6 will go in the "Characteristics of Eligible Studies" table of the review)

Total number		
Setting		
Diagnostic/entry criteria		
Age		(state whether mean, median, range etc.)
Sex		
Country		
Other char 1		(e.g. co-morbidity, socio-demographic, ethnicity)
Other char 2		

Section 5: Interventions

Total number of intervention/comparator groups in this study:	
For each intervention and comparison group of interest:	
Specific intervention/comparator group title	
Intervention details	
Number of allocated participants	

Section 6: Outcomes

For each outcome of interest reported in this paper: (Click on tab at bottom of section to add another outcome)

Outcome title		(should match outcome title to be used in the review)			
Time point(s) collected					
Time point(s) reported					
Outcome definition					
Units of measurement					
For scales – also need upper limit		lower limit		high or low good	

Section 7: Results

Repeat this section for each outcome (click at bottom of completed section to create a new table for another outcome)

Outcome title (from section 6 above)

Table has a column for each intervention / comparator group that contributes to this outcome-must be at least 2.

(Click at bottom of first completed column to create a new column for another intervention/comparator group for this outcome).

Intervention / comparator group title (from Section 5 above)	
Sample size for this outcome	
Number of missing participants	
Is this analysis ITT or per protocol?	
Events:	
Number of events or	
Event rate per unit time	
Specify time units (e.g. days, years)	
Continuous: (enter all that apply)	
Mean at start of study	
SD of mean at start of study	
Mean at end of study	
SD of mean at end of study	
Mean change	
SD of mean change (check !!!)	
Any other data to enable calculation	
Any comments on measurement of this outcome for this group	

Section 8: Risk of Bias

Adequate sequence generation?	
Description (quote from paper)	
Adequate allocation concealment?	
Description	
Blinding of treatment?	
Description	

For each outcome of interest reported in this paper: (click tab at bottom of section to create a new section for another outcome)

Outcome title (from Section 6 above)	
Blinding of outcome assessment?	
Description	
Incomplete outcome data addressed?	
Description	
Free of selective outcome reporting?	
Description	
Free of other bias?	
Description	

Section 9: Miscellaneous

Funding source	
Key conclusions of study authors	
References to other studies	
Any other information from study	
Any correspondence or further information required	
Other comments by review author	