



ORIGINAL ARTICLE

Assessing appropriateness of paediatric asthma management: A population-based sample survey

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ABSTRACT

Background and objective: We conducted a comprehensive assessment of guideline adherence in paediatric asthma care, including inpatient and ambulatory services, in Australia.

Methods: National and international clinical practice guidelines (CPG) relating to asthma in children were searched and 39 medical record audit indicator questions were developed. Retrospective medical record review was conducted across hospital inpatient admissions, emergency department (ED) presentations, general practice (GP) and paediatrician consultations in three Australian states for children aged ≤15 years receiving care in 2012 and 2013. Eligibility of, and adherence to, indicators was assessed from medical records by nine experienced and purpose-trained paediatric nurses (surveyors).

Results: Surveyors conducted 18 453 asthma indicator assessments across 1600 visits for 881 children in 129 locations. Overall, the adherence for asthma care across the 39 indicators was 58.1%, with 54.4% adherence at GP (95% CI: 46.0–62.5), 77.7% by paediatricians (95% CI: 40.5–97.0), 79.9% in ED (95% CI: 70.6–87.3) and 85.1% for inpatient care (95% CI: 76.7–91.5). For 14 acute asthma indicators, overall adherence was 56.3% (95% CI: 47.6–64.7). Lowest adherences were for recording all four types of vital signs in children aged >2 years presenting with asthma attack (15.1%, 95% CI: 8.7–23.7), and reviewing patients' compliance, inhaler technique and triggers prior to commencing a new drug therapy (20.5%, 95% CI: 10.1–34.8).

Conclusion: The study demonstrated differences between existing care and CPG recommendations for paediatric asthma care in Australia. Evidence-based

SUMMARY AT A GLANCE

This study provides comprehensive findings on the quality of health care received by children with asthma care across different healthcare settings in Australia. There was marked variation in the quality of both pharmacological and non-pharmacological management of paediatric asthma and children received quality care for <60% of occasions.

interventions to improve adherence to CPG may help to standardize quality of paediatric asthma care and reduce variation of care.

Key words: asthma, paediatric asthma, asthma management guidelines, paediatrics.

INTRODUCTION

Asthma is the most common chronic disease of childhood, with approximately 14% of children worldwide experiencing asthma symptoms.¹ In Australia, 1 in 10 school-aged children have asthma. Children with asthma often experience emergency department (ED) and unscheduled medical visits that result in significant healthcare burdens. This also results in school absenteeism and academic underperformance² and can impose significant burden on families, and may also contribute to psychological stress.

There are national and international clinical practice guidelines (CPG) for the management of paediatric asthma, aimed at standardizing clinical care and improving health outcomes. Despite guideline availability, variation in care and poor adherence to CPG have been shown in several studies; however, most focus was on one care setting (e.g. respiratory units³ or ED⁴ or limited aspects (phases) of care,⁵ or only on those who experienced asthma-related mortality,⁶ and are often many years out of date).⁷ There remains a dearth of information on the quality of overall clinical

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care for paediatric asthma provided across all healthcare settings and phases of care in Australia.

To address this knowledge gap, CareTrack Kids (CTK) assessed the care of Australian children aged 0–15 years in 2012 and 2013 across a variety of healthcare settings, to estimate adherence to CPG for 17 common conditions, including asthma. Across the 17 conditions, adherence to CPG was estimated to be 59.8% (95% CI: 57.5–62.0).⁸ This study presents detailed CTK results for guideline adherence for paediatric asthma care across different healthcare settings including ambulatory and inpatient settings.

METHODS

Study design

The CTK methods have been described in detail elsewhere.^{8,9} Broadly, the CTK care study sought to estimate adherence to asthma guidelines by: (i) developing clinical indicators for asthma care by reviewing existing CPG; (ii) taking a sample survey of medical records in multiple sites for each of the four clinical settings (including general practitioners, ED, inpatients and paediatricians' offices), in three Australian states; and (iii) undertaking medical record review to estimate adherence to each indicator, and for groups of indicators.

Ethical considerations

Primary ethics approval was received from relevant bodies including hospital networks (HREC/14/SCHN/113; HREC/14/QRCH/91; and HREC/14/WCHN/68) and the Royal Australian College of General Practitioners (NREEC 14-008), and site-specific approvals from 34 sites. The Australian Human Research Ethics Committees can waive requirements for patient consent for external access to medical records if the study entails minimal risk to providers and patients; all relevant bodies provided this approval. Ethics approvals included reporting by healthcare setting type for condition-level papers. Participants' identities and information were protected from litigation by gaining statutory immunity for CTK as a quality assurance activity, from the Federal Minister for Health under Part VC of the *Health Insurance Act 1973* (Commonwealth of Australia).

Indicator development

We modified and applied the RAND-UCLA method to develop indicators.¹⁰ An indicator was defined as a measurable component of a guideline, with explicit criteria for inclusion, exclusion, time frame and practice setting.⁸

A systematic search for Australian and international CPG for paediatric asthma care, relevant for the years 2012–2013, yielded three CPG, from which 109 recommendations were extracted. Recommendations were screened for eligibility and 29 were excluded because: the recommendation was not explicit (e.g. 'may' or 'could'); guiding statements were provided without recommended actions; the likelihood of information being

documented was considered low; or they addressed aspects of care deemed out of scope such as 'structure-level' recommendations.⁹ The remaining 80 recommendations entered the review process.

Recommendations were ratified by experts over a two-stage modified Delphi process, which comprised an email-based internal review (three rounds) and a collaborative, online, wiki-based external review (two rounds). Seven experts (six paediatricians and one general practitioner) were recruited for the 'internal' ($n = 3$) and 'external' reviews ($n = 4$).⁹ Internal and external reviewers completed their assignments independently to minimize group-thinking. An expert coordinator led the reviews.

In the internal review, experts scored each recommendation against three criteria (acceptability, feasibility and impact)⁹ and recommended inclusion or exclusion. Fifty-eight indicators were excluded, with 22 passed for external review. External reviewers applied the same scoring criteria as internal reviewers, and also used a nine-point Likert scale to score each indicator as representative of appropriate care delivered to children during 2012 and 2013.⁹ A total of 21 final recommendations were ratified by external reviewers and these were formatted into 39 medical record audit indicator questions. All indicators are shown in Table S1 (Supplementary Information). Additional details on indicator development and other methods are included in Appendix S1 (Supplementary Information).

Settings

Four healthcare settings were sampled (hospital inpatient and ED presentations, and consultations in general practices (GP) and paediatricians' offices) in selected health districts in Queensland (Hospital Health Services), New South Wales (Local Health Districts) and South Australia (Local Health Networks), for children aged ≤ 15 years receiving care in 2012 and 2013. Details of the sampling of health districts and individual sites for the CTK study have been published,⁸ and are summarized in Appendix S1 (Supplementary Information).

Participants/data sources/measurement

For the broader CTK study, the recruitment rate was 92% for hospitals, and estimated to be 25% for paediatricians and 24% for GP (Appendix S1, Supplementary Information). Information about participating and non-participating sites was not collected, so possible sources of bias could not be identified.

CTK targeted 400 paediatric medical records for asthma and 6000 medical records for 16 other conditions in the selected sites. We finally reviewed 881 records for asthma, principally because records targeted for other conditions also included visits for asthma management in 2012 or 2013, and these were sampled opportunistically. Data were collected by nine experienced paediatric nurses (surveyors), trained to assess eligibility for indicator assessment and adherence. To assist the surveyors in completing the medical record assessments, they were provided with definitions (surveyors' manual) that had been developed from experts' feedback obtained during the indicator

reviews and additional information contained within included CPG (Table S2, Appendix S2, Supplementary Information).

Study size

If any of the 6400 targeted records contained visits for asthma management, they were included in the study (Fig. 1).

Statistical analysis

At indicator level, adherence was measured as the percentage of eligible indicators which scored 'Yes'. Adherence to some indicators was aggregated as bundles of care, based on common eligibility criteria. For example, indicators ASTH07–ASTH09 all relate to children with asthma on prescribed medication being appropriately reviewed before a change in medication; all three of these indicators would have to be scored 'Yes' for the bundle to be scored as being CPG-adherent. When assessing bundles, a visit was only included if there were 'Yes' or 'No' responses for all indicators.

Sampling weights were constructed as specified in Appendix S1 (Supplementary Information). The weighted data were analysed in SAS/STAT version 9.4 (SAS Institute Inc., Cary, NC, USA), using the SURVEY-FREQ procedure. Variance was estimated by Taylor series linearization and domain analysis was applied. State and healthcare settings were specified as strata, where applicable, and the primary sampling unit (health district) was specified as the clustering unit. Controlling for the primary clustering unit adjusts the CI for cluster-

related variation for all stages of clustering below the primary unit.¹¹ Exact 95% CI were generated using the modified Clopper–Pearson method, except when the point estimate was 0% or 100%, where the unmodified Clopper–Pearson method was used. Results were suppressed if there were <25 assessments, to exclude unreliable estimates. As they are independent of each other, direct comparisons between GP, paediatrician and inpatient/ED were performed by chi-square tests using weighted data, where required; ED and inpatient records are related, so no comparisons were made. Statistical significance was computed for the difference between healthcare settings for the two bundles of care using F-test approximation of the Rao–Scott chi-square test, which adjusts for the design effect.

RESULTS

Participants

Details of the 881 children with one or more assessments of CPG adherence for asthma are provided in Table 1. Each child had between 1 and 14 asthma visits (median = 1). We did not collect information on child's insurance status as Australia has universal healthcare arrangements for all Australian residents. We also did not collect data on minority status or the socioeconomic status of the children.

Descriptive data

Of the 63 141 possible indicator assessments, 19 162 (30.3%) were automatically filtered out by age or

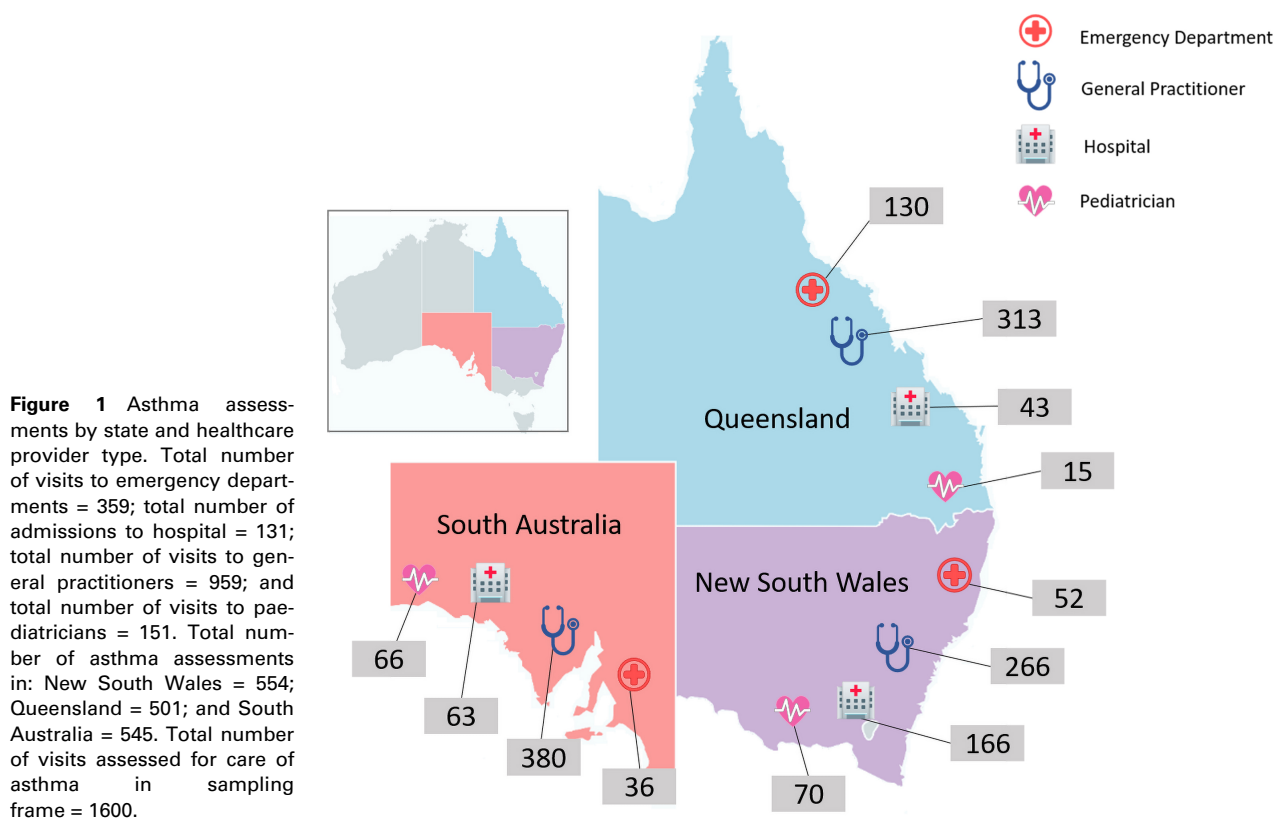


Table 1 Characteristics of children during 2012–2013

Characteristic	Children in the CTK Asthma Study
Age [†] , n (%)	
<6 years	492 (55.8)
<1 year	10 (1.1)
1 year	83 (9.4)
2 years	111 (12.6)
3–5 years	288 (32.7)
6–12 years	334 (37.9)
12–15 years	55 (6.2)
Male, n (%)	548 (62.2)

[†]Age was calculated as the age at visit for children with one visit, or the midpoint of the child's age at their first and last asthma visit.

CTK, CareTrack Kids.

healthcare setting restrictions, and 25 526 (40.4%) were designated by surveyors as not applicable. The main reason indicators were designated to be not applicable was that most indicators were targeted at subgroups of children with asthma. For example, ASTH07–09 were all restricted to children who were already on asthma medication; this could not be automated, so the surveyor manually designated these questions ineligible for assessment ('N/A') for children not on asthma medication.

The field team conducted 18 453 indicator assessments grouped into 1600 visits, at a median of 11 indicators per visit. Asthma indicator assessments were conducted in 76 GP and 19 paediatrician practices, 34 hospital ED and 30 hospital inpatient service providers.

Main results

The average guideline adherence of asthma care for the 39 indicators was 58.1% (95% CI: 53.7–62.5)⁸ with substantial variability across healthcare settings ranging from 54.4% for GP (95% CI: 46.0–62.5) to 85.1% for hospital inpatients (95% CI: 76.7–91.5) (Table 2).

Results by individual indicator are shown in Table 3; adherence is not reported for three indicators with insufficient data. Adherence ranged from 22.2% (95% CI: 14.9–31.1) for indicator ASTH02 to 100% (95% CI: 46.0–62.5) for ASTH15.

For 14 indicators related to acute asthma (ASTH01–04, ASTH10–16, ASTH33–34 and ASTH39), overall adherence was estimated as 56.3% (95% CI: 47.6–64.7); 49.8% (95% CI: 36.3–63.4) for GP, 64.0%

(95% CI: 46.7–78.9) for paediatricians, 90.6% (95% CI: 84.4–94.9) in ED and 94.6% (95% CI: 90.4–97.3) for inpatients.

The estimated adherence to two bundles of care is shown in Table 4. Bundle A assessed the recording of all four types of observations in children aged ≥2 years who presented with acute asthma and found 15.1% (95% CI: 8.7–23.7) adherence; the component indicator with the lowest adherence was documentation of the child's peripheral capillary oxygen saturation (SpO₂, 22.2%; ASTH02). The overall estimate was largely driven by low adherence by GP (3.2%), and obscures adherence rates above 80% in the two hospital settings ($P = 0.003$ compared to ED, and $P < 0.0001$ compared to inpatient settings).

Bundle B, assessed for children already prescribed asthma medication, appraised three items (i.e. reviewing patient compliance, inhaler technique and triggers) to be reviewed prior to commencing a new drug therapy, and estimated 20.5% (95% CI: 10.1–34.8) adherence; the component indicator with the lowest adherence was review of inhaler technique (25.3%; ASTH08). The difference in point estimates for adherence between GP (14.6%) and non-GP (40.6–53.4%) settings was substantial: GP versus paediatrician was statistically significant ($P = 0.04$), but GP versus ED ($P = 0.09$) and GP versus inpatient ($P = 0.054$) were not. There was no difference in the point estimates for adherence between paediatrician and ED ($P = 0.57$), and paediatrician and inpatient ($P = 0.85$) settings.

DISCUSSION

Our study provides comprehensive information on guideline adherence in providing ambulatory and inpatient care to children with asthma. Children received CPG-adherent care approximately 58% of the time, highlighting a large deficit between the actual care provided to children with asthma and appropriate care as recommended within CPG. Estimated adherence was lowest (54%) in primary care, where most preventive asthma care is provided.

Acute asthma attacks are among the most common causes of paediatric hospital presentations and unscheduled visits to clinicians.¹⁵ Our study demonstrated marked variation in the management of acute asthma, which has been previously documented in ED⁴ and paediatric respiratory unit settings.³ Recording of vital signs including conscious level, oxygen saturation, pulse rate and work of breathing in children with acute

Table 2 Guideline adherence by healthcare setting during 2012–2013

Healthcare setting	No. of children	No. of visits	No. of indicators	Proportion adherent, % (95% CI)
General practitioner	519	959	10 954	54.4 (46.0–62.5)
Paediatrician	105	151	1179	77.7 (40.5–97.0)
Emergency department	244	359	4529	79.9 (70.6–87.3)
Hospital	98	131	1791	85.1 (76.7–91.5)
Overall [†]	881	1600	18 453	58.1 (53.7–62.5)

[†]This result has been previously reported.⁸

Table 3 Quality of care by clinical indicator during 2012–2013

Indicator ID	Indicator description	No. of children	No. of visits	Proportion adherent, % (95% CI)
ASTH01	Children aged ≥ 2 years who presented with an acute exacerbation of asthma had their conscious level documented	471	763	54.8 (36.4–72.2)
ASTH02	Children aged ≥ 2 years who presented with an acute exacerbation of asthma had their SpO ₂ recorded	471	761	22.2 (14.9–31.1)
ASTH03	Children aged ≥ 2 years who presented with an acute exacerbation of asthma had their pulse rate recorded	471	761	32.2 (15.3–53.5)
ASTH04	Children aged ≥ 2 years who presented with an acute exacerbation of asthma had their work of breathing assessed	471	762	73.5 (57.9–85.8)
ASTH05	Children who presented with symptoms that were suggestive of persistent asthma were prescribed a trial of salbutamol, LTRA, cromones or inhaled steroid (not an FDC)	205	251	81.5 (68.1–91.0)
ASTH06	Children who presented with symptoms that were suggestive of persistent asthma and were commenced on a trial of salbutamol, LTRA, cromones or inhaled steroid (not an FDC) had their response assessed within 3 months	183	223	80.3 (68.3–89.3)
ASTH07	Children with asthma already prescribed medication were reviewed for compliance with existing therapies prior to commencing a new drug therapy	528	807	70.7 (60.6–79.5)
ASTH08	Children with asthma already prescribed medication had their inhaler technique checked prior to commencing a new drug therapy	527	800	25.3 (10.9–45.0)
ASTH09	Children with asthma already prescribed medication had their trigger factors documented prior to commencing a new drug therapy	539	820	61.0 (52.3–69.2)
ASTH10	Children aged < 2 years who presented with an acute exacerbation of asthma were not prescribed an oral β_2 agonist	65	108	92.1 (82.2–97.5)
ASTH11	Children aged ≥ 2 years who presented with a mild/moderate exacerbation of asthma were prescribed an inhaled β_2 agonist via a spacer	516	809	56.0 (36.1–74.6)
ASTH12	Children aged ≥ 2 years who presented with a severe exacerbation of asthma were prescribed an inhaled β_2 agonist via an oxygen-driven nebulizer	83	114	62.3 (42.8–79.3)
ASTH13	Children aged ≥ 2 years with life-threatening asthma or an SpO ₂ $< 95\%$ received supplemental oxygen	48	78	38.8 (17.3–64.1)
ASTH14	Children aged ≥ 2 years who presented with an acute exacerbation of asthma where there was no response to initial treatment were prescribed ipratropium bromide (250 μg via inhalation)	114	183	41.9 (17.5–69.5)
ASTH15	Children aged > 2 years who presented with an acute mild/moderate exacerbation of asthma were not prescribed aminophylline	450	712	100 (99.5–100)
ASTH16	Children aged > 2 years who presented with an acute exacerbation of asthma and who received antibiotics had another condition requiring antibiotic therapy	119	150	47.1 (33.4–61.1)
ASTH17	Children aged < 5 years with intermittent asthma were prescribed short-acting β_2 agonist (inhaled)	342	616	82.5 (69.3–91.7)
ASTH18	Children aged < 5 years with intermittent asthma were not prescribed an oral short-acting β_2 agonist	335	606	97.8 (91.8–99.8)
ASTH19	Children aged 5–12 years with intermittent asthma were prescribed short-acting β_2 agonist (inhaled)	355	560	88.9 (84.1–92.6)
ASTH20	Children aged 5–12 years with intermittent asthma were not prescribed oral short-acting β_2 agonists	350	548	97.1 (87.7–99.8)
ASTH21	Children aged 5–12 years with frequent intermittent asthma who required regular preventer medication were prescribed an LTRA, or cromone or low-dose ICS	133	196	64.6 (41.1–83.8)
ASTH22	Children aged 5–12 years with frequent intermittent asthma who required regular preventer medication were not prescribed an FDC	128	192	66.2 (47.8–81.6)
ASTH23	Children aged 5–12 years with persistent poorly controlled asthma were prescribed inhaled steroids	47	65	69.5 (46.1–87.3)
ASTH24	Children aged 5–12 years with persistent poorly controlled asthma requiring the maximum dose of inhaled steroids were referred to a specialist	14	18	Insufficient data

Table 3 Continued

Indicator ID	Indicator description	No. of children	No. of visits	Proportion adherent, % (95% CI)
ASTH25	Children with asthma prescribed inhaler medication received training on how to use the inhaler device	636	1013	27.8 (18.2–39.2)
ASTH26	Children with asthma prescribed inhaler medication had their technique reassessed within 6 months	699	1223	24.6 (14.1–38.0)
ASTH27	Children aged <5 years with asthma who required regular preventer medication were prescribed a LTRA	188	371	24.1 (10.6–42.7)
ASTH28	Children aged <5 years with asthma who required regular preventer medication were prescribed a low-dose ICS	196	381	66.4 (45.6–83.4)
ASTH29	Children aged 5–12 years with asthma that was not controlled with an LTRA and who required a preventer medication were prescribed a trial of a low-dose ICS	103	167	68.3 (50.8–82.6)
ASTH30	Children aged 5–12 years with asthma that was not controlled with a low-dose ICS and who required a preventer medication were prescribed a trial of a moderate-dose ICS	65	97	41.0 (9.5–79.5)
ASTH31	Children aged 5–12 years with asthma who required continuous or frequent use of oral steroids were prescribed a daily steroid tablet at the lowest dose	38	55	69.4 (33.2–93.4)
ASTH32	Children aged 5–12 years with asthma who required continuous or frequent use of oral steroids were referred to a respiratory paediatrician	29	43	47.3 (5.4–92.7)
ASTH33	Children aged <6 years who presented to a primary care setting with an acute exacerbation of asthma and had not improved after 4–6 puffs of a β_2 agonist were transferred urgently to hospital	9	9	Insufficient data
ASTH34	Children aged ≥ 6 years who presented to a primary care setting with an acute exacerbation of asthma and had not improved after 8–12 puffs of a β_2 agonist were transferred urgently to hospital	2	2	Insufficient data
ASTH35	Children with asthma prescribed preventer medication had their asthma control assessed at least every 6 months	548	999	75.7 (63.8–85.3)
ASTH36	Children with asthma prescribed preventer medication were assessed for side effects at least every 6 months	546	993	39.0 (28.3–50.5)
ASTH37	Children with asthma prescribed preventer therapy had a medical review at least every 6 months	551	1002	83.2 (76.3–88.7)
ASTH38	Children with asthma prescribed preventer therapy had a written asthma action plan	592	1070	46.5 (38.4–54.8)
ASTH39	Children discharged from hospital after an acute asthma episode had a written asthma action plan	94	125	91.5 (85.2–95.8)

FDC, inhaled fixed-dose combination of steroid and long-acting beta agonist; ICS, inhaled corticosteroid; LTRA, leukotriene receptor antagonist; SpO₂, peripheral capillary oxygen saturation.

asthma in our survey was inadequate; only 20% of children with an acute asthma attack had their oxygen saturation and pulse rate recorded at GP. These findings have significant clinical implications as assessment of vital signs for severity of disease plays an important role in prompt initiation of appropriate treatment. Previous studies have also noted that adherence with asthma management guidelines were lower for GP compared to specialists.^{12,13} Low compliance with asthma management guidelines in primary care setting is linked to GP perception of the usefulness of all items in asthma management guidelines,¹⁴ suggesting that strategies to improve guidelines acceptance through iterative consultative process may improve adherence among GP.

There was a marked variation in pharmacological treatment of acute asthma; for example, adherence with use of inhaled β_2 agonist via oxygen-driven nebulizer for severe exacerbation of asthma was estimated

to be 62.3% (ASTH12; inhaled β_2 agonist via an oxygen-driven nebulizer for severe asthma exacerbation). This treatment has been emphasized as the standard for severe or life-threatening asthma as use of nebulized β_2 agonist with air was linked with the death of a child in the UK.¹⁶ Asthma CPG do not recommend use of nebulizers in mild or moderate asthma flare-ups; use of spacers is clinically more effective in terms of reduced stay in the ED and is more cost-effective.¹⁷ We also found that almost half of the children with asthma who were prescribed antibiotics did not have another condition that required antibiotics (ASTH16; use of antibiotics for acute asthma exacerbation). This finding concurs with other studies suggesting that children with acute asthma are more likely to be inappropriately prescribed antibiotics that are not indicated in the management of acute asthma attacks.¹⁸

Personalized guidance for managing asthma symptoms, through a written action plan, is essential to

Table 4 Quality of care by bundle of care and for each component indicator[†] during 2012–2013

Bundle ID	Description	Indicator ID	Healthcare setting	No. of children	No. of visits [‡]	Proportion adherent, % (95% CI)
A	Children aged >2 years who presented with an acute exacerbation of asthma had appropriate observations recorded	ASTH01–ASTH04	GP	250	360	3.2 (1.1–7.3)
			Paediatrician	7	7	Insufficient data
			ED	201	293	82.2 (64.3–93.6)
			Inpatient	79	100	93.0 (79.8–98.7)
			Overall	470	760	15.1 (8.7–23.7)
	Bundle A: Component indicators Children aged ≥2 years who presented with an acute exacerbation of asthma had their conscious level documented	ASTH01	GP	250	360	49.1 (20.9–77.7)
			Paediatrician	7	7	Insufficient data
			ED	201	293	91.0 (82.9–96.1)
			Inpatient	79	100	95.3 (87.1–98.9)
			Overall	470	760	55.2 (37.0–72.5)
	Children aged ≥2 years who presented with an acute exacerbation of asthma had their SpO ₂ recorded	ASTH02	GP	250	360	8.9 (6.2–12.3)
			Paediatrician	7	7	Insufficient data
			ED	201	293	96.9 (82.5–100)
			Inpatient	79	100	100 (96.4–100)
			Overall	470	760	22.2 (14.9–31.1)
	Children aged ≥2 years who presented with an acute exacerbation of asthma had their pulse rate recorded	ASTH03	GP	250	360	20.4 (4.4–48.9)
			Paediatrician	7	7	Insufficient data
			ED	201	293	99.9 (98.5–100)
			Inpatient	79	100	100 (96.4–100)
			Overall	470	760	32.3 (15.3–53.5)
	Children aged ≥2 years who presented with an acute exacerbation of asthma had their work of breathing assessed	ASTH04	GP	250	360	70.4 (39.2–91.7)
			Paediatrician	7	7	Insufficient data
			ED	201	293	90.8 (73.0–98.5)
			Inpatient	79	100	95.9 (83.8–99.7)
			Overall	470	760	73.6 (58.0–85.8)
B	Children with asthma already prescribed medication were reviewed prior to commencing a new drug therapy	ASTH07–ASTH09	GP	296	457	14.6 (2.0–42.4)
			Paediatrician	59	67	49.4 (5.7–93.9)
			ED	144	198	40.6 (20.6–63.2)
			Inpatient	49	60	53.4 (22.9–82.1)
			Overall	514	782	20.5 (10.1–34.8)
	Bundle B: Component indicators Children with asthma already prescribed medication were reviewed for compliance with existing therapies prior to commencing a new drug therapy	ASTH07	GP	296	457	64.2 (50.7–76.1)
			Paediatrician	59	67	99.6 (94.0–100)
			ED	144	198	83.9 (69.2–93.4)
			Inpatient	49	60	92.9 (80.2–98.6)
			Overall	514	782	69.3 (59.5–78.0)
	Children with asthma already prescribed medication had their inhaler technique checked prior to commencing a new drug therapy	ASTH08	GP	296	457	20.3 (2.9–54.4)
			Paediatrician	59	67	49.4 (5.7–93.9)
			ED	144	198	42.7 (22.3–65.1)
			Inpatient	49	60	55.4 (25.1–83.0)
			Overall	514	782	25.3 (10.9–45.3)
	Children with asthma already prescribed medication had their trigger factors documented prior to commencing a new drug therapy	ASTH09	GP	296	457	54.9 (42.2–67.1)
			Paediatrician	59	67	90.5 (73.5–98.2)
			ED	144	198	79.0 (54.3–94.0)
			Inpatient	49	60	86.4 (66.5–96.8)
			Overall	514	782	60.5 (52.4–68.2)

[†]Component indicator data restricted to visits where all component indicators had Yes/No responses. Thus, 'overall' estimate for the component indicators may differ marginally from the indicator data presented in Table 3.

[‡]There were 765 visits with one or more indicators from bundle A assessed, of which 760 (99.3%) had responses to all four component indicators and could be included in the analysis. For bundle B, there were 835 visits with one or more component indicators assessed, of which 782 (93.7%) had responses to all indicators and could be included in the analysis.

ED, emergency department; GP, general practice; SpO₂, peripheral capillary oxygen saturation.

improve asthma control.⁶ Having a written asthma action plan can significantly reduce the risk of ED visits due to asthma attacks¹⁹ and fatal asthma.⁶ Reassuringly, over 90% of children with acute asthma episodes in our study had a written asthma action plan on discharge

from a hospital inpatient stay (ASTH39; asthma action plan provided after discharge from hospital); however, less than half of the children who were prescribed a preventer had a written asthma action plan (ASTH38; written asthma action plan).

Adherence for all three indicators assessing intermittent asthma (ASTH17-20; children with intermittent asthma prescribed inhaled short-acting β_2 agonists) was >80%. In our survey, children with infrequent asthma were not inappropriately on regular preventer therapy. Infrequent or intermittent asthma is the most common type in children,²⁰ and regular use of preventer therapy is not recommended.²¹ Guideline adherence for children with persistent asthma (ASTH05-06; commenced on trial of salbutamol, leukotriene receptor antagonist (LTRA), cromones or inhaled steroid and had response assessed within 3 months) was also high (~80%) in our study across all healthcare settings, which has been documented previously.²² Conversely, >30% of children with poorly controlled persistent asthma (ASTH23; not prescribed inhaled steroids), or whose asthma required regular preventer medication (ASTH28; required regular use of low dose of inhaled steroids), were not managed appropriately.

Although low-dose inhaled corticosteroids can improve asthma-related symptoms and morbidity in children with persistent asthma, previous studies in Australia and the United States have reported that only 20–40% of children who required maintenance therapy were prescribed inhaled corticosteroids.^{22,23} The pattern of asthma symptoms indicating level of control guides management of asthma in children and requires a step-up and step-down approach.²⁴ Our data suggest that there is likely a need to increase clinician awareness of the different categories of asthma and the need to change treatment modalities according to symptoms. Fewer than 30% of children with persistent asthma received training on inhaler techniques (ASTH25; training on how to use inhaler device) or had their inhaler technique reassessed (ASTH26; assessment of inhaler technique). This is consistent with a report from Sweden where only 14% of children with asthma attending primary care received a demonstration of inhalation techniques.²⁵ The first National Review of Asthma Deaths in UK, published in 2015, has identified appropriate regular assessment and documentation of inhaler technique by healthcare professionals as one of the key factors associated with improved care for people with asthma.⁶

Limitations

This study was based on medical record review and it is possible for discrepancies between the care documented, and the actual care provided. This method of assessing adherence has been utilized previously,⁷ and it has been estimated that this could manifest as a 10% point underestimate of adherence.²⁶ The low recruitment rates for GP and paediatricians, around 25%, create the possibility of bias due to self-selection; for example, participating providers could be more likely to provide guideline-adherent care. The study had a large sampling frame covering 60% of the Australian paediatric population that allowed for the assessment of guideline adherence at scale. The study did not investigate clinicians' familiarity with, or knowledge of, existing guidelines and did not assess which guidelines, if any, were used by them. The Australian Asthma Handbook developed by National Asthma Council is widely available and easily accessible through the internet.

Although our study was undertaken in the Australian setting, our results were comparable to findings from studies carried out in other high-income settings and may be generalizable to other similar healthcare settings. Our study has provided a comparative analysis of clinical care for paediatric asthma across different healthcare settings in Australia and identified areas where there is variation from CPG. The results have identified important areas for improvement including: the management of acute asthma, appropriate prescribing of inhaled corticosteroids when indicated, use of written asthma action plans and assessment of inhaler techniques, across different healthcare settings, but most marked in primary care. Studies have suggested lack of familiarity and lack of awareness of CPG as potential barriers to their use.²⁷ Initiatives to improve systematic implementation of CPG, such as a system to monitor adherence to guidelines,⁵ use of opinion leaders to promote CPG use²⁸ and reminder cards²⁹ or evidence-based asthma management protocols at the point of care, may improve adherence.³⁰ In conclusion, the findings of this study provide comprehensive baseline assessment of paediatric asthma care across the entire patient journey (i.e. all phases of care) and among different healthcare settings. The data from this study can help prioritize, target, implement and evaluate interventional initiatives to optimize health care for children with asthma.

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Abbreviations: CPG, clinical practice guideline; CTK, CareTrack Kids; ED, emergency department; FDC, inhaled fixed-dose combination of steroid and long-acting beta agonist; GP, general practice; ICS, inhaled corticosteroid; LTRA, leukotriene receptor antagonist; SpO₂, peripheral capillary oxygen saturation.

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Supplementary Information

Additional supplementary information can be accessed via the *html* version of this article at the publisher's website.

Table S1 Detailed information on each asthma indicator.

Table S2 Characteristics of asthma exacerbations (acute and sub-acute) and worsening of asthma control.

Appendix S1 Additional details relating to study methods.

Appendix S2 Guidance and definitions provided for CareTrack Kids Asthma medical record assessments (extract from surveyor's manual).

Visual Abstract Assessing appropriateness of paediatric asthma management: A population-based sample survey.