

Accuracy of asthma treatment in schoolchildren in NSW, Australia

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ABSTRACT: Insufficient use of anti-inflammatory drugs, such as inhaled corticosteroids and cromoglycate, may contribute to the disease burden associated with asthma. Conversely, aggressive treatment of mild disease may result in avoidable costs and/or adverse drug effects. The aim of this study was to determine the relationship between asthma severity and inhaled corticosteroid/cromoglycate use in a large (n=4,909) random sample of children, aged 8–11 yrs, in NSW, Australia.

Asthma and its treatment were assessed by questionnaire responses. Asthma, defined as diagnosis plus current wheeze, was present in 901 children (18% of the sample), of whom 225 (5%) had moderate asthma, defined as asthma plus additional symptoms (sleep disturbance), utilization (hospital, casualty), or disability (reduced activity, school absence). Use of inhaled corticosteroid/cromoglycate was reported by 636 children (13% of the sample). Determinants of use included: asthma diagnosis, current wheeze, and troublesome dry nocturnal cough. There was also a strong relationship between anti-inflammatory treatment and a multicomponent asthma severity score constructed for each child.

Inhaled corticosteroids and/or cromoglycate were used by 56% of the children with asthma (24% daily) and by 76% of children with moderate asthma (42% daily). Undertreatment, defined as less than daily inhaled corticosteroids/cromoglycate in moderate asthma, was identified in 130 children (14% of those with asthma or 3% of the sample). Conversely, apparently aggressive treatment, defined as inhaled corticosteroid/cromoglycate use in children with persistent minimal symptoms (asthma severity score of less than 3) was identified in 101 children (2% of the sample).

Although there were significant differences between regions in the choice of anti-inflammatory drugs and in the prevalence both of undertreatment and apparently aggressive treatment, there was no clear relationship to regional utilization of emergency and hospital services for asthma. Nevertheless, the frequency of undertreatment suggests an opportunity to reduce asthma morbidity by more consistent application of current therapeutic guidelines.

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Asthma is common in Australia, particularly in children. In recent Australian surveys, the rate of wheezing in the past 12 months (current wheeze) has been 20–40% of children [1–4], and the prevalence of current asthma has been estimated at about 10–15% [4]. Asthma prevalence has increased over the past decade [3, 5, 6], and the condition is now associated with substantial morbidity [4] and health care costs [7, 8]. In recognition of these trends, considerable effort has been devoted to the development and dissemination of detailed asthma management plans [9–12], based on the reasonable assumption that widespread adoption of such protocols will improve asthma outcomes and/or reduce the costs of care.

If a consensus management plan is adopted uniformly, its impact will be reduced if the regimen is not always effective or if patient compliance is low. However, before effectiveness and compliance can be assessed, the denominator, *i.e.* the number of asthmatics in whom the regimen will be newly implemented, must be known. This requires knowledge both of the previous practice

patterns (*i.e.* the "baseline" prevalence of suboptimal management in the asthmatic population) and the "market penetration" of the new approach (*i.e.* the number of previously undertreated asthmatics in whom the new regimen has been adopted). The latter is particularly pertinent in view of uncertainties about the degree to which guidelines influence practice patterns [13, 14].

Studies in Australia [15], as well as in other countries such as Finland [16], suggest that undertreatment of childhood asthma is common. On the other hand, increased community and physician awareness of asthma and its treatment may have resulted in unnecessarily aggressive treatment of some children with minimal asthma. Such treatment would constitute an avoidable cost and would confer unnecessary risks on the recipients.

In 1992 and 1993, information about the use of inhaled corticosteroids and cromoglycate was collected from large random samples of children living in five regions of New South Wales [4]. The use of these "anti-inflammatory" medications is recommended only for children

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with asthma of at least moderate severity [10–12]. In this paper, the factors which influenced the use of anti-inflammatory medications in the survey populations were assessed, and the prevalence both of undertreatment and apparently aggressive treatment with these drugs was estimated.

Methods

Survey population

The original survey [4] comprised seven regions of New South Wales. Approval for the survey was obtained from the Ethics Committees of the University of Sydney and Royal Prince Alfred Hospital. In each region, all primary schools were included in the sampling frame and were chosen at random. Children in years 3, 4 and 5 (aged 8–11 yrs), whose parents had given informed consent, participated. In the current study, surveys of five regions (coastal Sydney, western Sydney, Belmont, Broken Hill and Wagga Wagga) were chosen for further analysis because these regions constitute a spectrum of geographic location, climate and socioeconomic status. Surveys of these regions had been conducted during 1992 and 1993. The total sample size was 4,909 children.

Questionnaires

Questionnaires completed by parents were used to collect details of the respiratory symptoms, disability, health care utilization and medication use. These questions have good repeatability [17].

Definitions

Each child in the sample was assigned to one of three groups: 1) "asthma", if both a diagnosis of asthma by a physician or hospital and wheezing, at rest or after exercise, in the past year were reported; 2) "possible asthma" if either pertinent respiratory symptoms within the past year (wheezing, exercise wheezing, or a troublesome cough at night lasting more than 2 weeks) without a diagnosis of asthma, or a diagnosis of asthma, with or without cough, but without current wheezing (at rest or after exercise) were reported; and 3) "no asthma", being the remainder of the sample.

The asthma group was further divided into two subgroups: mild and moderate asthma. Moderate asthma was defined by the presence of: additional symptoms (sleep disturbance by wheezing on most nights); disability (activity limitation by wheezing on most days, or school absence for more than a week because of asthma or wheezing); or health care utilization (casualty visit or hospitalization for breathing problems within the past year). The remainder of the asthma group was classified, by exclusion, as having mild asthma.

Asthma severity score

For all children in the "asthma" and "possible asthma" groups, an asthma severity score was calculated, with

Table 1. – Criteria and points assigned in calculation of the asthma severity score

Criterion	Points
Diagnosis	1
Wheezing >12 times-yr ⁻¹	1
Persistent troublesome night cough	1
Decreased activity some days	1
Disturbed sleep some nights	2
School absence some days	2
Decreased activity most days	6
Disturbed sleep most nights	6
School absence >1 time-week ⁻¹	6
Casualty visit in past year	6
Hospitalization in past year	6

points assigned for symptoms, asthma diagnosis, disability and emergency health care utilization (table 1). Sleep disturbance and school absence were considered more important than reduced activity, and were therefore assigned two points. Each of the reference criteria for moderate asthma was assigned six points.

Statistical methods

The Statistical Analysis System (SAS) package [18] was used to analyse the data. The significance of differences in mean proportions was determined by Chi-squared statistic, with a p-value less than 0.05 considered significant. To determine the relative impact of various factors on treatment, a forward logistic regression model was constructed with trial insertion of each potential variable of interest. Adjusted odds ratios (AORs) with 95% confidence intervals (95% CIs) were calculated for those factors which contributed significantly to the model.

Results

Prevalence and treatment of asthma

As shown in table 2, 901 children, constituting 18% of the sample, were classified as having asthma. Of these, 225 children, corresponding to 25% of the asthma group or 5% of the sample, had moderate asthma. An additional 1,193 children, constituting 24% of the sample, were classified as having possible asthma. Use of inhaled corticosteroids or cromoglycate was reported for 10% of

Table 2. – Asthma prevalence and treatment

Group	Prevalence n (% sample)	Treated# n (% group)	Daily use n (% group)
Possible asthma			
Symptoms only	641 (13)	27 (4)	4 (1)
Diagnosis only	552 (11)	94 (17)	20 (4)
Total	1193 (24)	121 (10)	24 (2)
Asthma			
Mild	676 (14)	339 (50)	122 (18)
Moderate	225 (5)	170 (76)	95 (42)
Total	901 (18)	509 (56)	217 (24)

#: use of inhaled corticosteroids or cromoglycate.

children with possible asthma, 56% of children with asthma, and 76% of children with moderate asthma. Daily use was confined to 2% of children with possible asthma, 24% of children with asthma, and 42% of children with moderate asthma.

The prevalence of asthma varied significantly ($p < 0.001$) between regions: 16% in western Sydney, 17% in coastal Sydney, 18% in Wagga Wagga, 20% in Broken Hill, and 22% in Belmont. The prevalence of moderate asthma also varied significantly ($p < 0.01$) between regions, but in this case the 8% prevalence in Broken Hill significantly ($p < 0.05$) exceeded that of all other regions (3% in western and coastal Sydney, 5% in Wagga Wagga and 5% in Belmont).

The proportion of children using inhaled corticosteroids or cromoglycate varied significantly ($p < 0.01$) between regions in children with mild asthma, ranging from 75 out of 179 (42%) in coastal Sydney to 74 out of 121 (61%) in western Sydney. Daily use of these drugs also varied substantially between regions in children with mild asthma ($p < 0.01$), ranging from 12 out of 111 (11%) in Wagga Wagga to 30 out of 101 (30%) in Broken Hill. There were no regional variations in the anti-inflammatory drug treatment proportions for children with moderate asthma.

Factors influencing anti-inflammatory drug treatment

Figure 1 shows that the reported use of anti-inflammatory drugs was not confined to the asthma group. Use of inhaled corticosteroids or cromoglycate was uncommon (0.2%) in the group with no asthma. However, use of these drugs was reported in both of the subgroups constituting the possible asthma group: 4% of children with symptoms compatible with asthma but no asthma diagnosis, and 18% of those with an asthma diagnosis but no current wheezing. Figure 1 also shows the relationship between treatment and report of a troublesome

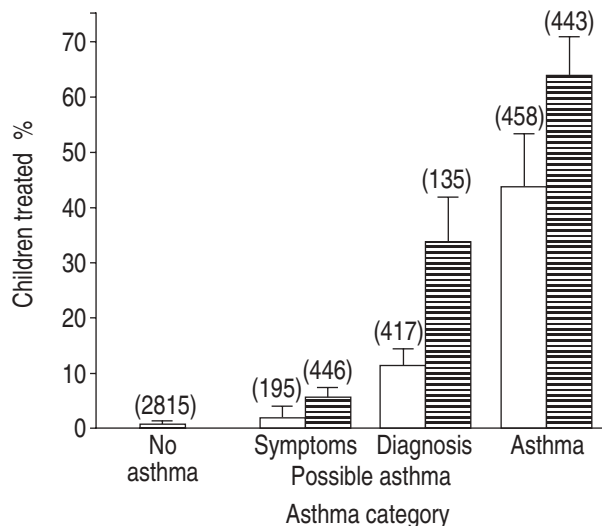


Fig. 1. — The use of anti-inflammatory drugs in children with no asthma, possible asthma (two subgroups, with either symptoms only or diagnosis only) and asthma. The number in each group is shown in parenthesis. Each group is divided into children with (■) or without (□) persistent troublesome dry night cough, with the bars indicating 95% confidence intervals.

dry night cough lasting more than 2 weeks. A significantly greater proportion of children with this symptom used anti-inflammatory drugs both in the asthma group ($p < 0.001$) and the subgroup with diagnosed asthma but no current wheeze ($p < 0.001$).

The independent association of various factors with use of anti-inflammatory drugs was examined by logistic regression. The most powerful association was with a diagnosis of asthma. Children with diagnosed asthma were 24.2 times more likely (95% CI, 16.6–35.5) to receive treatment than those without this diagnosis. The next most powerful predictor was current wheezing (AOR 3.5; 95% CI 2.6–4.8). The third factor selected in the logistic regression was persistent cough (AOR 2.4; 95% CI 1.9–3.0). Urgent doctor visits, school absence and current exercise wheezing, in that order, also made significant contributions to the model.

To evaluate the relationship between asthma severity and treatment with anti-inflammatory drugs, a composite asthma severity score (table 1) was calculated for each child in the asthma and possible asthma groups. The mean score for the asthma group was 7.1, compared with 1.9 for the possible asthma group. Within the asthma group, those with moderate asthma had a mean score of 14.3, indicating the presence, on average, of severity markers in addition to the reference criterion leading to the classification as moderate. There was a clear relationship between the severity score and the proportion receiving anti-inflammatory drugs (fig. 2). Only 9% of children with severity scores of 0–2 received inhaled corticosteroids or cromoglycate, whereas 84% of those with scores > 14 received one or both of these drugs, and 53% did so on a daily basis.

The relationship is further illustrated by the calculation of AORs for the use of anti-inflammatory drugs, as a function of the asthma severity score. For children with scores of 3–6, the AOR, *i.e.* the relative likelihood of receiving inhaled corticosteroids or cromoglycate, was 7.3 (95% CI 5.6–9.6), and for those with scores of ≥ 7 (including all those with moderate asthma), the AOR was 22.1 (95% CI 16.5–29.6). Each point in the severity score corresponded to an AOR of 1.60 (95% CI 1.55–1.65).

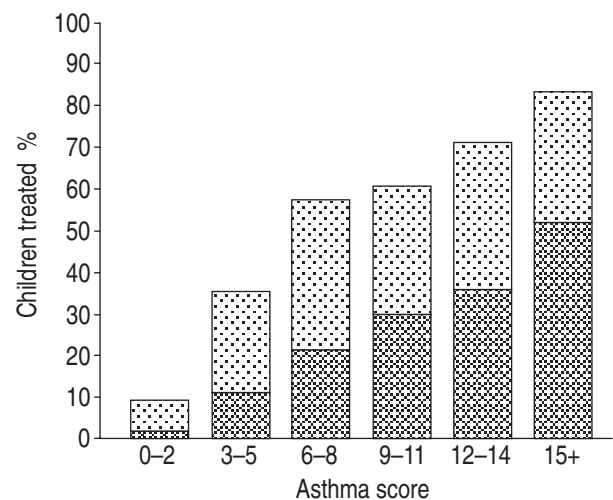


Fig. 2. — The relationship between the proportion of children receiving any (□) and daily (■) treatment with cromoglycate and/or inhaled corticosteroids and the asthma severity score among children with asthma or possible asthma.

Drug choice

Use of inhaled corticosteroids substantially exceeded that of cromoglycate. Of the 636 children (13% of the sample) for whom use of one or both of these drugs was reported, 65% (8% of the sample) received corticosteroids alone, compared with cromoglycate alone in 20%, and both in 15%. Among the 242 children (5% of the sample) for whom daily use of one of these drugs was reported, the proportion receiving corticosteroids was even greater: 67% corticosteroids only, 10% cromoglycate only, and 23% both.

The proportions of drug types used did not differ among children with persistent cough. However, as shown in figure 3, the selection of anti-inflammatory drug differed significantly between mild and moderate asthma ($p < 0.001$), with combined therapy reported for 25% of chil-

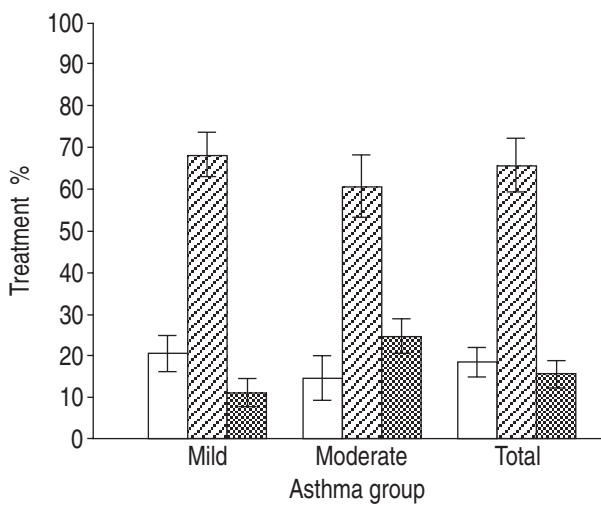


Fig. 3. — The proportion (expressed as a percentage) of those children using inhaled anti-inflammatory medications receiving cromoglycate (□), corticosteroid (▨), or both (▩), in mild and moderate asthma. The bars indicate 95% confidence intervals.

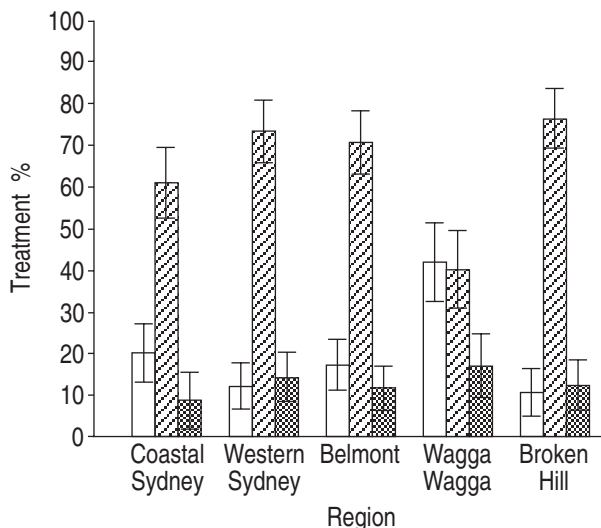


Fig. 4. — The use of cromoglycate (□), inhaled corticosteroid (▨), or both (▩), in coastal Sydney, Western Sydney, Belmont, Wagga Wagga and Broken Hill. The number receiving a particular drug or combination is expressed as a percentage of the total receiving any anti-inflammatory medication. The bars indicate 95% confidence intervals.

dren with moderate asthma, compared with 11% of those with mild asthma.

Figure 4 shows that the pattern of use varied ($p < 0.001$) between regions. In Wagga Wagga, use of cromoglycate, with or without corticosteroid, was reported for 60% of children receiving anti-inflammatory therapy, compared with corticosteroids (with or without cromoglycate) in 58%. This was in contrast to Broken Hill where corticosteroids, with or without cromoglycate, were used by 87% of those receiving drugs, whereas cromoglycate was used by only 24%. The proportions of drug types used in other regions resembled those of the Broken Hill region, *i.e.* the predominant use of inhaled corticosteroids. Thus, the proportion receiving cromoglycate in Wagga Wagga was significantly greater ($p < 0.01$) than in any other region.

Undertreatment

Estimates of the rates of undertreatment are shown in table 3. The estimate depended on the stringency of the undertreatment definition. Restriction of the definition to those children with moderate asthma not receiving any anti-inflammatory drugs led to the lowest estimate: 55 children, corresponding to 6% of the asthma group and 1% of the total sample. Defining undertreatment as the absence of daily inhaled corticosteroids and/or cromoglycate in children with an asthma score of >6 led to the highest estimate: 255 children (28% asthma group, 5% of the sample). Use of an intermediate definition of undertreatment, namely lack of daily inhaled corticosteroids or cromoglycate in children with moderate asthma, yielded an estimate of 138 children (14% asthma group, 3% of the sample).

The proportion of children with moderate asthma who were undertreated did not differ significantly between regions, whereas the absolute prevalence of undertreatment varied significantly ($p < 0.01$), from 2% of the sample in western Sydney to 4% of the sample in Broken Hill, reflecting the different prevalence of moderate asthma in those regions. Reported utilization of emergency medical services tended to be higher in regions with higher prevalence of undertreatment (figure 5a).

Apparently aggressive treatment

To evaluate the rate of apparently aggressive treatment, the number of children with low asthma scores using inhaled corticosteroids and/or cromoglycate was determined. As for undertreatment, the prevalence estimate depended on the stringency of the definition, ranging from 70 children (7% of the group, 11% of all treated children, 1% of the sample) if only those with scores of 0–1 were included, to 138 children (12% of the group,

Table 3. — Undertreatment

	n	Not treated n (% group)	Not treated daily n (% group)
Moderate	225	55 (24)	130 (58)
Score >6	397	113 (28)	255 (64)

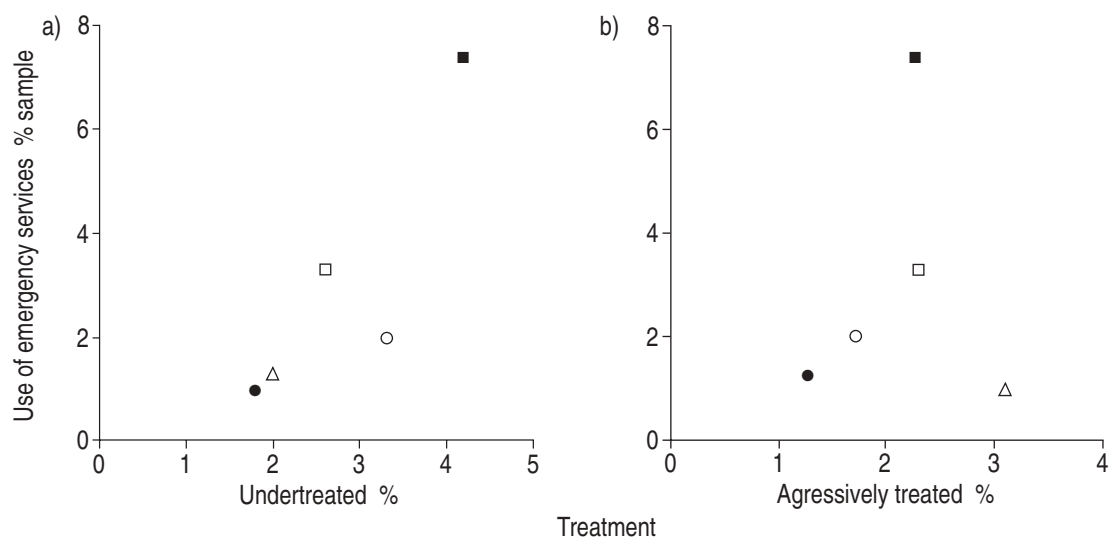


Fig. 5. — Regional patterns of asthma treatment with anti-inflammatory drugs and utilization of emergency medical service. The two panels show the relationship between the percentage of children utilizing hospital and/or emergency departments within the past year and the percentage of children in that region classified as: a) undertreated; or b) aggressively treated. ● : Coastal Sydney; △ : Western Sydney; ○ : Belmont; □ : Wagga Wagga; ■ : Broken Hill.

Table 4. — Aggressive treatment

Score	n	Treated (%)
0	131	6 (5)
1	808	64 (8)
2	143	31 (22)
3	125	37 (30)

22% of all treated children, 3% of the sample) if children with scores in the range 0–3 were included (table 4). The use of an intermediate definition of apparently aggressive treatment, namely inhaled corticosteroid and/or cromoglycate use in the group of children with scores in the range 0–2, yielded an estimate of 101 children (9% of this group, 16% of all treated children, 2% of the sample). There was no relationship between the regional rate of aggressive treatment and the reported use of emergency services (fig. 5b).

Discussion

We analysed the factors influencing treatment with anti-inflammatory drugs in a large random population sample of Australian children. By matching treatment details to an asthma severity estimate based on multiple questionnaire criteria, we found that 3% of the children in this sample were receiving a less intensive asthma regimen than is currently recommended. Conversely, use of inhaled corticosteroids and/or cromoglycate was reported for 13% of the total sample, and the analyses suggest that this treatment was apparently aggressive for at least 16% of those receiving it, *i.e.* 2% of the total sample.

Children were classified as having asthma if both diagnosed asthma and current wheezing were reported. This definition was chosen because both the component criteria represent information available to the local practitioner at the time that drug therapy is initiated. Use of this definition yielded an asthma prevalence of 18%. This

is somewhat higher than our previous estimate (11%) from the same sample [4], in which current asthma was defined as current wheezing plus measured airway hyperresponsiveness. We decided not to use airway hyperresponsiveness as an asthma criterion in this analysis, since this information was not available to the practitioner at the time of treatment allocation, and since the relationship between airway responsiveness and asthma severity in individual subjects is inexact [19, 20] and varies over time [21].

Patterns of use of anti-inflammatory medications (inhaled corticosteroids and cromoglycate) were examined because there are explicit recommendations concerning their use in asthma [9–12], because their administration is controlled by physicians and there is good evidence of their efficacy in the treatment of asthma [22–26]. Asthma is not the only condition for which these drugs are prescribed. Nevertheless, in this population, 509 of the 636 children receiving inhaled corticosteroids and/or cromoglycate were in the asthma group, and all but six met at least one of the two criteria for asthma (*i.e.* diagnosis or current wheezing). The "diagnosis" criterion was more strongly associated with anti-inflammatory drug use than was the "current wheezing" criterion, suggesting a physician tendency to assign a diagnostic label of asthma at the time of prescribing anti-inflammatory drugs. Similarly, children with a persistent cough may have received a diagnosis of "cough-variant asthma" at the time anti-inflammatory drugs were prescribed, thereby accounting for the significantly greater use of these drugs in this group (fig. 1). However, we found an additional independent association between anti-inflammatory drug treatment and cough.

The choice of anti-inflammatory drug varied both with asthma severity and between regions. For the total sample, combined therapy was more common in moderate asthma than in mild asthma (fig. 3). Although this trend is understandable, there is no evidence that use of cromoglycate in combination with inhaled corticosteroids is more effective or steroid-sparing [27–29]. Cromoglycate was used more often in Wagga Wagga than in any other

region (fig. 4). This pattern may have been prompted by a more episodic pattern of asthma in Wagga Wagga, where there is a high prevalence of sensitivity to seasonal aeroallergens [4]. However, the proportion receiving cromoglycate did not differ between mild and moderate asthma, whereas the latter group might be expected to have more persistent disease.

This study enabled us to assess the relationship between asthma severity and the use of anti-inflammatory asthma medications in a large population sample of children, thereby permitting estimates of the rates of undertreatment and apparently aggressive treatment, as compared with a gold standard of published recommendations [9–12]. No previous study has provided these estimates. Two studies [15, 16] reported the rate of anti-inflammatory drug use in asthmatic children, but did not examine the relationship to asthma severity. BAUMAN *et al.* [15] reported that only 18% of 214 symptomatic asthmatic children in western Sydney were receiving bronchodilators and preventive therapy. Similarly, KORPPI *et al.* [16] found that, during the period 1985 to 1993, the percentage of asthmatic children in eastern Finland receiving inhaled corticosteroids remained constant between 14 and 15%. JONES *et al.* [30] interviewed 300 asthmatic patients, aged 5–65 yrs, randomly selected from the repeat prescribing registers of three general practices in England. Asthma was defined as the repeat use of anti-asthma medication. A relationship between "use of prophylaxis" and an asthma morbidity index could not be demonstrated. In view of the age range of the study population and the definition of asthma, the relevance to the current findings is limited.

In the current study, undertreatment was defined as the absence of daily use of anti-inflammatory drugs in children with moderate asthma. In published treatment guidelines, criteria used to define moderate asthma have included: symptoms, such as daily wheezing or wheezing on most nights [8, 10]; disability markers, such as avoidance of sports activities or school absence [8]; and markers of emergency health care utilization, such as hospital admissions, casualty visits, *etc.* [8, 10]. These criteria were incorporated into the definition of moderate asthma used in the present study. In addition, a composite severity score was calculated for all children with asthma or possible asthma. Although the score probably had limited homogeneity [31], since it combined different types of severity markers, its strong relationship with anti-inflammatory drug therapy (fig. 2) supported the conclusions reached by analysis of treatment of the moderate asthma group. Taken together, these analyses suggest that our undertreatment estimate (58% moderate asthma, 14% asthma, 3% of the sample) was, if anything, conservative.

The current study also permitted an estimate of the rate of apparently aggressive treatment. In the current paradigm, anti-inflammatory drugs are not recommended for very mild asthma [9–12]. Respiratory specialists have estimated that 58% of asthma in Australia is very mild [8]. In the current analysis, a severity score of less than 3 was chosen to identify this group. Since this choice of cut-off score limited inclusion to those children with diagnosed asthma plus a single mild symptom (table 1), it is not surprising that only 15% of the asthma group, compared with 58% in the National Asthma

Campaign (NAC) estimate [8], were classified as very mild. In addition, there were 946 children in the possible asthma group with a severity score of 2 or less. Thus, although only 9% of all children with scores of 0–2 reported use of anti-inflammatory drugs, they constituted 16% of the total number treated with these medications.

Although anti-inflammatory treatment of children with low scores has been characterized as "apparently aggressive", it was not necessarily excessive, since the minimal difficulties experienced by these children might have been a desirable consequence of the treatment. However, conversion (by treatment) of previously more severe asthma into the "very mild" category seems unlikely, since the proportion of the asthma group identified as very mild was lower than in previous estimates, and since only 19% of those treated "aggressively" reported daily therapy. The alternative is that children in this group either had very mild disease (unaffected by treatment), or had a sustained improvement due to treatment. In any case, the data suggest that more attention should be directed to the opportunities for weaning of anti-inflammatory drugs in children with minimal symptoms for at least a year.

As illustrated in figure 4, there were significant differences between regions in the prevalence both of undertreatment and aggressive treatment. If more aggressive use of anti-inflammatory medications results in better asthma control, one might anticipate that a region with a low prevalence of undertreatment and a high prevalence of aggressive treatment might exhibit a lower utilization of emergency services than a region with the converse pattern. For example, GOTTLIEB *et al.* [32] found that the rate of asthma hospitalizations in different areas of Boston was inversely related to the ratio of anti-inflammatory to beta-agonist medication use. However, in the current study, there was no significant relationship between the regional treatment pattern and indices of emergency health service utilization (fig. 5). Although the power of this observation is limited by the small sample size (of regions), other factors (*e.g.* practitioner accessibility, emergency practice patterns, *etc.*) may have been more important determinants of emergency utilization.

In conclusion, we estimated that 3% of children in a large population sample had asthma that was undertreated with anti-inflammatory drugs, and that a further 2% of the sample were receiving apparently aggressive therapy. The use of inhaled corticosteroids and/or cromoglycate could, thus, be categorized as suboptimal in 36% of all children receiving these drugs. Thus, substantial opportunities remain for improved application of current guidelines for asthma therapy, with regard both to undertreatment and aggressive treatment.

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