Poor asthma control in children: evidence from epidemiological surveys and implications for clinical practice

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SUMMARY
The objectives of this study is to compile current knowledge about asthma control in children in relation to goals proposed in international guidelines, to elucidate the factors associated with insufficient asthma control and to address the implications for clinical practice.

Review of recent worldwide large population epidemiological surveys and clinical asthma studies of more than 20,000 children are the methods used in this study.

The studies report high frequencies of sleep disturbances, emergency visits, school absence and limitations of physical activity due to asthma. Only a small percentage of children with asthma reach the goals of good asthma control set out by Global Initiative for Asthma (GINA). There is evidence of underuse of inhaled corticosteroids even in children with moderate or severe persistent asthma and over-reliance on short-acting β2-agonist rescue medication. Both parents and physicians generally overestimate asthma control and have low expectations about the level of achievable control. Many children with asthma are not being managed in accordance with guideline recommendations, and asthma management practices vary widely between countries.

Asthma control falls short of guideline recommendations in large proportions of children with asthma worldwide. Simple methods for assessing asthma control in clinical practice are needed. Treatment goals based on raised expectations should be established in partnership with the asthmatic child and the parents. Effective anti-inflammatory treatment should be used more frequently, and patients should be reviewed regularly.

Keywords: Asthma control; children; education; medication; perception; severity; treatment

INTRODUCTION

Asthma is a common chronic disease that affects children worldwide. In 1998, the International Study of Asthma and Allergies in Childhood (ISAAC) reported a global prevalence of ‘wheeze in the last 12 month’ of 11.8% for children aged 6–7 years and 13.8% for children aged 13–14 years, although there were large differences in prevalence rates (up to 15-fold) between countries (1). Childhood asthma causes considerable morbidity, especially during periods when it is insufficiently controlled. This is reflected in frequent symptoms, high rates of unscheduled emergency department visits and hospitalisation, as well as absence from school. These combine to interfere with normal daily activities and education and result in a considerable burden for the whole family of an asthmatic child (2,3).

Physicians, children with asthma and their parents all play important roles in asthma management and have the common goal of trying to achieve good asthma control. International and national guidelines have been introduced to help physicians better manage asthma by giving them guidance on how to provide optimal asthma care. The Global Initiative for Asthma (GINA) advises that markers of good asthma control in children consist of no asthma symptoms (e.g. coughing, shortness of breath, wheezing and chest tightness); no night-time waking due to asthma; no episodes of asthma that require a doctor visit, urgent care or hospitalisation; no absences from school due to asthma; normal, or near normal, lung function and normal activities (4,5). GINA also provides treatment recommendations based on asthma severity, which is distinct from (but related to) asthma control (6,7). Asthma severity is divided into four levels: intermittent, mild persistent, moderate persistent and severe persistent (4,5). Inhaled anti-inflammatory (controller) medication, especially inhaled corticosteroid, is recommended for all children with persistent asthma. Regular (daily) use of inhaled corticosteroid is associated with improved asthma control and reduced hospitalisation for asthma exacerbations (8,9,10). All
POOR ASTHMA CONTROL IN CHILDREN

Markers of Asthma Control

There is no consensus on the definition of asthma and classification of asthma control and no single measure of asthma control, making it difficult to compare findings from various studies. In each of the surveys comprising the global Asthma Insights and Reality (AIR) survey (11–20), patients with current asthma were identified as those with physician-diagnosed asthma, current symptoms or who were currently taking medication for asthma. Asthma control was determined from the percentage of subjects who met the various markers of asthma control in the GINA guidelines. The AIR surveys found that the current level of asthma control in children is poor and falls far short of the goals set out in the GINA guidelines (12). For example, only one in 20 children with asthma in Western Europe (5.8%) met all the GINA criteria for asthma control (11). Other recent surveys determining asthma control based on GINA guidelines have found high levels of inadequate asthma control: in the Patient Outcomes Management Survey (POMS) in New Zealand, 90% of children had suboptimally controlled asthma (21), and 31% of children in the Hunair Study had moderate or poor asthma control (22).

Poor asthma control is manifest as a high frequency of sleep disturbance, unscheduled urgent care visits, asthma hospitalisation, absence from school and physical activity limitations in the past 12 months (Table 1). In general, the proportions of children with these markers of poor asthma...
control were similar across the AIR and other surveys (Table 1) (2,23). Furthermore, data collected within the framework of the ISAAC survey indicate that many children in the general population continue to have severe asthma symptoms: globally, 3.7% of 13–14-year olds reported four or more attacks of wheezing over a 12-month period, 1.7% sleep disturbance due to wheezing at least one night per week and 3.8% wheezing severe enough to limit speech (1).

Further evidence that asthma control in children is inadequate comes from studies conducted in selected patient populations such as those in primary care practices (24), urban populations (25) or maintenance care organisations (26,27). Additionally, Lozano and co-workers found that teenagers (aged 12–15 years) were significantly more likely to experience inadequate asthma control (74%) than younger children (54% aged 3–5 years, p = 0.001; 62% aged 6–11 years, p = 0.02) (24). Table 1 summarizes data from various studies and shows that children worldwide exhibited high levels of unscheduled urgent care visits and school absence due to their asthma.

Normal or near-normal lung function is another important marker of asthma control. However, evidence indicates there is insufficient measurement of lung function in children with asthma (Table 2). In the AIR surveys, a high proportion of parents reported that their child with asthma had never had a lung function test, ranging from 60% in Western Europe to 80% in Japan (11,20). In a cross-sectional postal survey of the Swiss Association of Parents of Asthmatic and Allergic Children (SEAKK), 20% of children with unsatisfactory or poor asthma control and 26% with good or satisfactory asthma control were reported to never have had their lung function tested (23).

### Parental and Physician Perception of Asthma Control

One of the most striking findings of the AIR survey was that worldwide, parental perception of the current level of asthma control differed markedly from that based on reported symptom severity. In general, parents tended to underestimate the severity of their child’s asthma and overestimate the degree of asthma control. In Western Europe, only 52% of the children considered to have well-controlled asthma by their parents actually had good asthma control (0 or 1 GINA factors failed); 35% had moderate asthma control (2 or 3 GINA factors failed) and 14% had poor asthma control (4 or 5 GINA factors failed). Moreover, the proportion of children with symptoms suggestive of severe persistent asthma (15%) was threefold higher than that perceived by parents (11). This disparity between actual and perceived asthma control was seen consistently in all countries surveyed in the AIR survey, albeit to varying degrees (12). Data from a similarly designed Canadian survey also indicate that parents overestimate the quality of their child’s asthma control, with approximately

<table>
<thead>
<tr>
<th>Study (Reference)</th>
<th>Children (%)</th>
<th>Lung function measured in last 12 months</th>
<th>Have a peak flow meter</th>
<th>Have a written action plan</th>
<th>Patient Perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIRE (11,16)</td>
<td>753</td>
<td>n = 60</td>
<td>30 (of those with ‘probable asthma’)</td>
<td>6 (have both a PEF meter and an action plan)</td>
<td>27 (60 Spain, 53 Italy, 44 France, 24 Germany, 24 Sweden, 20 The Netherlands, 9 UK)</td>
</tr>
<tr>
<td>Cross-sectional survey of primary school children in NSW, Australia (40)</td>
<td>8753 (20% current wheezers, 17% diagnosed asthma)</td>
<td>22</td>
<td>39</td>
<td>30 (age ≥ 5 years)</td>
<td></td>
</tr>
<tr>
<td>Survey of previously hospitalised children with asthma in US (61)</td>
<td>220 (age 2–12 years)</td>
<td>51 (Given), 34 (still have)</td>
<td>30 (age 2–12 years)</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2. Asthma management practices in children with asthma**
half (47%) reporting their child’s asthma was very well controlled when it was poorly controlled based on guideline criteria (28). Despite this lack of consistency between parental perception and the reality of control, many parents appear to be satisfied with the levels achieved in their children. In the SEAKK survey of parents of 572 Swiss–German children with asthma, 89% were satisfied with their child’s asthma control despite objective assessments (guideline-based) indicating that asthma control was unsatisfactory or poor (23).

Evidence suggests that physicians also may underestimate asthma severity and overestimate the degree of asthma control in children (29,30). Of the 266 physicians surveyed in the Asthma in Canada survey (31), 81% believed they were obtaining optimal control of their patients’ asthma, whereas 52% of children had poorly controlled asthma, because they did not reach acceptable levels of control on at least two of the six parameters for asthma control within Canadian guidelines. The difference between physician-perceived and actual asthma control may partly be due to variations in the criteria used to assess asthma control and that these criteria are not always consistent with those recommended by guidelines such as GINA (32).

**KEY FACTORS INFLUENCING ASTHMA CONTROL**

Although cross-sectional surveys only provide a ‘snapshot’ of the current level of asthma control, which can vary over time, they have been helpful in identifying several factors associated with poor asthma control in children.

**ASTHMA MANAGEMENT PRACTICES**

The conclusions that can be drawn from the various surveys reviewed are that many children with asthma are not being managed according to guideline recommendations and that there are wide variations in asthma management practices worldwide. Indicators of healthcare quality include the use of spirometry, written asthma action plans, frequency of patient review and rates of appropriate prescription and use of inhaled corticosteroids and aerosol delivery devices.

**Lung Function**

Overall, lung function is not assessed at all or only irregularly in a large portion of children with asthma (Table 2). The global AIR survey revealed that lung function testing is rarely performed in children with asthma in Asia; 80% of children in Japan and 75% of children in the Asia-Pacific countries have never had their lung function tested (12). In Western Europe, parents reported that lung function testing in their children in the past year ranged from 14% in the UK to 60% in Germany (16). Kuehni and Frey (23) demonstrated that there are age-related differences in lung function testing. Thirty-nine per cent of all children in their study had undergone spirometry or plethysmography testing in the last 12 months, but it was significantly less likely to have been done in younger children (aged 4–6 years) compared with older children. This may be due to the long-held assumption that spirometry is impossible in young children, but evidence does exist that, in fact, the procedure can be adequately performed in many children under 6 years using dynamic spirometry with an animation program (33,34).

Lung function measurement is one of the few available objective ways to assess asthma severity. An additional bronchodilator test or a relevant bronchial challenge, such as an exercise challenge or a similar physical challenge test, may provide further information on asthma severity (35,36,37).

Guidelines recommend regular home monitoring of PEF, because it may help detect early signs of asthma deterioration (4,5). However, Kamps et al. (38) reported that routine peak expiratory flow (PEF) monitoring had poor compliance in children followed for 4 weeks, actual daily compliance being lower than reported compliance (77.1 vs. 95.7%, respectively). Accuracy reduced as time increased due to self-invented entries. This suggests that peak-flow monitoring should form part of the asthma care recommendations but only for occasional use when children are symptomatic (39). However, peak-flow meter ownership is low, especially among children with asthma from Asia, Australia or Eastern Europe (Table 2) (12,40). Only 27% of children in the Asthma Insights and Reality in Europe (AIRE) population owned a peak-flow meter, and only 7% were reported to use a peak-flow meter at least once a week (16).

**Written Action Plans**

Despite being clearly recommended in guidelines (4,5), data from the various surveys comprising the global AIR survey indicate that the use of written action plans for asthma is highly variable between countries (Table 2). Overall, only 24% of children with asthma in Western Europe were reported by parents to have a written action plan, although possession of a plan ranged from 60% in Spain to 9% in the UK (16,18). In their community-based survey in Germany, Maziek et al. (41) found that less than 46% of children with severe wheeze (>12 attacks in the last year) had a written action plan. Additionally, 48% of children (aged 2–5 years) who visited an emergency department for asthma did not have a written action plan (42). Furthermore, several epidemiological surveys in Australia indicate that despite an initial increase in the use of written action plans in the early 1990s (43), this has not been sustained (44). Ownership of written asthma action plans among people aged 15 years or older in the community decreased from 42% in 1995 to 22% in 2001 (45). A national survey in New Zealand found that general
practitioners were just as likely as paediatricians to provide asthma action plans (92 vs. 93%, respectively). General practitioners, however, gave the plans to a smaller proportion of children than adults with asthma and were more likely to include a step that involved increasing the dose of inhaled corticosteroid (46).

The reason plans may not be given could be due to reasons supported by evidence from a recent Cochrane review which concluded that there is insufficient evidence to identify whether they have any effect on asthma control (47). In a cross-sectional survey of a primary care population in the US, 21.5% of children with asthma were reported to have ever received a written action plan, but there was no significant association between having a written action plan and adequacy of asthma control on multivariate analysis (24). However, written action plans have been associated with improved outcomes and may protect against death from asthma (48,49,50). In the Asthma in America survey (51), patients with a written action plan were significantly more likely to report using anti-inflammatory medication than those without a plan (odds ratio 1.63; 95% CI 1.3–2.1; p < 0.001) (14). In school-aged children admitted to hospital for acute asthma, action plans have been shown to reduce readmission rates (52,53). Nevertheless, many doctors do not perceive asthma action plans as useful (54) and do not provide them for patients, even though patients may view them positively (55).

Provider of Asthma Care

Health care systems and the provision of asthma care vary between countries worldwide. The AIRE survey reported that 63% of children with asthma received their asthma care primarily from general practitioners and had never seen an asthma specialist or saw one only when they had acute problems (16). Even among a community pharmacy-based population of Canadian children with asthma receiving intensive medication (suggesting more severe asthma), only one in three were reported to have seen an asthma specialist during the 6 months of the study (56).

Evidence suggests that the provider of asthma care influences asthma outcomes. The Asthma in America survey (51) found that patients seen by an asthma specialist (23% of the sample population) were significantly more likely to report current use of anti-inflammatory medication than patients managed by other types of clinician (p < 0.001) (14). A cross-sectional survey of managed care organisations in the US has also shown that when asthma specialists are primarily responsible for asthma care in children, the care is more likely to be consistent with guidelines, and the likelihood of using controller medications is much higher than when care is provided by a generalist (odds ratio 6.7; 95% CI 2.4–18.1) (57). Furthermore, children with frequent emergency department visits for asthma are more likely to be managed by a primary care physician (67%) than an asthma specialist (33%) (58).

The Asthma in America survey confirmed that the patient–physician relationship is an important factor (14). Patients who rated their physician more highly in terms of the physician’s ability to explain asthma management, willingness to spend time with the patient and encourage patient participation in treatment decisions were more likely to use their anti-inflammatory medication (14).

Other studies have reported poor adherence by physicians to asthma management guidelines, even for children who have been hospitalised for their asthma (42,60–63). This is probably an important factor influencing asthma control.

Medication Usage

**Underuse of inhaled corticosteroids.** Inhaled corticosteroids are safe and effective for long-term use in children with asthma (8,9,64–66), and recent guidelines recommend they should be used regularly by all patients with persistent asthma (4,5,67). Ideally, sufficient use of inhaled corticosteroids should minimise the need for quick-relief bronchodilators (rescue medication).

There is compelling evidence from many studies that many children with asthma are undertreated. In particular, there is underuse of inhaled corticosteroids together with over-reliance on quick-relief medications in most countries (Table 3). The use of inhaled corticosteroids is particularly low in Japanese children with asthma (5%) (20). Using data collected during 1988–1994 as part of the US NHANES III survey (62) found that 74% of children with moderate to severe asthma were inadequately treated; only 8% had received inhaled corticosteroids, and only 26% had received any type of controller medication (inhaled corticosteroids, cromolyns and theophylline). Even among children previously hospitalised for asthma, only 35% were reported to be receiving daily anti-inflammatory agents (25).

In contrast to expectations, the global AIR survey found there was not an increasing use of inhaled corticosteroids with increasing severity of asthma (12). In Western Europe, only 33, 32 and 26% of children with mild-, moderate- or severe-persistent asthma, respectively, were reported to be using inhaled corticosteroids (11). However, there were large variations in inhaled corticosteroid use between the European countries taking part in the AIRE study (16). They were...
Table 3  
Asthma medication use from studies published in the last five years among children with asthma

<table>
<thead>
<tr>
<th>Study (References)</th>
<th>n</th>
<th>Inhaled corticosteroids</th>
<th>Quick relief bronchodilator</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIA (13)</td>
<td>721 (&lt;16 years)</td>
<td>13 (persistent asthma)</td>
<td>80 (persistent asthma)</td>
<td>60 Reliever or anti-inflammatory</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>43 (mild intermittent asthma) [includes adults]</td>
<td>18 Anti-inflammatory</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11 Cromolyn</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6 Anti-leukotrienes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40 Anti-inflammatory (including ICS)</td>
</tr>
<tr>
<td>AIRE (11)</td>
<td>753</td>
<td>22 (mild intermittent)</td>
<td>61</td>
<td>40 Anti-inflammatory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 (mild persistent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>33 (mild persistent)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>32 (moderate persistent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 (severe persistent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIRJ (20)</td>
<td>402</td>
<td>5</td>
<td>56</td>
<td>&lt;4 other controllers</td>
</tr>
<tr>
<td>AIRIAP (Zainudin et al in submission)</td>
<td>884</td>
<td>15 (mild intermittent)</td>
<td>71</td>
<td>9 Controller only</td>
</tr>
<tr>
<td>Asthma in Canada (31)</td>
<td>200</td>
<td>62 (mild-moderate asthma)</td>
<td>74</td>
<td>55 Any controller</td>
</tr>
<tr>
<td>Managed care organisation primary care population, USA (20)</td>
<td>638 mild-moderate asthma (age 3–15 years)</td>
<td>34 (plus SABA)</td>
<td>21 (SABA only)</td>
<td>46 Controller + reliever</td>
</tr>
<tr>
<td>Children with current asthma in a German general population study (79)*</td>
<td>454 (aged 5–7 and 9–11 years)</td>
<td>16 (patients with moderate-severe asthma)</td>
<td>47</td>
<td>70 at least one anti-asthma drug</td>
</tr>
<tr>
<td>German children with current wheeze (41)</td>
<td>868</td>
<td>9 (patients with moderate-severe asthma)</td>
<td>9</td>
<td>7 at least one anti-asthma drug</td>
</tr>
<tr>
<td>USA NHANES III population-based survey 1988–1994 (62)</td>
<td>1025 with physician-diagnosed asthma</td>
<td>8 (patients with moderate-severe asthma)</td>
<td>40 (5–7 years vs 53) (9–11 years) p &lt; 0.05</td>
<td>43 Cromolyn</td>
</tr>
<tr>
<td>Childhood Asthma Management Program (CAMP) in USA (132)†</td>
<td>1041 children with mild-to-moderate asthma (age 5–12 years)</td>
<td>26 (patients with moderate-severe asthma)</td>
<td>35 Oral steroids</td>
<td>7 Cromolyn</td>
</tr>
<tr>
<td>Cross-sectional survey of parents of asthmatic children group of Swiss–German children with wheeze (23)</td>
<td>572 (aged 4–16 years)</td>
<td>68 (patients with moderate-severe asthma)</td>
<td>82</td>
<td>15 sodium cromoglycate</td>
</tr>
<tr>
<td>Inner city children previously hospitalised for asthma, USA (25,61)</td>
<td>220 (age 2–12 years)</td>
<td>11 (patients with moderate-severe asthma)</td>
<td>97 (have equipment for inhaling beta-agonists)</td>
<td>35 daily anti-inflammatory (of those with persistent asthma)</td>
</tr>
<tr>
<td>Survey of Pediatric family paediatricians in Italy (76)</td>
<td>1263 children with asthma (&lt;14 years)</td>
<td>34 (patients with moderate-severe asthma)</td>
<td>31</td>
<td>39 anti-inflammatory (of those with persistent asthma)</td>
</tr>
</tbody>
</table>

AIA, Asthma in America; AIRE, Asthma Insights and Reality in Europe; AIRIAP, Asthma Insights and Reality in Asia-Pacific; AIRJ, Asthma Insights and Reality in Japan; ICS, inhaled corticosteroids; LTRA, leukotriene receptor antagonists; NHANES, National Health and Nutrition Examination Survey; SABA, short-acting beta-agonist.

*Medication use in past year; †medication use in past 6 months.
used by a high proportion of Swedish children with moderate-persistent asthma (71%) and severe-persistent asthma (83%) (16), and such high use of inhaled corticosteroids has been associated with reductions in hospitalisation rates for asthma and asthma-related morbidity (68). Underuse of inhaled corticosteroids is probably a major factor contributing to poor asthma control and puts patients at increased risk of asthma exacerbations and the need for emergency care (69).

Over-reliance on short-acting β-agonist therapy. Frequent use of quick-relief bronchodilators in the past month is an indicator of inadequate asthma control. In most surveys, the majority of children with asthma were reported to have used quick-relief bronchodilators in the past month (Table 3). Further evaluation of medication use in several patient populations has suggested there is over-reliance on reliever medication (24,60). In a US primary care population of children with persistent asthma, one-third (32.6%) of those using relievers had high levels of use defined as 3–4 days/week (\( \geq 5 \) puffs/day) or \( \geq 5 \) days/week (24). In a cross-sectional review of patients with diagnosed asthma (over the age of 4 years) in general practice in the UK, 14% had received 10 or more β-agonist inhalers in the past year (which would provide coverage for multiple doses every day of the year); of these, 54% were on steps 1 or 2 of the British guidelines on asthma management, and almost a quarter were not taking regular inhaled corticosteroids (70). Moreover, contrary to guideline recommendations that they should be used on an as-needed basis, short-acting β-agonists were prescribed for regular administration in 36% of patients in the study by Walsh et al. (70) and for 62% of children in an earlier UK study (71).

Over-reliance on quick-relief medication in Western Europe was reflected in the ratio of reported inhaled corticosteroid use to bronchodilator use, which was less than one for children from all countries taking part in the AIRE study (16). Similar conclusions were reached based on the ratio of children from all countries taking part in the AIRE study to bronchodilator use, which was less than one for Europe was reflected in the ratio of reported inhaled corticosteroids to bronchodilator use, which was less than one for Germany, 43% of children with current asthma used inhaled cromolyns, whereas only 16% used inhaled corticosteroids in the previous 12 months (Table 3) (79). Because cromolyns are less effective than inhaled corticosteroids, this indicates undertreatment for children with asthma in some countries (80,81). Evidence also suggests the use of leukotriene modifiers instead of inhaled corticosteroids as single controller medication may lead to impaired asthma control and increased risk for hospitalisations due to exacerbations of asthma (82).

**PARENTAL PERCEPTIONS, ATTITUDES AND KNOWLEDGE**

Parents are the key link between health care providers and children with asthma; they provide information on their child’s asthma symptoms upon which physicians make their decisions regarding the child’s asthma management and the need for treatment. Parents tend to overestimate their child’s asthma control and underestimate asthma severity. This may be related to parental perception of symptoms, which is inaccurate about one-third of the time (83). Parental underestimation of their child’s asthma severity and reporting of good asthma control occurs especially when parents are asked only a single general question about asthma control (84).

Parents of children with asthma have numerous fears and concerns. The Paediatric Asthma Pan European Survey of 631 parents of children with asthma found that the most frequent parental concerns were their child being in contact with asthma triggers outside the home environment (37%), their child being in a situation with people who do not know what to do when the child has an asthma attack (34%) and the unpredictability of when an asthma attack may occur (32%) (85).

Parents’ attitudes and beliefs about their child’s health influence the use of medication and health care services (86). Parental attitudes and concerns about asthma medicines
and managing acute asthma attacks have been associated with the frequency of urgent care visits for childhood asthma (87,88,89).

Surveys in several countries have assessed parental understanding regarding the cause of asthma. Among the global AIR surveys, only 7% of Japanese parents were aware that airway inflammation is the underlying cause of asthma (20), whereas 66% of parents in Western Europe had this knowledge. However, less than half of the parents surveyed in the AIRE study believed that the underlying condition is treatable or that there is effective medication to reduce airway inflammation (11).

There appears to be considerable parental confusion about using asthma medication and the role of reliever and controller medications. Almost one-third (32%) of parents in the American Lung Association survey believed that asthma should be treated only when symptoms appear (90). Likewise, 26% of parents in the Paediatric Asthma Pan European Survey thought short-acting β-agonist was controller therapy (85). Kuehni and Frey (23) found that only 45% of parents could distinguish the effects of anti-inflammatory inhalers from bronchodilators.

Parents may have low expectations of what can be achieved in asthma, and this may be a major contributor to poor asthma control. In the Asthma Control and Expectations (ACE) survey of 1031 asthma patients or their parents, 69% of respondents accepted there were things they could not do because of their asthma (91). Furthermore, 31% of parents in the AIRE study believe that asthma usually causes lifestyle limitations even with proper treatment (11).

Adherence to Medication
Adherence to prescribed asthma medication is poor even among preschool children whose medication was administered by their parents (92). Adherence measured objectively is worse than parent-reported adherence (93–96). Non-adherence to prescribed asthma therapy by children is influenced by many factors including parental beliefs, knowledge and attitudes, such as whether controller medicine should be used daily or worries about adverse effects, as well as perception of effectiveness (lack of immediate symptom relief) and difficulties of inhaler administration (93,95,97,98). Parents of children with poor adherence (based on irregular collection of controller medication) were less likely to perceive the controller medication as effective and were more reluctant to administer it than parents of children who collected the prescriptions for asthma medication (99).

A relationship between adherence and asthma control or morbidity has been demonstrated in several studies (100,101). Symptom control in children with recently diagnosed mild to moderate persistent asthma prescribed anti-inflammatory treatment was positively associated with having understood how the medication works (OR 3.38, p = 0.03) and taking the prescribed doses (OR 4.82, p = 0.002) (101). Moreover, Farber et al. found that parental misunderstanding of the role of inhaled anti-inflammatory medication was a predictor of non-adherence to daily use of that medication by children with persistent asthma (102). Likewise, parents’ diminished treatment expectations and fears about anti-inflammatory medication were significant predictors of non-adherence to medication (83,103). In contrast, some studies have found no association between asthma knowledge, medication adherence and asthma control (104). In the study reported by Kuehni, the rate of non-adherence was the same (28%) in children with well-controlled and poorly controlled asthma (23).

IMPLICATIONS FOR CLINICAL PRACTICE
Asthma control, as defined by evidence-based guidelines such as GINA, remains elusive but is achievable (105). Indeed, it should be possible to achieve good asthma control in most children except those with severe therapy-resistant asthma (23,106). Efforts to achieve optimal asthma control are worthwhile, as well-controlled asthma can result in fewer visits to emergency rooms and hospitalisations (107). Good asthma control is meaningful to patients and has been associated with improved quality of life (108,109). The long-term consequences of uncontrolled asthma in childhood are not fully understood, but it may allow preventable progression of the underlying disease, resulting in lower lung function and more severe symptoms as the children grow into adulthood. Several longitudinal studies following children with asthma into adulthood have found that those children with more asthma symptoms and a lower lung function have a worse prognosis in adulthood (110–113).

The successful management of childhood asthma requires a comprehensive approach and involves a ‘therapeutic partnership’ between the patients, their parents and the health care provider. The first step towards improved asthma control is a realistic assessment of asthma severity and current asthma control in the patient, including perceived and non-perceived limitations due to asthma. Low expectations of what level of asthma control can be achieved, both among patients/parents and care givers, form a mental barrier that must be passed. Ignorance among patients and parents about the underlying nature of asthma and unrealistic fears about side-effects from regular anti-inflammatory controller medication constitute further barriers. Improved knowledge about and adherence to modern asthma treatment guidelines among physicians and other health care providers are fundamental. Achievements needed to improve asthma control in general include raising the standard of clinical care and better patient adherence to prescribed medication, both of which require education programs.
Improved Standards of Clinical Care

A self-critical assessment of the limitations to successful asthma care set by the local organisation of paediatric health care is necessary. Local guidelines and strategies for asthma care should be implemented and further audited and evaluated. Efforts should be taken to improve physician adherence to asthma treatment guidelines.

There remains a need for a simple method of assessing asthma control that is suitable for use in everyday clinical practice. This measure of asthma control should be brief, easy to administer and patient-based. Physicians should ask specific questions about asthma symptoms to establish asthma control rather than a general question about asthma control. It should be based on a number of parameters (105) such as the seven-item asthma control questionnaire developed by Juniper et al. (114) but currently validated only in subjects aged 17 years and over. The five-item asthma control test (ACT) developed by Nathan and coworkers to evaluate asthma in subjects aged 12 years and over has been validated for use in clinical practice and is thus more suitable for paediatric patients (115,116). There remains no validated control test for children under 12 years.

Additional contributors to poor asthma control in children, e.g. gastro-oesophageal reflux, sinusitis, rhinitis, respiratory tract infections (RTIs) and psychological factors, need to be identified. Good partnership and communication with the asthmatic child and the parents are necessary to establish treatment goals that are acceptable to all and which should take into account everyone’s fears and concerns. Discussing the impact of asthma on the daily life of the child and the family may lead the child and the family to view asthma as a problem that needs more attention and could motivate them to use prescribed treatment. Physicians and other health professionals may need to improve their skills in consulting with adolescents (117). Efficient approaches to build rapport with adolescent have been reported (118). They are urgent to adopt, because adherence to controller medication is poor in this period of life (24,60,71), leading to worsened asthma control (24), and because many young people pick up the tobacco smoking habit at this time.

More widespread use of written asthma action plans coupled with regular structured review of children with asthma is needed. These action plans should take into account the individual needs of each child and should be based on symptoms and/or peak flow. Regular check-ups should include objective measurement of lung function as recommended in current guidelines. Parents must be made aware of the potential usefulness of peak-flow meters when their child is having symptoms or is potentially at risk of having an exacerbation, e.g. at times of medication change, and that repeated measurements can help them evaluate how severe the child’s asthma attack is and how it responds to treatment (119). However, it is unrealistic to expect children to use a peak-flow meter every day due to the burden on the family, the child and the stigmatisation that can occur for the child (120).

Exercise-induced bronchoconstriction is one of the most frequent and important manifestations of childhood asthma and is a marker of asthma severity and airway inflammation (121,122). A simple exercise challenge has been known for decades as an important and useful adjunct when assessing asthma control (35,36).

Both physicians and patients/parents must raise expectations of the level of asthma control that can be achieved, and the physicians must take action and prescribe appropriate anti-inflammatory treatment to optimise control of persistent asthma in children. Earlier intervention and more aggressive therapy of persistent asthma should be considered as poorly controlled asthma, and poor lung function in childhood is likely to continue in adulthood (110,113).

Improved Adherence to Controller Medication

Over-reliance on quick-relief bronchodilators should be removed and be replaced by improved regular use of controller therapy. Because 85% of patients say they would prefer to take fewer drugs to control their asthma (123), it is important to simplify asthma treatment regimens. Simple but effective and safe tailored regimens that fit with the patient’s daily lives should be prescribed. In addition, parental understanding of the rationale for these asthma treatments must be improved, and parental fears and concerns about medications must be addressed.

Education Programmes

Programmes to educate physicians and other health care providers on asthma care and current guidelines should be launched, as studies have shown that educating physicians can increase adherence to guidelines and result in improved asthma outcomes in children and greater parental satisfaction (124,125). The use of medical services by asthmatic children is also reduced following training of doctors in asthma guidelines and communication skills (126). Asthma education is complex and time consuming however, and therefore priority must be given to important messages, which need to be reported and refined at follow-ups.

Parental education can improve the management of asthmatic children (127,128). Improved parental education about asthma and a better relationship between doctor and parent may not only lead to better asthma management in children but may also lead to improved asthma control and a reduction in the use of medical services. It is appropriate to educate parents/children on the nature and long-term course of asthma and the need for regular anti-inflammatory treatment.
and to point out the long-term safety of inhaled corticosteroids. Recent innovations, such as internet-enabled interactive multimedia education programs aimed at parents, caregivers and children, have demonstrated improvements in knowledge and outcomes of increased symptom-free days and fewer emergency department visits (129), and their usefulness should be explored further. Among teenagers, peer-led asthma education programs may be more successful than conventional programs led by adult health professionals (130).

Future developments. In the future, there may be alternative means of improving asthma control, whether by new drugs or by better methods of monitoring inflammation. Recently, a Dutch study in paediatric patients found that using the fraction of nitric oxide in exhaled air (FE\textsubscript{NO}) as a means of estimating inflammation allowed more accurate titration of ICS and led to reduced hyperresponsiveness and inflammation. However, despite this being an intriguing concept, this method is far from realistic for primary care. Any new development for asthma control will require ease of use and access to allow children in primary care to benefit (131).

CONCLUSIONS

Childhood asthma is an increasing global health problem. Asthma control in children is poor worldwide and is associated with poor adherence to GINA or other guideline recommendations. Guidelines are composed to provide evidence-based recommendations from clinical trials and practical information that are relevant for both primary and secondary care clinical practice. However, several epidemiological studies indicate that poor asthma control in children is associated with asthma management practices and additionally the attitudes and behaviour of parents. Low expectation on the level of possible asthma control, both among parents and physicians, is an important factor contributing to these observations.

Parents need better understanding of (i) the underlying inflammatory mechanisms of asthma and the safety of anti-inflammatory therapy; (ii) the importance of adhering to regular inhaled corticosteroid therapy to reduce reliance on quick-relief medication and prevent exacerbations; (iii) the importance of regular check-ups of the child’s asthma which include assessment of lung function and (iv) the right to have a written action plan to use when asthma goes out of control or to help maintain optimal control.

Physicians and other healthcare providers have considerable room for improvement in various areas of asthma management, including the prescription of adequate controller medication and educating patients and parents on its purpose and the benefits associated with medication adherence. Education and interventions aimed at physicians, and parents should be targeted to change these behaviours and attitudes to improve asthma control, to minimise the morbidity of asthmatic children and to possibly improve the long-term course of asthma.

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POOR ASTHMA CONTROL IN CHILDREN


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