Inhaled disodium cromoglycate (DSCG) as maintenance therapy in children with asthma: a systematic review

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Abstract
Background—Disodium cromoglycate (DSCG) is included in the BTS guidelines on the treatment of asthma for use in children, but is now used only infrequently. We have identified and interpreted the findings of all published randomised, placebo controlled trials of DSCG in the prophylactic treatment of children with asthma.

Methods—Several databases were searched to identify trials. Studies were included if they investigated subjects with asthma aged 0–18 years old, addressed maintenance treatment with inhaled DSCG, and were published in English. The methodological quality of the studies was assessed independently by three reviewers. The 95% confidence intervals (CI) of differences in the treatment effect for cough and wheeze between placebo and treatment with DSCG were computed. The estimates were pooled and tested for homogeneity and, to assess possible publication bias, a funnel plot was made and tested for symmetry.

Results—Of the 24 randomised, placebo controlled trials identified, the methodological scores varied widely. The null hypothesis of homogeneity was rejected. Under the assumption of heterogeneity the overall CI for wheeze was 0.11 to 0.26 and for cough was 0.13 to 0.27. The overall tolerance intervals (–0.11 to 0.48 and –0.04 to 0.43 for wheeze and cough, respectively) both included zero, so it cannot be concluded that future studies will show an effect of DSCG compared with placebo. Older studies were more often in favour of DSCG. The funnel plots suggest publication bias; small studies with negative or equal outcomes are lacking.

Conclusion—Given the apparent publication bias, the small overall treatment effect, and the tolerance interval including zero, there is insufficient evidence that DSCG has a beneficial effect as maintenance treatment in children with asthma.

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Keywords: disodium cromoglycate; asthma; children

Several guidelines for the management of childhood asthma have been published by international consensus groups, recommending early preventive treatment to reduce the need for bronchodilators and to enable asthmatic children to lead a normal and active life. The consensus statements recommend disodium cromoglycate (DSCG) as maintenance treatment for children with moderate asthma. DSCG is supposed to be effective in 60% of cases, but predictors of success are not known. Although it has been used for decades, the precise mechanism of its action is still not fully understood. No serious side effects have been reported in trials, but occasional cases of dysuria, urticaria, bronchospasm, angio-oedema, and anaphylaxis have been reported.

In the current review and position statement of the British Thoracic Society published in 1997 DSCG and inhaled corticosteroids were both recommended as first choice preventive treatment in young children rather than DSCG being recommended as the first choice before inhaled corticosteroids; the grounds for this decision are, however, still unclear. The long term side effects of prophylactic treatment with inhaled steroids in early childhood are unknown. Nevertheless, there is concern that treatment of very mild cases of asthma with inhaled steroids may have an adverse effect on the balance between risk and benefit, so DSCG may still be considered as first choice preventive treatment. Other guidelines continue to recommend DSCG as first choice in young children.

The use of DSCG has decreased since 1990 while the use of inhaled corticosteroids is increasing, even in young children. Nowadays, few consultant paediatricians use DSCG as first line treatment in young children while some studies suggest overtreatment of children with mild asthma with inhaled corticosteroids.

Because of the discrepancy between guideline recommendations and daily practice and the debate on the role of DSCG which led to its withdrawal as first line treatment in young children, we have undertaken a systematic review of all published randomised, placebo controlled trials of DSCG in the prophylactic treatment of asthma in children. The aim of the study was to assess the methodological quality of the studies and the effectiveness of inhaled DSCG by statistical pooling of the study results.

Methods
DATA SOURCES AND STUDY SELECTION
Literature searches of Medline, Embase, the Cochrane Controlled Trial Register, and the database of the manufacturers of DSCG were carried out for the period from January 1966 to
<table>
<thead>
<tr>
<th>Study</th>
<th>Setting</th>
<th>Design</th>
<th>Inhaled DSCG</th>
<th>Additional study arm</th>
<th>Inclusion criteria</th>
<th>Age (years)</th>
<th>No of patients included/analysed</th>
<th>Duration of intervention period(s)</th>
<th>Major effect parameters</th>
<th>Side effects</th>
<th>Authors’ conclusion</th>
<th>Methodological quality score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith et al (1968)</td>
<td>School health service</td>
<td>Crossover</td>
<td>4 dd 20 mg Spinhaler</td>
<td>None</td>
<td>Longstanding perennial asthma</td>
<td>5-16</td>
<td>51/44</td>
<td>2 x 4 weeks</td>
<td>Daily symptom scores, lung function, additional medication, laboratory</td>
<td>Cough</td>
<td>Positive</td>
<td>Jadad: 4; Jadad: 3</td>
</tr>
<tr>
<td>Hyde et al (1970)</td>
<td>Not specified</td>
<td>Crossover</td>
<td>4 dd 20 mg Spinhaler</td>
<td>None</td>
<td>Duration of asthma &gt;1 year, definite symptoms before inclusion</td>
<td>6-16</td>
<td>60/57</td>
<td>2 x 3 weeks</td>
<td>Daily symptom scores, clinical assessment, lung function, additional treatment</td>
<td>Irritated throat, cough, wheeze</td>
<td>Positive</td>
<td>Jadad: 3</td>
</tr>
<tr>
<td>Shoda et al (1970)</td>
<td>Hospital inpatients and outpatients</td>
<td>Crossover</td>
<td>4 dd 20 mg Spinhaler</td>
<td>None</td>
<td>Perennial asthma</td>
<td>6-15</td>
<td>34/33</td>
<td>2 x 4 weeks</td>
<td>Daily symptom scores, lung function, additional medication, school absence</td>
<td>Contact dermatitis, headache</td>
<td>Jadad: 3</td>
<td></td>
</tr>
<tr>
<td>Sly (1970)</td>
<td>Outpatients</td>
<td>Crossover</td>
<td>4 dd 20 mg Spinhaler</td>
<td>None</td>
<td>Asthmatic, responded on exercise with bronchospasm</td>
<td>6-12</td>
<td>21/16</td>
<td>2 x 4 weeks</td>
<td>Daily symptom scores, clinical assessment, lung function</td>
<td>Sore throat</td>
<td>Positive/equal</td>
<td>Jadad: 3</td>
</tr>
<tr>
<td>Collins-Williams et al (1971)</td>
<td>Outpatients and inpatients</td>
<td>Crossover</td>
<td>4 dd 20 mg Turbohaler</td>
<td>None</td>
<td>Severe allergic asthma, wheezed at least once a week</td>
<td>7-17</td>
<td>63/63</td>
<td>2 x 4 weeks</td>
<td>Daily symptom scores, clinical assessment, lung function</td>
<td>Cough, dry mouth, dizziness, nausea, headache</td>
<td>Positive</td>
<td>Jadad: 2</td>
</tr>
<tr>
<td>Limburg (1971)</td>
<td>Inpatients</td>
<td>Crossover</td>
<td>4 dd 20 mg Spinhaler</td>
<td>None</td>
<td>In asthma centre and regular asthma symptoms</td>
<td>6-16</td>
<td>30/29</td>
<td>2 x 4 weeks</td>
<td>Daily symptom scores, lung function, additional treatment</td>
<td>Cough</td>
<td>Positive</td>
<td>Jadad: 4</td>
</tr>
<tr>
<td>Fox et al (1972)</td>
<td>Hospital</td>
<td>Crossover</td>
<td>4 dd 20 mg Spinhaler</td>
<td>None</td>
<td>Chronic severe perennial bronchial asthma, a period of observation in the clinic for at least one year and pulmonary function impairment</td>
<td>5-16</td>
<td>28/23</td>
<td>2 x 12 weeks</td>
<td>Daily symptom scores, clinical assessment, lung function</td>
<td>Cough</td>
<td>Positive</td>
<td>Jadad: 4</td>
</tr>
<tr>
<td>Silverman et al (1972)</td>
<td>Outpatients</td>
<td>Parallel</td>
<td>4 dd 20 mg capsules</td>
<td>None</td>
<td>Perennial asthma and disability exceeding 6-8 wks in preceding year, or 3-4 wks in preceding 3 months despite regular bronchodilator therapy, never use of corticosteroids or cromoglycate</td>
<td>7-9</td>
<td>62/33</td>
<td>2 weeks baseline, 8 weeks treatment</td>
<td>Daily symptom scores, clinical assessment, lung function</td>
<td>Cough, dry throat</td>
<td>Positive</td>
<td>Jadad: 2</td>
</tr>
<tr>
<td>Hyde et al (1973)</td>
<td>Hospital</td>
<td>Crossover</td>
<td>4 dd 20 mg Spinhaler</td>
<td>None</td>
<td>Chronic disabling asthma</td>
<td>5-16</td>
<td>38/38</td>
<td>4 weeks baseline, 2 x 4 weeks treatment</td>
<td>Additional treatment, clinical assessment, lung function</td>
<td>Cough, throat pain, dizziness</td>
<td>Positive</td>
<td>Jadad: 3</td>
</tr>
<tr>
<td>Crisp et al (1974)</td>
<td>Unspecified</td>
<td>Crossover</td>
<td>4 dd 20 mg small device</td>
<td>None</td>
<td>Chronic asthma and 2 out of: nearly daily symptoms; nearly daily medication needed; intermittent or long term steroid usage</td>
<td>5-17</td>
<td>40/40</td>
<td>2 weeks baseline, 2 x 4 weeks treatment</td>
<td>Daily symptom scores, clinical assessment, lung function, additional medication</td>
<td>Rash, wheeze</td>
<td>Positive</td>
<td>Jadad: 4</td>
</tr>
<tr>
<td>Hiller et al (1975)</td>
<td>Unspecified</td>
<td>Crossover factorial</td>
<td>4 dd 20 mg Spinhaler</td>
<td>BMV</td>
<td>Chronic perennial asthma, symptoms inadequately controlled by DSCG and bronchodilators</td>
<td>9-13</td>
<td>11/9</td>
<td>4 x 1 month</td>
<td>Daily symptom scores, clinical assessment, additional medication</td>
<td>None</td>
<td>Positive</td>
<td>Jadad: 4</td>
</tr>
<tr>
<td>Hiller et al (1977)</td>
<td>Hospital</td>
<td>Crossover</td>
<td>3 dd 20 mg nebulised</td>
<td>None</td>
<td>Frequent troublesome asthma</td>
<td>2-4</td>
<td>17/17</td>
<td>1 week baseline, 2 x 4 weeks treatment</td>
<td>Daily symptom scores, clinical assessment, lung function</td>
<td>Unspecified</td>
<td>Positive</td>
<td>Jadad: 3</td>
</tr>
<tr>
<td>Mathew (1977)</td>
<td>Outpatients</td>
<td>Crossover</td>
<td>4 dd 20 mg nebulised</td>
<td>None</td>
<td>Severe chronic perennial asthma + symptoms in baseline period</td>
<td>3-6</td>
<td>109</td>
<td>8 weeks baseline, 2 x 4 weeks treatment</td>
<td>Daily symptom scores, clinical assessment, lung function, additional treatment</td>
<td>Nausea, vomiting, abdominal pain</td>
<td>Positive</td>
<td>Jadad: 3</td>
</tr>
<tr>
<td>Edmunds et al (1980)</td>
<td>Unspecified</td>
<td>Crossover</td>
<td>4 dd 1 capsule</td>
<td>Slow releaseaminophylline</td>
<td>Perennial asthma</td>
<td>5-15</td>
<td>30/30</td>
<td>3 x 4 weeks</td>
<td>Daily symptom scores, lung function, additional medication</td>
<td>Minor</td>
<td>Equal</td>
<td>Jadad: 3</td>
</tr>
<tr>
<td>Glass et al (1981)</td>
<td>Hospital</td>
<td>Crossover</td>
<td>4 dd 20 mg nebulised</td>
<td>Theophylline syrup</td>
<td>Control of asthma poor under routine treatment</td>
<td>1-4</td>
<td>1616</td>
<td>4 x 4 weeks</td>
<td>Daily symptom scores, additional treatment</td>
<td>Cough, sneeze</td>
<td>Positive</td>
<td>Jadad: 4</td>
</tr>
<tr>
<td>Geller-Berstein et al (1982)</td>
<td>Hospital</td>
<td>Crossover</td>
<td>4 dd 2 ml nebulised</td>
<td>None</td>
<td>Frequent troublesome wheezy bronchitis despite regular bronchodilator therapy + symptoms in baseline period</td>
<td>0-2</td>
<td>49/44</td>
<td>2 weeks baseline, 2 x 4 weeks treatment</td>
<td>Daily symptom scores, clinical assessment, additional treatment</td>
<td>Unspecified</td>
<td>Equal/positive</td>
<td>Jadad: 2</td>
</tr>
<tr>
<td>Macias del Guadice et al (1992)</td>
<td>Hospital</td>
<td>Crossover</td>
<td>3 dd 20 mg nebulised</td>
<td>None</td>
<td>Perennial asthma and symptoms despite bronchodilator therapy</td>
<td>0-5</td>
<td>31/31</td>
<td>2 x 4 weeks</td>
<td>Daily symptom scores, additional treatment, clinical assessment</td>
<td>Cough, sneeze</td>
<td>Positive</td>
<td>Jadad: 4</td>
</tr>
</tbody>
</table>
### Table 1—continued

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>No of patients included/analysed</th>
<th>Duration of intervention period(s)</th>
<th>Major effects parameters</th>
<th>Side effects</th>
<th>Other effects</th>
<th>Study Setting Design</th>
<th>Study Setup</th>
<th>Inclusion criteria</th>
</tr>
</thead>
</table>
| **Inhaled disodium cromoglycate (DSCG) as maintenance therapy in children with asthma**
| **Geller et al. (1983)** | Crossover        | 48/43                          | 2 weeks baseline, 6 weeks treatment | Daily symptom scores, cough, wheeze and eczema | Cough, wheeze, eczema | None          | Hospital Parallel 3 dd 20 mg         | **23/91**   | Hospital, at least one episode of asthma in past 2 years |
| **Bernstein et al. (1983)** | Crossover        | 23/20                          | 2 weeks baseline, 8 weeks treatment | Daily symptom scores, additional treatment | Cough, wheeze, eczema | None          | Hospital Crossover 4 dd 20 mg         | **50/94**   | Previous history of asthma, presence of symptoms |
| **Chalmers et al. (1985)** | Hospital Parallel | 37/31                          | 3 weeks baseline, 6 weeks treatment | Daily symptom scores, cough | Daily symptom scores, cough | None          | Hospital Parallel 3 dd 20 mg         | **57/91**   | Hospital, recurrent wheezy bronchitis |
| **Cogswell et al. (1992)** | Crossover        | 16/16                          | 2 weeks baseline, 26 weeks treatment | Daily symptom scores, additional treatment | Cough, wheeze, eczema | None          | Hospital Crossover 6 dd 40 mg         | **22/94**   | Hospital, recurrent episodes of asthma |
| **Korelitz and colleagues (1994)** | General practice setting | 10/10                          | 2 weeks baseline, 26 weeks treatment | Daily symptom scores, cough | Daily symptom scores, cough | None          | Outpatients Parallel 3 dd 10 mg       | **13/91**   | General practice setting, recurrent episodes of asthma |
| **Bertelsen et al. (1994)** | Hospital Crossover | 16/16                          | 2 weeks baseline, 8 weeks treatment | Daily symptom scores, additional treatment | Cough, wheeze, eczema | None          | Hospital Crossover 6 dd 20 mg         | **26/94**   | Hospital, recurrent episodes of asthma |
| **Yuksel et al. (1995)** | Hospital Crossover | 16/16                          | 2 weeks baseline, 8 weeks treatment | Daily symptom scores, additional treatment | Cough, wheeze, eczema | None          | Hospital Crossover 6 dd 20 mg         | **25/94**   | Hospital, recurrent episodes of asthma |
| **Furfaro et al. (1996)** | Hospital Crossover | 16/16                          | 2 weeks baseline, 8 weeks treatment | Daily symptom scores, additional treatment | Cough, wheeze, eczema | None          | Hospital Crossover 6 dd 20 mg         | **22/94**   | Hospital, recurrent episodes of asthma |

**Note:** Jadad: 4 = Strong positive, Chalmers: 4 = Strong positive.
Results

STUDIES
A total of 251 articles was identified in Medline of which 18 met our inclusion criteria.23 40 Embase provided one additional trial,16 and two additional trials were provided by the database of the pharmaceutical company.41 The Cochrane Controlled Trial Register did not supply further trials but two more trials were found by searching the references of relevant articles.43 44 One additional trial was revealed to us by an expert in the field who also pointed out the trial by Shioda40 which we had overlooked in the Medline search. Excluded studies were either not double blind, not randomised, not controlled, did not concern the appropriate age group, or investigated the effectiveness of DSCG in exercise-induced asthma; one double blind crossover study was excluded because the results were only partially presented.44 Thus, 24 randomised controlled trials of DSCG as a prophylactic agent in children with asthma were reviewed (table 1). Most of the studies were European (n=14, 10 of which were British) or North American (n=7). Two studies were performed in Israel and one in Japan. Studies differed in design, severity of asthma, number of children included, age of children, administration of medication, and follow up period. In total, more than 1000 children were studied in the 24 trials with sample sizes ranging from nine to 218; about half of the children (11 trials) were of preschool age and half were five years or older (13 trials). Before 1977 the studies included only children aged four years and over. The median duration of intervention (period of active medication in case of crossover studies) was 4 weeks (range 3–26). All studies included children with moderate to severe asthma, and all but one study were hospital based. In nine papers it was unclear whether the population was hospitalised or ambulatory, nor was it clear whether and what concurrent medication was permitted during the trial.24 26 31 34 36 38 39 41 45 Only one trial selected children with moderate asthma through general practitioners.16 Compliance was discussed in only five papers.16 23 27 28 42
SIDE EFFECTS
Fifteen of the trials reported side effects, all of which were minor with a low incidence. Cough was most often reported, followed by bitter taste, sneezing, throat irritation, and perioral eczema. Some studies did not specify the kind of adverse effects but merely stated “minor”.

OUTCOME
A positive outcome was concluded by the authors in 16 of the studies and in three the outcome was partially positive, depending on age and outcome measure. Five of the trials had an equal outcome. No studies in favour of placebo treatment were found.

METHODOLOGICAL ASSESSMENT
The results of the methodological assessments are given in the last column of table 1. The Chalmers scores ranged from 24% to 79% with a mean score of 43% indicating mediocre methodology. The most prevalent methodological shortcomings were in the areas of compliance, selection and inclusion, and statistics and analysis. The descriptions of blinding and intervention were relatively good. Fourteen studies were published before 1980 and the mean method score for these was similar to that for the 10 trials reported after 1980. Our own recent study scored highest; to control for reviewers’ review bias the independent observer re-evaluated our study which resulted in similar scores. The Jadad scores ranged from 2 (five studies) to the maximum of 5 (one study).

STATISTICAL POOLING
For most studies the data were insufficient to allow a formal meta-analysis with odds ratios. Two studies did not give symptom score data or data that could be converted into symptom scores. Figure 1 presents two graphs of 95% CIs of differences in mean symptom score (placebo minus DSCG) for each study. The CIs are ordered according to year of publication of the study. In eight studies the CIs were calculated using the separate symptom score of wheeze and cough, and in 12 studies we used daytime symptoms. In two studies only the results for cough were presented; data on wheeze were not published because the difference in treatment effect between placebo and DSCG was not significant.

The χ² test rejected the hypothesis of homogeneity of the study results (p<0.001), both for the absolute and the relative outcome measures. Taking heterogeneity into account, the pooled 95% CIs for wheeze and cough were 0.11 to 0.26 and 0.13 to 0.27, respectively, and the pooled 95% CIs for RIM were 0.16 to 0.37 and 0.19 to 0.36. The heterogeneity was not related to the placebo symptom level (that is, severity of asthma), method of administration of the medication, duration of follow up, frequency of dosage, methodological scores, and other study characteristics. Only year of publication, age of the children, study design, and duration of follow up were significant predictors of outcome in the univariate regression analysis. The multivariate regression analysis showed that only year of publication was a significant predictor of effect size: older studies were more likely to produce a positive effect of DSCG treatment. Age of the children, which was strongly correlated with year of publication (r=0.82), was not significant in this analysis. The pooled 95% CIs under the assumption of heterogeneity and the corresponding tolerance intervals are shown in figs 1 and 2. The latter include zero, both for the absolute treatment effect (−0.11 to 0.48 for wheeze, −0.04 to 0.43 for cough) and for the relative treatment effect (−0.12 to 0.64 for wheeze, −0.02 to 0.57 for cough). The funnel plots are shown in fig 3; the hypothesis of symmetry was rejected for both cough (p=0.095) and wheeze (p=0.01). The asymmetrical funnel plots show that studies with low precision and negative outcome are underrepresented, indicating publication bias.

Discussion
Our results show heterogeneity of study results, a small overall treatment effect, and publication bias indicated by the absence of small negative trials.

STUDY CHARACTERISTICS
Although DSCG was indicated as treatment for mild to moderate asthma, nearly all trials
The diagnosis and measurement of asthma in young children is difficult and age effects might reduce or mask the effects of DSCG. Therefore, this is unlikely since, although children’s age was a significant predictor for treatment effect in the univariate analysis, the multivariate analysis showed that publication date of the trial was a confounder for age of the children. Duration of follow up in most of the trials did not exceed four weeks which may be too short to assess the effect of the treatment. Although the duration of follow up was not a predictor of outcome, it was notable that none of these short term trials had an “equal” conclusion (12 were positive and two were positive/equal). In severa trials the authors tried to find characteristics or criteria to predict which children would respond to DSCG but none were found.16 24 25 34 35 37 44 Silverman et al55 reported that only the acute protective effect of DSCG in exercise tests predicted the probable success or failure of long term treatment with the drug.

EARLIER REVIEWS
The effects of treatment with DSCG have been reviewed previously. Edwards50 examined the evidence for the anti-inflammatory action of DSCG in adults and children in a large number of controlled and uncontrolled studies but it is unclear how these were selected. Hoag and McFadden51 summarised studies on the effect of DSCG on bronchial hyperreactivity in adults and children. The review by Schweitzer and Brossier Ballano52 discussed three controlled studies assessing the efficacy of DSCG in children aged two years and younger. Finally, Holgate53 reviewed recent trials with metered dose inhalers in children and adults and discussed challenge studies, therapeutic studies, and the long term effects of DSCG. None of these earlier reviews were systematic, assessed the methodological quality, or tried to quantify treatment effects.

METHODOLOGICAL ASSESSMENT
Meta-analyses have been criticised but they are becoming increasingly popular because they give insight into the combined results of trials and provide data for rational decision making.54 55 A review of scales and checklists for assessing the quality of randomised controlled trials shows limitations in virtually every scale.55 We decided to use the items proposed by Chalmers53 because these address both the methodology and the presentation of the study extensively. However, we found shortcomings while using the scale, including the lack of attention to sample size, protocol violations, and permitted concurrent medication. The methodological quality of the trials was mediocre, as shown by the mean score of 43% of the maximum attainable. We have to take into account the fact that 13 studies were published before 1980. Informed consent, clear description of inclusion criteria, rejection logs and baseline characteristics, adequate sample size calculation, calculation of confidence intervals, and regression analysis were not common practice at that time.

We also scored the trials according to the criteria of Jadad as this is the only validated scoring system available.15 This scoring system was not found to be very discriminatory because, when dealing with randomised, placebo controlled trials only, as in our review, the outcome score was limited to 2–5. However, half of the studies scored 3 points or less, which is compatible with serious or extensive flaws.

STATISTICAL POOLING
The estimates of the differences between placebo and DSCG treatment for cough and wheeze symptom scores (assuming heterogeneity) were 0.17 and 0.11, respectively, which suggests a small therapeutic effect for DSCG. We doubt whether an effect of this size is of clinical relevance. On the other hand, the overall relative improvement estimates were 27% and 26%, respectively. This considerable relative improvement combined with the minor absolute improvement shows that, overall, the severity of symptoms under placebo treatment was low. Indeed, although most studies in our review included children with severe asthma, the mean daily symptom score in the placebo groups was low (0.8), probably because of dilution by symptom free days which is a common finding in trials of childhood asthma.56 57

Care must be taken in drawing definitive conclusions about the role of DSCG in the treatment of asthma in children on the basis of this review for several reasons. Medical literature can be misleading as a result of selective submission and publication of randomised controlled trials showing a statistically significant treatment effect.58 The year of publication of the study proved to be the most significant predictor of treatment effect and the asymmetrical shape of the funnel plots suggests bias; studies with a positive treatment effect had relatively little precision and most were performed before 1980. Trials with little precision and a negative outcome have probably not been submitted or published, which is understandable in a period when a newly developed drug is tested and marketed. Our meta-analysis is therefore optimistic in its outcome; the addition of unpublished negative trials would change the results towards an even more negative conclusion.

The trials were heterogeneous in their treatment effects. Refraining from pooling was seriously considered, given the heterogeneity and the suspected publication bias. Nevertheless, we calculated the pooled confidence intervals and the tolerance intervals because these are
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useful summary measures. In cases of heterogeneity, in particular, we consider the tolerance interval to be more informative than the (heterogeneous) confidence interval because the first gives the range of treatment effects found by studies while the latter is a confidence interval for a theoretical treatment effect.

In two trials &\textsuperscript{36} &\textsuperscript{39} the results for wheeze were not published because the difference between placebo and DSCG was not significant. This could result in some bias in favour of DSCG in the calculation for wheeze. On the other hand, two trials &\textsuperscript{36} &\textsuperscript{39} with a positive outcome were omitted from the pooling because the published data were insufficient. The results of the statistical pooling were based on symptoms only because symptom scores were available in all trials.

We did not include studies on the immediate effects of DSCG on exercise induced asthma. This is a different issue which does not pertain to the use of DSCG as advised in the current guidelines. Finally, we did not include studies on the effects of combined treatment—that is, the corticosteroid sparing effects of DSCG.

Given the strong indication of publication bias, the tolerance interval including zero, and the small overall treatment effect, we conclude that, on the basis of published randomised trials, the superiority of DSCG over placebo in the maintenance treatment of children with asthma is not proven. We therefore consider that it is no longer justified to recommend DSCG as a first line prophylactic agent in childhood asthma.

We thank Fisons plc, Loughborough, UK for searching their database for clinical trials, Dr A Edwards for pointing out two trial reports, and S M A Bierma-Zeinstra for scoring our trial.