

ORIGINAL ARTICLE

Effects of allergen and trigger factor avoidance advice in primary care on asthma control: a randomized-controlled trial

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Summary

Background Allergy contributes significantly to asthma exacerbation, yet avoidance of triggers, in particular allergens, is rarely addressed in detail in regular asthma review in primary care.

Objective To determine whether structured, individually tailored allergen and trigger avoidance advice, given as part of a primary care asthma review, improves lung function and asthma control.

Methods In a randomized-controlled trial 214 adults with asthma in six general practices were either offered usual care during a primary care asthma review or usual care with additional allergen and trigger identification (by skin prick testing and structured allergy assessment) and avoidance advice according to a standardized protocol by trained practice nurses. Main outcome measures were lung function, asthma control, asthma self-efficacy.

Results Both intervention groups were equivalent in demographic and asthma-related variables at baseline. At 3–6-month follow-up, patients receiving the allergen and trigger avoidance review showed significant improvements in lung function (assessed by blinded research nurses) compared with those receiving usual care. Significantly more patients in the intervention group than in the control group showed improvements in forced expiratory volume in 1 s $\geq 15\%$. No significant differences were found in self-report measures of asthma control. Asthma-specific self-efficacy improved in both groups but did not differ between groups.

Conclusions Allergen and trigger identification and avoidance advice, given as part of a structured asthma review delivered in primary care by nurses results in clinically important improvements in lung function but not self-report of asthma control.

Trial Registration ISRCTN45684820.

Keywords allergen, asthma, asthma management, education, primary care, skin prick test

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Introduction

Allergen exposure is among the major risk factors for asthma exacerbations [1]. National guidelines emphasize the need to address the allergic components of care [1, 2], and people with asthma rate advice about allergy and allergen avoidance as one of their highest priorities [3]. Both allergy and infection contribute to acute exacerbations of asthma resulting in hospital admission [4]. The burden of illness due to allergy is increasing and recommendations call for urgent improvements in the services

provided by the British National Health System [5]. Routine asthma care rarely addresses proactive allergen avoidance, focusing instead on reactive pharmacological manipulation in response to symptom control. Studies and meta-analyses of single allergen [house dust mite (HDM)] avoidance show inconsistent results [6, 7], and there is some evidence that an intensive multi-faceted programme of allergen and trigger avoidance improves asthma control in children [8]. In primary care, providing patients with HDM allergy with mattress covers and asthma self-management plans failed to improve asthma

control [9]. An effective intervention addressing allergen and trigger avoidance, and deliverable in primary care would represent a considerable advance in asthma care.

We recently reported the development and piloting of a structured allergy assessment and advice tool for primary care asthma review consultations [10]. These randomized data showed that structured allergy assessment and avoidance advice tailored to patients' environment given by a nurse during a routine asthma check was feasible, welcomed by patients and improved lung function.

We therefore carried out a larger randomized-controlled trial to test the hypothesis that structured identification of allergen and triggers, and avoidance advice given during a primary care asthma review improved asthma control. The study was powered to detect improvements in lung function, asthma control, and self-efficacy.

Methods

The study was a randomized-controlled trial with single-blinded repeated measurements, with data collection at baseline and 3–6-month follow-up. The study ran during a 13-month period from March 2005 to April 2006. Ethical approval was obtained from the Central and Bristol Research Ethics Committee.

Recruitment and selection of practices and patients

Six general practices in South London agreed to participate. We sent postal invitations to all adult patients between 18 and 65 years of age with a diagnosis of asthma on the practice asthma computer databases, inviting them to participate. Inclusion criteria were:

- Diagnosis of asthma [confirmed by 20% peak expiratory flow (PEF) diurnal variation in medical records or 15% reversibility on spirometry].
- Prescribed asthma medication within the past year.
- No skin prick testing (SPT) in the past 10 years.

Patients expressing an interest in taking part were invited to attend an assessment at their practice by the study research nurse comprising spirometry and baseline assessment. Written informed consent was obtained from eligible patients.

Spirometry and baseline assessment

We asked patients to discontinue short- and long-acting bronchodilators for 12 h before assessment. Lung function was measured using a MicroLab spirometer (Micro Medical Ltd, Rochester, UK) recording forced vital capacity (FVC), forced expiratory volume in 1 s (FEV₁) and PEF. Reversibility was tested 20 min after a dose of 400 µg of the patients' regular short acting β -agonist inhaler (salbu-

tamol or terbutaline), administered by their normal inhaler. A small volume spacer was used with a multi-dose inhaler if the patients' inhaler technique was found to be poor. Patients completed questionnaires of demography and study outcomes.

Randomization

After baseline assessments by blinded study nurses, patients were passed to the practice nurse, who then contacted the research coordinator with details of the eligible patient. The coordinator randomized patients to structured allergen and trigger avoidance advice (AAA – intervention) or usual asthma review (UC – control) using a computer minimization programme (MINIM 2.0), maintaining allocation concealment. Minimization variables were: gender, smoking status, atopy, and British Thoracic Society (BTS) treatment step. The practice nurse then carried out the appropriate asthma review according to the patient's allocation.

Intervention and usual care

All reviews for intervention and usual care patients were carried out by practice nurses trained in asthma and allergy management by the National Asthma and Respiratory Centre. All practice nurses underwent a training day to standardize the asthma reviews and assessments delivered in the study.

Control patients. UC consisted of assessment of symptoms, inhaler technique, and medication usage, and provision of self-management action plans.

Intervention patients. AAA intervention comprised the elements of a usual review as above, supplemented by an asthma and allergy assessment consisting of:

- Completion of the Structured Allergy Inventory (SAI) and Asthma Trigger Inventory (ATI).
- SPT.
- Individual avoidance advice for identified triggers.

After 3–6-month follow-up assessments, UC patients received the additional AAA intervention.

Instruments used in allergen and trigger avoidance advice reviews

SPT was carried out for seven common aeroallergens: grass pollen, tree pollen, HDM, cat dander, dog dander, and two fungi, with histamine and saline solutions for positive and negative controls. Tests were performed according to standard protocols on the volar aspect of the forearm > 5 cm above distal skin crease at the wrist.

After 15 min the test site was examined for the presence of wheal and erythema formation. A wheal size ≥ 3 mm (test solution minus negative control) was regarded as positive. Antihistamines were discontinued for at least 48 h before the test.

The SAI is a structured interview by the practice nurse, with self-administered inventory of asthma trigger history and avoidance behaviours [10]. The first part of the interview explores history, type, frequency, duration, and seasonal patterns of allergic symptoms, trigger factors, and previous treatments. In addition, aspects of the home environment that may constitute allergic or non-specific triggers (moulds, dust mite, pollen, pets, smoking, indoor climate) are explored [11]. Two open-ended questions allow patients to elaborate on their main concerns related to these aspects and on any additional allergy-related problems. The second part focuses on avoidance measures. Patients complete a checklist of standard measures for allergen avoidance indicating those which they already took. The problem areas include prevention or reduction of exposure to HDM (number of measures: 14), pets (8), pollens (5), indoors (7) and outdoors (5) mildew or fungus, irritants (10), and other non-specific triggers (6) (adapted from standard material provided by the British Allergy Foundation, Welling, UK, and the UCB Institute of Allergy, Watford, UK). Typical advice for HDM avoidance was for example, 'Vacuum beds once a week – air bed/sheets twice weekly', 'Limit the amount of furry toys or cushions', and 'Bed mattress and pillows should be latex or polyester foam (consider buying dust free covers)'. For pet allergen, typical suggestions were 'Brush furry pets regularly outside house' or 'Restrict to kitchen or one particular room' (see Appendix for the full list). From the measures listed for a respective problem area, the percentage of measures endorsed by the patient are calculated and averaged across problem areas.

The ATI [12] is a self-completed checklist of asthma trigger factors (including allergens, infection, air pollution/irritants, physical activities, and psychological triggers). Patients rate on a five-point scale how often the particular trigger has been related to their asthma symptoms. These scales have good to excellent reliabilities in community practice. In addition, patients list up to six of their most important asthma triggers and rate on a five-point scale the degree to which the respective trigger affects their daily life and how much they were able to control or avoid the trigger without bronchodilator medication. Scores for trigger impact and trigger control are obtained by averaging the ratings for the (up to) six triggers.

Outcome measures

Blinded research nurses assessed the following measures before randomization and at a follow-up visit 4 months

after asthma review. Asthma control, determined by the Asthma Control Questionnaire (ACQ) and FEV₁ were co-primary outcome measures.

Self-completion scales. The ACQ [13] comprises seven items and has excellent validity and reliability. Only the six self-report items were used to separate more clearly aspects of lung function and patients' perception as outcome variables.

The Perceived Control of Asthma Questionnaire is an 11-item measure of patients' perception of how well they are able to control and manage their asthma [14].

The Asthma Self-Efficacy Scale [15] is a 20-item scale measuring patients' confidence and feeling of mastery in the management of their illness.

The North of England Asthma Scale [16] measures symptom frequency and distress using 10 symptom items.

Lung function measures comprised FEV₁, FEV₁% predicted, FEV₁/FVC, PEF, and PEF% predicted.

Unblinded practice nurses carrying out the asthma reviews collected further information on standard clinical audit cards (Glaxo Smith Kline, Brentford, Middlesex, UK) at baseline and at 3–6-month-follow-up: prescribed medication, current smoking, inhaler technique and perceived concordance with therapy (1 = good, 2 = poor), and current restrictions by symptoms at daytime and nighttime (0 = never, 1 = once or twice per month, 2 = once or twice per week, 3 = daily/nightly), and on activity (0 = rarely, 1 = on exercise, 2 = hills/stairs, 3 = walking on flat). In addition, PEF standing was recorded and lung age [17] calculated.

Procedure

Patients were scheduled for two individual appointments in their primary care practice. They were asked to discontinue short- and long-acting bronchodilators before test sessions. Initially, all patients received the regular elements of UC. Patients in UC were told that they had been randomized into this condition and would receive skin testing at the second visit. Patients then underwent spirometry and reversibility testing and were administered the questionnaire measures for self-completion in a separate room by blinded research nurses. The AAA intervention group was additionally administered the ATI and SAI and received SPTs. After 15-min wait-time, practice nurses discussed test results with the patients and referred back to their perceptions of triggers reported in the SAI and ATI. Depending on the identified problem areas and reported avoidance skills, further individualized avoidance advice was provided (for non-atopic patients focused on irritants and non-specific triggers). Overall, the procedures in the AAA condition added approximately 45 min to the time patients spent in the practice. Patients returned for a follow-up visit 3–6 months later for regular check-up (UC) and blinded assessments of

outcome variables. All patients filled in the ATI and SAI at this stage and all previous UC patients were now offered SPTs followed by individualized allergen and trigger advice.

Study power

Power estimation was based on the ACQ and FEV₁. With mean scores for the ACQ in an average population of asthmatics of 1.49 (SD = 0.66), (ELEVATE study, D. Price, personal communication), we needed 78 patients per group to have over 90% power, with $\alpha = 0.05$, to detect a minimum clinically important difference of 0.5. Allowing for a dropout rate of 20% this figure was inflated to 100 per group as the recruitment target. Lesser numbers – 45 per group – are needed to detect a clinically relevant 10% change in FEV₁.

Data analysis

To test for equivalence of groups in dependent variables at baseline we calculated *t*-tests, Mann–Whitney *U*-tests, or χ^2 -tests where appropriate. As trigger assessment and education by the ATI was not provided in UC, only before and after comparisons within the AAA intervention were made. All analyses were conducted on an intent-to-treat basis.

For the primary outcome measures, ACQ and FEV₁, and further main outcome variables we calculated analysis of covariance (ANCOVA) with baseline values as covariates to compare follow-up values of outcome variables between both groups [18]. Additional two-way repeated measure analysis of variance (ANOVA) were calculated with Group (intervention, control) as the between-subjects variable and Time (baseline, follow-up) as the within-subjects variable to establish whether changes from baseline to follow-up had occurred in both groups equally (Time effects) or dependent on group assignments (Group $\times$ Time interactions; e.g. increase in FEV₁ for intervention vs. stable FEV₁ in controls). Changes in variables that deviated from normal distribution were calculated within each group by Wilcoxon's rank sum test. We expected that outcome measures of clinical asthma control (symptoms, lung function, and perceived control) would improve specifically in the intervention group. A significance level of $P < 0.05$ was set for all tests.

Results

Participation

Figure 1 gives participant flow through the study. Of 1296 patients contacted, 339 (26%) patients responded. Of these, 125 were excluded for one or more of the following reasons: chronic obstructive pulmonary disease, restric-

tive defect on spirometry, learning difficulties, SPTs within the recent 10 years, pregnancy, difficulty with spoken or written English language, or moving home in the near future.

Two hundred and fourteen patients were randomly assigned to the AAA intervention or UC and seen for the baseline assessment. At follow-up, data were unavailable for 35 (16%) for the following reasons: did not attend, current illness, pregnancy, or moving home from the area. The sample at follow-up was 179 patients, of these, $n = 82$ had been assigned to UC and $n = 97$ patients to AAA intervention.

Baseline assessment

Intervention and control groups did not differ significantly in demographics and disease manifestation (see Table 1). Patients were mostly treated on Step 2 or 3 of the BTS guidelines. Among the patients' personal strongest triggers, house dust was reported by 39.4% of the intervention group, animal- and hair-related triggers by 33.9%, and pollen by 30.3%. Moulds or mildew were reported by none of the patients. Initial awareness of trigger countermeasures in the intervention group was with 5.5% low on average, recognition rates ranged between 1.3% (non-allergic triggers) and 13.6% (HDM). Reports of animals and house dust, but not pollen, as major triggers were related to the level of knowledge of avoidance measures, $Z = 1.87$ and 2.72 , $P = 0.062$ and 0.007 , respectively.

There were no significant differences between groups for outcome measures at baseline (P 's < 0.060 – 0.870).

Intervention effects

FEV₁ was higher in the intervention than control group at endpoint (ANCOVA findings in Table 2), whereas the ASQ did not distinguish both groups. Among the additional outcome variables, further spirometric lung function indices PEF% predicted, FEV₁% predicted, and FEV₁/FVC were also significantly higher and lung age was lower in the intervention group at endpoint. Effect sizes (Cohen's *d*) for group differences at follow-up in FEV₁, PEF% predicted, FEV₁% predicted, FEV₁/FVC and lung age were small to moderate on average by convention (Table 2). Questionnaire measures of clinical asthma control did not distinguish groups at follow-up.

Repeated measures ANOVAS showed that spirometric lung function was improved at follow-up in the intervention group but remained stable in the control group, as suggested by the significant Group $\times$ Time interaction for PEF% predicted, FEV₁, FEV₁% predicted, and FEV₁/FVC, and lung age (Table 2). A significantly larger number of patients in the intervention than control group improved their FEV₁ by $\geq 12\%$ [24.1% vs. 9.6%, $\chi^2(1) = 7.86$,

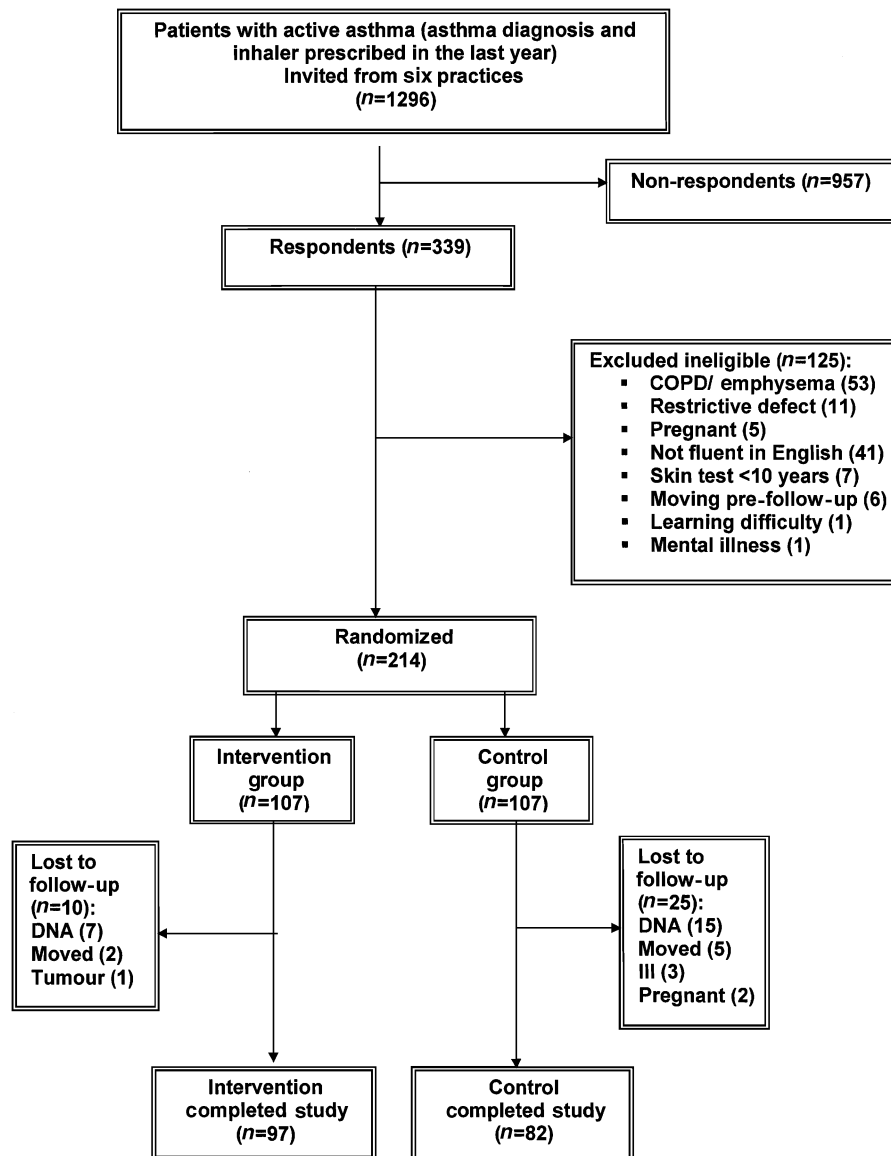


Fig. 1. Participant flow: allergen and trigger advice intervention and usual care control groups.

$P=0.006$] or $\geq 15\%$ [17.6% vs. 3.8%, $\chi^2(1)=10.35$, $P=0.002$]. The questionnaire measure of asthma self-efficacy showed significant improvements over time for both groups equally, as suggested by a significant time effect only (Table 2).

Results did not change substantially when analyses were repeated only for trial completers. Separating groups according to the season of the initial session (May–September vs. October–April, as the additional independent variable Season in the repeated measures ANOVA) did not change results in outcome variables, only for perceived control of asthma a three-way interaction of Group $\times$ Season $\times$ Time was observed, $F(1, 207)=5.51$, $P=0.020$, with decreases in perceived control in the intervention group when the initial appointment was in May to September,

compared with increases under all other group by season combinations.

Among the secondary variables collected by nurses not blind to the group assignments only nurse-determined standing PEF reflected the advantage of the intervention group seen in blinded assessments of spirometry (Table 2). Repeated measures ANOVAS suggested improvements in restrictions by symptoms at daytime, nighttime, and on activity in both groups equally, Time effects were $F(1, 207)=9.94$, 6.81, and 20.49, $P<0.002$, 0.010, and 0.001, respectively. Inhaler technique and therapy compliance also improved over time in the intervention ($Z=-3.40$ and -4.75 , $P's<0.001$, respectively) and control group ($Z=-2.36$ and -4.26 , $P=0.018$ and $P<0.001$, respectively).

Table 1. Demographics, asthma-related variables, and lung function at baseline

	Intervention	Control	P-level of group difference
Sex, women (%)	66.1	70.2	0.558
Ethnic origin, White European (%)	73.3	62.4	0.102
Education, A-levels and degree (%)	34.0	41.7	0.303
Smoking, current non-smoker (%)	85.9	80.0	0.334
Family history of asthma, positive (%)	67.0	76.8	0.175
Seasonal variations in asthma (%)	54.8	52.9	0.889
Rarely sleep night through (%)	22.2	20.6	0.862
BTS treatment step (%)			
Step 1	11.8	15.1	0.533
Step 2	55.9	51.6	0.568
Step 3	32.4	32.3	1.000
Step 4	0.0	1.1	0.477
Age, years (<i>M</i> , <i>SD</i>)	47.2 (11.9)	41.3 (11.2)	0.055
Age at asthma onset, years (<i>M</i> , <i>SD</i>)	26.0 (18.3)	25.5 (17.4)	0.860
Asthma-related GP visits, previous year (range)	1.8 (0–20)	2.5 (0–12)	0.108
Repeat prescription visits, previous year (range)	3.5 (0–12)	3.1 (0–12)	0.405
E&A visits, lifetime (range)	1.9 (0–30)	1.1 (0–14)	0.127
Limitation on physical activity, rating 0–3 (<i>SD</i>)	1.5 (0.8)	1.6 (0.8)	0.231
PEF (L/min)	361.3 (100.0)	372.5 (113.6)	0.445
FEV ₁ (ml)	2.43 (0.73)	2.47 (0.78)	0.624
FEV ₁ (% predicted)	84.2 (18.4)	85.6 (17.5)	0.553
Bronchodilator: Δ FEV ₁ > 200 ml (%)	43.3	40.8	0.283
Skin prick test (% negative*)	26.0	28.8	0.739
Skin prick test (% positive*)			
House dust mite	51.9	41.3	0.656
Cat dander	45.2	41.3	0.654
Dog dander	51.0	41.3	0.233
Tree pollen	29.8	33.8	0.632
Grass pollen	48.1	53.8	0.461
Indoor fungus	19.2	17.5	0.849
Outdoor fungus	21.2	22.5	0.858

*Data for the control group was collected after 3–6-month follow-up assessments.

BTS, British Thoracic Society; FEV₁, forced expiratory volume in 1 s; PEF, peak expiratory flow.

The overall number of avoidance measures increased from baseline to follow-up, $Z = -5.57$, $P < 0.001$. At follow-up, patients of the intervention group showed positive associations of their baseline SPT wheal size for cat and dog allergens with pet avoidance measures, $r = 0.36$ and 0.31 , $P < 0.001$ and 0.002 , respectively, as well as wheal size for grass allergens with pollen avoidance measures, $r = 0.25$, $P = 0.010$. Also, patients in this group who had not reported animal triggers among their top triggers ($n = 74$) showed an increase in their animal-related ATI trigger score at follow-up ($Z = -2.73$, $P = 0.008$). Reports of ATI perceived trigger impact and control remained stable.

There were no substantial changes in finding when groups were separated into atopic vs. non-atopic patients (at least one positive skin test result vs. none). The only additional significant finding was that within the intervention group, perceived trigger control was higher at follow-up in the atopic subgroup, ANCOVA group effect, $F(1, 96) = 5.58$, $P = 0.020$.

In the intervention group, 12 patients increased their medication one step, one stepped up two steps, and five stepped down one step. On average, there was a significant change towards higher BTS steps for the intervention group, $Z = -1.96$, $P = 0.050$. In the control group, six patients increased their medication one step and three decreased one step, resulting in no change in medication on average in this group ($Z = -1.00$ NS). Intervention patients who increased their medication were not significantly different in FEV₁ at follow-up from intervention patients who remained on a stable medication: 2.62 (95% CI: 2.44–2.80) vs. 2.53 (95% CI: 2.47–2.60), ANCOVA group effect $F < 1$. Nevertheless, in order to ascertain that intervention effects were not due to medication change, analysis of outcome variables was repeated with only those patients that showed no medication change ($n = 91$ intervention and $n = 94$ control patients, based on intent-to-treat). Findings were not substantially different in this reduced sample and all significant effects were retained.

Table 2. Outcome measures at follow-up and effects

	Group	Follow-up		ANCOVA group effect	Effect size		ANOVA effects involving time
		<i>M</i>	95% CI		<i>d</i>	95% CI	
Asthma self-efficacy	Control	78.4	76.8–80.0		0.07	–0.34–0.96	T**
	Intervention	79.0	77.4–80.6				
PEF%	Control	87.0	84.4–89.7	G*	0.28	0.00–0.55	T***; G×T*
	Intervention	90.7	88.2–93.3				
FEV ₁ (L)	Control	2.45	2.40–2.50	G**	0.40	0.13–0.67	T**; G×T***
	Intervention	2.57	2.52–2.62				
FEV ₁ %	Control	85.5	83.6–87.4	G*	0.38	0.10–0.65	T***; G×T**
	Intervention	89.0	87.2–90.8				
FEV ₁ /FVC	Control	73.1	72.0–74.2	G**	0.42	0.15–0.69	T**; G×T**
	Intervention	75.4	74.4–76.5				
Lung age (years)	Control	62.4	60.6–64.2	G**	0.36	0.08–0.63	T**; G×T**
	Intervention	59.1	57.3–60.8				
Nurse-review standing PEF (L/min)	Control	394.6	385.1–404.0	G**	0.42	0.15–0.70	T*; G×T**
	Intervention	414.8	405.7–424.0				

p* < .05.*p* < .01.****p* < .001.ANOVA, analysis of variance; *M*, mean; 95% CI, 95% confidence interval; T, time effect; G×T, Group×Time; G, group effect; FEV₁, forced expiratory volume in 1 s; FVC, forced vital capacity; PEF, peak expiratory flow.

No patients were admitted to hospital and none were seen as emergencies in the time between appointments while taking part in the study. Only two patients visited their practice before follow-up for medication changes. The remaining patients that had medication changes initiated these independently following their asthma action plan.

Discussion

Our study showed that structured assessment of allergens and triggers and avoidance advice provided by a trained practice nurse in a primary care asthma review resulted in clinically important improvements in lung function 4 months later, while perceived symptoms and disease control were unaffected. The improvements in lung function were found in data provided by both blinded research nurses carrying out the research assessments and by unblinded practice nurses during the asthma reviews, lending support to the veracity of our finding. Furthermore, these findings replicate those of our pilot study suggesting the efficacy of structured allergy advice [10].

In the current study, more patients in the intervention group increased their medication step than did control patients. However, sensitivity analysis excluding patients who altered their treatment step did not materially alter the results, suggesting that improved lung function was unlikely to be due to increased medication use alone.

We found that changes in self-report measures of asthma control, either reported by patients or assessed by

practice nurses during clinics, did not reflect the lung function changes observed in the intervention group. This could have a number of explanations. First, the relationship between lung function and perceived symptoms is not strong and patients, on average, may simply not have perceived an improvement. It must be taken into account that symptom self-report and lung function change have been divergent in other treatment studies before [19–22] and correlations between these assessment domains are often far from perfect [23–25]. Second, our instruments may have been too insensitive to detect a change. This seems unlikely since we used a range of measures which have demonstrated responsiveness to change in other studies. Third, we may have used too many questionnaires, resulting in reporting fatigue by patients and inaccurate recording of symptom data. Further studies are needed to elucidate the impact of our intervention on patients' perception of asthma control.

Our study had good internal validity with allocation concealment during randomization, blinded assessment of the main outcomes, was analysed on an intention-to-treat basis, and was adequately statistically powered to detect clinically important changes. We recruited a group of patients to the study from primary care who had perhaps slightly more troublesome asthma than average, with just over one third from BTS step 3. Notwithstanding, they were representative of primary care patients with moderate asthma. Follow-up rates were acceptable for a pragmatic primary care health service research trial [9]. We did not have the resources to carry out a health economic assessment, but since the allergy assessment

takes extra nursing time, the benefits may be balanced against opportunity costs of nursing time.

This is the first full trial to report the effect of a structured allergy assessment and advice intervention in primary care. Studies testing allergen avoidance interventions (rather than education or advice about allergen and trigger avoidance) have shown conflicting results and have been generally disappointing in their impact. Those promoting interventions around a single allergen [7, 9, 26] have perhaps been less successful than multi-allergen avoidance interventions [8, 27, 28]. Indeed, a relatively intense intervention delivered in primary care (bed mattresses and self-management plans) proved ineffective [9]. This view would be consistent with our findings, since intervention patients in our study acting on the advice they received would presumably have altered their behaviour with respect to a range of allergens. Most asthma patients are sensitive to a range of allergens or triggers and control is unlikely to be improved by addressing only one allergen.

Our study is limited in that only a smaller percentage of those invited to the study were included in the trial. We do not know whether responders were different from non-responders, which may have affected the representativeness of our sample. The rigour of an RCT that is necessary to prove that an intervention is efficacious may work against high recruitment and retention rates and thus limit the generalizability of findings. A further limitation was the lack of behavioural indicators of avoidance measure implementation. Budgetary constraints did prohibit the collection of such data. However, overall knowledge of avoidance measures and awareness of pet allergens as triggers improved in the intervention group and those who had tested positive in certain allergens at baseline also demonstrated higher awareness of relevant avoidance measures at follow-up. More complex studies are needed in the future that also implement ambulatory behaviour monitoring. Our study also did not control for non-specific effects such as more time and attention dedicated to the intervention group. However, it would be difficult to understand how an additional 45 min of practice time (approximately 15-min questionnaires and skin test, 15-min wait-time, and 15-min individualized avoidance advice) as such would lead to improved lung function 3 months later. Finally, we do not know at this point which element of the intervention was more effective, the allergy testing, the advice, or the general non-specific trigger advice given to everyone in treatment. Studies are needed that systematically investigate effects on individual components of our intervention.

Our finding of clinically relevant improvements in lung function in people with asthma after an asthma review directed at improving allergen and trigger avoidance suggests this is an intervention that could improve asthma management. We recommend that further well-designed

studies, including health economic analyses, examine this question. If these confirmed our results there would be a strong case for incorporating this activity into routine primary care asthma reviews. The recommended structure of asthma reviews currently lack structured assessment of triggers, allergy skin testing, and individualized allergen avoidance and focus on reactive management by pharmacological manipulation. Many patients welcome non-pharmacological approaches to controlling asthma. This approach could meet with approval of patients as well delivering improved asthma control.

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Appendix: Structured Allergen Inventory – Avoidance Measures

Please tick any of the avoidance measures that you already take on the lists below.

HDM

- Principally for the bedroom, where we spend one 1/3 of our lives.
 - Vacuum every day (you may need to consider changing your vacuum cleaner to one with filters that prevent dust coming back into the room).
 - Vacuum beds once a week – air bed/sheets twice weekly.
 - Wash bed linen at a wash of 55 °C or higher weekly and change bed linen twice weekly.
 - Wash furry toys at a wash of 55 °C or higher once monthly – freeze unwashable toys monthly for 6 h.
 - Limit the amount of furry toys or cushions.
 - Bed mattress and pillows should be latex or polyester foam (consider buying dust free covers).
 - No eiderdowns or feather quilts or pillows.
 - Damp dust furniture or vacuum.
 - Avoid wall to wall carpeting or rugs.
 - Discard unnecessary furniture that might harbour dust.
 - Washable flooring is preferable, e.g. Linoleum, wood, stone, tiles.
 - Smooth walls with latex paint or washable wallpaper.
 - Thin curtains (washable) or blinds.
 - Fresh air room briefly daily.

Pets

- Pets are one of the major sources of allergy that are commonplace and may make other allergies worse.

Some animal allergens:

- saliva (dog, cat, horse, etc.),
- urine (cat, dog, small laboratory animals, etc.),
- serum (= part of blood),
- scales (dead skin debris),
- epithelium (= skin),
- excrement (parrot, pigeon, etc.)
 - Do not keep pets such as – hamsters, guinea-pigs, rabbits, mice, rats or birds.
 - Brush furry pets regularly outside house.
 - Bath/or damp dust the pet weekly.
 - Do not replace pet when gone – animal allergens can linger for several months after pet has gone.
 - Keep out of the bedroom.
 - Avoid and reduce contact with pets.
 - Occasional contact can also set off the allergy e.g. when visiting other places where animals are.
 - Restrict to kitchen or one particular room.

Pollens

- Listen to pollen counts on the radio, television, or read newspaper report.
- Avoid going out when pollen counts are high in afternoon or evening.
- During the pollen season keep windows of house and car shut.
- Refrain from country walks or gardening in peak periods.
- Beware of honey (there might be pollen allergen in it).

Mould/mildew

- Is a kind of filamentous fungus that produces spores. The atmospheric spore count depends on hot and humid weather conditions (maximum in the late summer and early autumn). They can be found outside, in the air or on rotting vegetation as well as indoors.

Mildew indoors

- Allow plenty of fresh air or sunshine to the places where mildew grows.
- Ventilate confined areas in bathrooms, kitchens, laundry, cellars and attics.
- Resolve any damp problems, e.g. seeping water, rising damp, etc.
- Clean and disinfect air conditioning conduits.
- Do not leave mouldy food in the fridge or lying around.
- Watch out for flower pots with soil coated with white or orange substance (= mildew).
- Wallpaper encourages mildew-it grows behind the paper.

Outdoor mildew

- Don't go for walks in the woods after rainfall or in foggy weather.

- Don't touch rotting dead leaves or dead wood.
- Avoid turning compost heaps, cutting grass, raking up leaves.
- Avoid walking near fields during grain harvesting; avoid entering grain and hay barns.
- Don't go into buildings, which are damp and musty.

Irritants which may cause bronchial hyperreactivity, to avoid

- Tobacco smoke.
 - Do not smoke, tobacco, nicotine (makes congestion worse).
 - Ask smokers not to smoke inside the house.
 - Have household members smoke outside, they should also remain outside for 1/2 h after smoking.
- Irritant gases (often aerosol sprays).
- Fibre-glass.
- Chalk dust.
- Insecticides and fungicides (these are often sprayed on fruit and vegetables).
- Perfume and hair lacquer.
- Paint.
- Chemicals (often sprayed on new carpets and other soft furnishings).

Other non-specific triggers to also be aware of

- Hyperventilation (use a paper bag).
- Temperature changes.
- Cold/fog (wear a scarf over mouth).
- Stress or strain.
- Strong emotions (laughing/crying).
- Exercise (use β_2 -agonist before exercise).

(adapted from British Allergy Foundation, Welling, UK, and the UBC Institute of Allergy, Watford, UK)