

Predicting asthma control: The role of psychological triggers

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ABSTRACT

Asthma triggers have been linked to adverse health outcomes in asthma, but little is known about their association with asthma control. Because trigger avoidance is an integral part of successful asthma management, psychological triggers in particular may be associated with suboptimal asthma control, given the difficulty of controlling them. We examined cross-sectional and longitudinal associations of perceived asthma triggers with self-report of asthma control impairment, symptoms, and spirometric lung function (forced expiratory volume in the 1st second, [FEV₁]) in 179 adult primary care asthma patients. Perceived asthma triggers explained up to 42.5% of the variance in asthma control and symptoms, but not in FEV₁ alone. Allergic triggers explained up to 12.1% of the asthma control and symptom variance, three nonallergic trigger types, air pollution/irritants, physical activity, and infection, explained up to 26.2% over and above allergic triggers, and psychological triggers up to 9.5% over and above all other triggers. Psychological triggers alone explained up to 33.9% of the variance and were the only trigger class that was consistently significant in all final multiple regression models predicting control and symptoms. Psychological triggers also predicted lower asthma control 3–6 months later, although controlling for initial asthma control eliminated this association. In free reports of individually relevant triggers, only psychological triggers were associated with suboptimal asthma control. Trigger factors are important predictors of self-reported asthma control and symptoms but not actual lung function. Particular attention should be directed to psychological triggers as indicators of patients' perceptions of suboptimal asthma control.

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Asthma continues to pose a significant burden to health care systems.^{1–3} Control of asthma is currently viewed as paramount among the clinical end points of asthma treatment.^{2–4} Expanding our knowledge about factors that determine asthma control has thus become a priority. Because a variety of trigger factors is known to result in asthma symptoms or exacerbations and thus reductions in asthma control, reducing the impact of asthma triggers is one of the major goals of asthma management.^{1,2,5} However, individuals vary in their susceptibility to triggers^{6,7} and little is known about the extent to which individual susceptibilities are systematically related to asthma control. Given that atopy is strongly associated with asthma pathophysiology, allergic triggers are generally viewed as particularly detrimental to asthma control. Thus, much research has focused on reducing exposure to allergic triggers such as house-dust mites, pets, and molds.^{8,9} However, outcomes in terms of improvements of asthma control have not always been convincing.^{10,11}

Little attention has been directed toward other trigger factors and their association with asthma control, although models of illness perception have identified patients' perceptions of their illness, including its potential causes, as major predictors of patients' illness management outcomes.^{12–14} We have recently developed and evaluated a self-report inventory to capture trigger perceptions of patients with asthma.^{7,15,16} It measures the perceived importance of major trigger classes, such as animal and pollen allergens, air pollution/irritants, physical activity, infections, and psychological triggers for eliciting symptom episodes. One of the major findings from this work was that patients who endorse more nonallergic asthma triggers are more likely to also report feeling less in control of their asthma management and having a lower quality of life.^{7,15} In contrast, patients' reports of allergic triggers were not associated with any of these variables. Among the nonallergic triggers, psychological trigger factors were most prominent predictors of perceived control over asthma management and reduced quality of life.

Given our earlier insights with perceived asthma triggers, we expected that nonallergic triggers in particular would be associated with a reduced asthma control. To measure impairment of asthma control, we used the Asthma Control Questionnaire (ACQ),^{17,18} which includes scoring of forced expiratory volume in the 1st second (FEV₁) as one of seven phenomena of asthma control, in addition to symptoms, daily functioning, and bronchodilator use. We sought to study

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the cross-sectional and longitudinal relationship of perceived asthma triggers with this composite score of asthma control impairment as well as FEV₁ and symptoms separately. Spirometric lung function, including FEV₁, is currently viewed as one of the most fundamental indicators of asthma control.¹⁹ Among possible nonallergic trigger factors, psychological triggers were expected to be particularly problematic for asthma control, given the difficulty of avoiding them and the uncertainty about pathophysiological pathways and their responsiveness to medication.

METHODS

Participants

Patients with asthma ($n = 179$) were recruited from six general primary care practices in south London. Inclusion criteria were prior diagnosis of asthma (confirmed by 20% peak flow diurnal variation in medical records or 15% reversibility on spirometry), age between 18 and 65 years, and asthma medication prescribed within the past year. Patients participated in a randomized clinical trial testing asthma trigger avoidance advice intervention. The active intervention ($n = 97$) included an individualized assessment of triggers including allergen skin testing and advice focused primarily on allergic triggers and standard indoor and outdoor avoidance measures (further details of the intervention are discussed by Bobb *et al.*²⁰). Patients in usual care served as controls ($n = 82$). Intervention patients provided measurements at pretrial and 3–6 months posttrial whereas the control group provided only posttrial measurements to avoid contamination of usual care with pretrial trigger assessments. The study was approved by the Central and Bristol Research Ethics Committee, and all patients signed informed written consent.

Instruments and Tests

Spirometric lung function was measured with a MicroLab spirometer (Micro Medical, Ltd., Rochester, U.K.). The best of three blows provided FEV₁ as percent of predicted. Patients had been asked to discontinue short- and long-acting bronchodilators for 12 hours before assessment.

The Asthma Trigger Inventory (ATI)⁷ is a 32-item list measuring patients' frequency of experience of asthma triggers on six subscales with 3–10 items each: psychological factors (*e.g.*, depressed mood, being angry), animal allergens (*e.g.*, animal hair, cats), pollen allergens (*e.g.*, pollen from trees, pollen from grass), physical activity (*e.g.*, running, climbing flights of stairs), infection (*e.g.*, colds, flu), and air pollution/irritants (*e.g.*, cigarette smoke, perfume) as triggers of asthma symptoms or exacerbations. The 10-item psychological trigger subscale also included items such as "feeling

alone," "stress at home," "being excited," "arguments with people," "intense worries," "feeling unhappy," "feeling weak," and "feeling tense." Patients rated on a 5-point scale (from 0 = "never" to 4 = "always") how often they had experienced each trigger personally as a cause of their symptoms. An additional free response format section of the questionnaire allows patients to list up to six of their personally most relevant triggers. Among other trigger categories sometimes mentioned as personally relevant are climate, medication, food, and sleep,⁷ but because these were not established as separate subscales in the initial questionnaire evaluation the present report was limited to trigger categories that matched the extracted subscales.

The Asthma Control Questionnaire (ACQ)^{17,18} is a seven-item measure of asthma control in the previous week supported by current guidelines.² Although it is primarily a self-report measure, the inclusion of FEV₁ with one item distinguishes it for other control measures that exclusively reflect the perception of the patient, such as the Asthma Control Test.²¹

The Asthma Symptom Questionnaire (ASQ; also North of England Asthma Scale)²² was used to assess frequency of asthma-related symptoms in the past week with 10 items.

Additional Variables. Information on demographics, disease manifestation, and treatment were collected on a separate *ad hoc* questionnaire. Asthma severity was rated by study personnel following the British Thoracic Society scheme based on steps of medication treatment.²³

Procedures

All patients received the regular elements of usual care (assessment of symptoms, inhaler technique, and medication usage and provision of self-management action plans). A blinded research nurse performed spirometry and administered the questionnaires in a separate room. The advice group was additionally administered the ATI, was further interviewed about individual triggers, and received skin-prick tests. Patients returned for a follow-up visit 3–6 months later for usual care checkup and blinded assessments with spirometry and questionnaires. All patients filled in the ATI at this stage.

Statistical Analysis

An earlier report²⁰ on intervention outcomes showed that groups were equivalent in baseline characteristics, including ACQ, ASQ, and FEV₁. At postintervention, only FEV₁ was significantly improved over control. Here, we focus on the cross-sectional and longitudinal associations between asthma triggers and asthma control for the whole sample. Means are provided as

mean $\pm$ SD. Hierarchical multiple regressions were calculated to examine the extent to which the ATI psychological trigger subscale predicted asthma control, after controlling for demographics, asthma severity, and other trigger factors. The order of predictors entered was as follows: (i) sex, age, race, and education level in the first step; (ii) asthma severity variable by British Thoracic Society steps 1 to 5; (iii) two ATI allergen subscales; (iv) ATI nonallergic except for the psychological subscales; and (v) ATI psychological subscale. To determine the overall amount of variance in asthma control measures explained by the allergic, nonallergic, and psychological subscales, R^2 change and F statistics were calculated for these steps. Dependent variables of asthma control were the ACQ, ASQ, and FEV₁ percent predicted. Whereas the ACQ combined self-report and FEV₁, trigger associations with symptoms and lung function aspects of asthma control were separated in the analysis of ASQ and FEV₁. For the advice group, we calculated the cross-sectional association of asthma control with ATI scales at both T1 and T2, as well as the longitudinal prediction of asthma control at T2 by ATI at T1 with and without asthma control at T1 as a control variable. Because control group ATI data were only obtained at T2, it was merged for T2 with the advice group data to replicate the cross-sectional associations at T2 with an expanded

sample. For each multiple linear regression analysis, we confirmed the assumption of normal distribution of the residuals using the Kolmogorov–Smirnov test (skewness, <1) and ensured that criteria for extreme outliers (Cook's distance, >1.0) and multicollinearity (variance inflation factors, >4) were not met.²⁴

RESULTS

Sample Characteristics

Table 1 provides information on basic characteristics for the total sample.

Asthma Trigger and Asthma Control Variables

Means and SDs of the asthma triggers and asthma control variables are shown in Table 2. The most frequently reported major trigger factor was air pollution/irritants with 62%, followed by infection (46.4%), house-dust mite (43.6%), physical activity (42.3%), pollen allergens (37.4%), animal allergens (34.6%), psychological factors (20.1%), and climate (19.0%). Overall, asthma control was in the “indeterminate” range between “well controlled” and “not well controlled.”⁴ ASQ was highly correlated with the ACQ ($r[179] = 0.81$ and $p < 0.001$, but not with FEV₁, $r[179] = 0.02$). The significant association between ACQ and FEV₁ ($r[179] = -0.27$ and $p < 0.001$), was most likely caused

Table 1 Demographics, asthma-related variables, and lung function of the total sample ($n = 179$)

Sex, women (%)	67.7	
Race, white European (%)	67.8	
African Caribbean (%)	11.5	
African (%)	6.9	
Asian (%)	4.7	
Others (%)	9.2	
Education, A-levels and degree (%)	37.7	
Smoking status, current nonsmoker (%)	82.1	
Family history of asthma, positive (%)	71.7	
Seasonal variations in asthma (%)	53.8	
Rarely sleep through the night (%)	20.5	
British Thoracic Society treatment step (%)		
Step 1	12.3	
Step 2	52.0	
Step 3	35.3	
Step 4	0.6	
Age, yr (SD)	46.6	(11.7)
Age at asthma onset, years (SD)	26.0	(18.3)
Asthma-related GP visits, previous year (range)	2.1	(0–20)
Repeat prescription visits, previous year (range)	3.4	(0–12)
Emergency visits, lifetime (range)	1.4	(0–30)
Limitation on physical activity, rating 0 - 3 (SD)	1.6	(0.7)
PEF, L/min (SD)	368.6	(104.2)
Bronchodilator: Δ FEV ₁ > 200 mL (%)	41.1	

PEF = peak expiratory flow; FEV₁ = forced expiratory volume in the 1st second.

Table 2 Means and SDs or percentages of asthma trigger variables and indicators of asthma control (*n* = 179)

	Mean	SD
ATI animal allergen (0–4)	1.62	1.29
ATI pollen allergen (0–4)	1.69	1.21
ATI physical activity (0–4)	1.74	0.90
ATI air pollution/irritants (0–4)	1.79	0.95
ATI infection (0–4)	2.19	0.98
ATI psychology (0–4)	1.03	0.88
ACQ (0–6)*	1.41	0.92
ASQ (0–4)	1.27	0.80
FEV ₁ , % predicted	85.3	18.1

*Higher values indicate lower control.

ACQ = Asthma Control Questionnaire; ASQ = Asthma Symptom Questionnaire; ATI Asthma Trigger Inventory; FEV₁ = forced expiratory volume in the 1st second.

by overlapping information, with FEV₁ scored on one of the seven items (higher values on the ACQ indicate lower control).

Asthma Triggers as Predictors of Asthma Control and Symptoms

Asthma triggers as measured by subscales of the ATI explained 32.9–42.5% of the variance in ACQ and ASQ scores cross-sectionally and longitudinally (Table 3), with two allergic trigger types contributing 5.8–12.1% of the variance, three nonallergic trigger types (without psychological triggers) an additional 13.9–26.2%, and psychological triggers an additional 6.9–9.5% over and above the other triggers. The contribution of psychological triggers to the final models was always substantial, whereas other trigger factors typically contributed less and varied in their importance across equations. Interestingly, susceptibility to animal allergens was more than once related to better asthma control. In contrast, susceptibilities to triggers rarely predicted variance in FEV₁.

Entering the ATI psychological trigger scale as the only trigger scale into the equation yielded explained variance portions of 33.9 and 27.3% for the ACQ as well as 29.7 and 27.0% for the ASQ, in the initial cross-sectional (*n* = 97) and the expanded cross-sectional (*n* = 179) analyses, respectively. Longitudinally, the ATI psychological trigger scale at T1 alone explained 24.2 and 28.5% of the variance for the ACQ and ASQ at T2, respectively.

Although trigger factors at T1 predicted asthma control at T2, the associations were not significant any more when controlling for ACQ and ASQ (or FEV₁) at T2, suggesting that the concurrent relationships between ATI subscales and these variables were suffi-

cient in explaining any significant longitudinal association.

Reports of major individually relevant triggers largely mirrored these findings for psychological trigger factors, explaining 6–8% of the variance in the ACQ and 8–12% in the ASQ (Table 4). Again, no significant portion of the variance in FEV₁ was explained by psychological triggers. In addition, none of the other trigger factors contributed significantly in these analyses, with the exception of nonallergic triggers contributing a significant increment in explained variance of the ACQ and ASQ in the cross-sectional sample at T1 ($\Delta R^2 = 0.109$ and 0.088 ; $p = 0.007$ and 0.034 , respectively), with physical activity being a significant predictor in the final models ($\beta = 0.256$ and 0.259 ; $p = 0.007$ and 0.008 , respectively).

Comparing means of asthma control variables for subgroups with and without particular major trigger factors yielded findings for psychological triggers and air pollution/irritants. Patients with psychological triggers (*n* = 36) had lower asthma control with higher scores on the ACQ and ASQ (mean = 2.0 ± 1.2 and 1.8 ± 0.9 , respectively) when compared with those without such triggers (mean = 1.2 ± 0.9 and 1.1 ± 0.8 , respectively; $t[177] = 3.57$; $p < 0.001$). For the psychological trigger subgroup, the ACQ was in the “not well-controlled” range, whereas for the subgroup without psychological triggers the ACQ was in the “well-controlled” range.² In addition, patients with more air pollution/irritants as triggers (*n* = 111) had higher ASQ scores (mean = 1.4 ± 0.9) compared with those without these triggers (mean = 1.1 ± 0.8 ; $t[177] = 2.28$; $p = 0.024$). FEV₁ was not different between any of the subgroups.

DISCUSSION

Our findings suggest that asthma trigger factors are strong determinants of asthma symptoms and control as measured by questionnaire instruments. Asthma triggers explained relatively consistently >35–40% of the variance in both the ASQ as a pure measure of symptoms and the ACQ as a control questionnaire that covered information on symptoms, functional limitations, and bronchodilator intake. The latter also included the level of spirometric lung function (FEV₁) scored in one question, thus not being a pure self-report measure. The distinction is important as shown by our findings from analyzing FEV₁ alone (not in the context of the ACQ), which was mostly unrelated to trigger factors. Thus, patients’ perceptions of their asthma control rather than their actual lung function showed a consistent relationship with perceived trigger factors. Similar diverging findings between self-report and airway function are often observed in asthma and may be related to distinct behavioral phenotypes of patients.²⁵

Table 3 Explained variance in asthma control variables by ATI subscales cross-sectionally at pretrial ($n = 97$) and posttrial ($n = 179$) as well as longitudinally from pre- to posttrial ($n = 97$)

Dependent variable	ATI Allergen		ATI Nonallergen		ATI Psychology			Significant ATI Subscales in Final Model	R ² for Final Model
	ΔR ^{2*}	p Value	ΔR ^{2#}	p Value	ΔR ^{2§}	p Value	β Value		
Cross-sectionally at pretrial									
ACQ	0.088	0.010	0.262	0.001	0.075	0.001	0.390	Psychology, air pollution	0.535
ASQ	0.058	0.061	0.208	0.001	0.095	0.001	0.439	Psychology, animal allergen ⁽⁻⁾	0.411
FEV ₁	0.000	0.994	0.005	0.912	0.014	0.248	0.168		0.129
Cross-sectionally at posttrial									
ACQ	0.121	0.001	0.153	0.001	0.081	0.001	0.360	Psychology, physical activity, pollen allergen	0.412
ASQ	0.117	0.001	0.178	0.001	0.071	0.001	0.338	Psychology, physical activity	0.400
FEV ₁	0.003	0.737	0.050	0.027	0.001	0.631	0.045	Physical activity ⁽⁻⁾ , air pollution	0.109
Longitudinally pre- to posttrial									
ACQ	0.121	0.002	0.139	0.001	0.069	0.002	0.375	Psychology, animal allergen ⁽⁻⁾ , pollen allergen	0.412
ASQ	0.100	0.007	0.190	0.001	0.079	0.001	0.400	Psychology, animal allergen ⁽⁻⁾ , pollen allergen	0.407
FEV ₁	0.003	0.858	0.034	0.364	0.004	0.514	0.096		0.110

* R^2 change in step 2 for the two ATI allergen trigger subscales, animal allergens and pollen allergens, after controlling for sex, age, race, education level, and British Thoracic Society treatment levels in step 1.

R^2 change in step 3 for the three ATI nonallergic trigger subscales, physical activity, air pollution, and infection.

$\$R^2$ change in step 4 for ATI psychological trigger subscale.

ACQ = Asthma Control Questionnaire; ASQ = Asthma Symptom Questionnaire; ATI Asthma Trigger Inventory; FEV₁ = forced expiratory volume in the 1st second.

As expected, psychological triggers played a special role in predicting asthma control. Even after controlling for demographics, asthma severity, and all other trigger factors, psychological triggers still explained up to 9.5% of the variance in asthma control. Psychological triggers also remained important in all final regression models on asthma control and symptoms. Even more remarkable, using psychological triggers alone typically predicted up to one-third of the variance in asthma control measures. Psychological triggers were also the only category of free reported top triggers that distinguished patients with well-controlled asthma versus not well-controlled asthma. It is conceivable that psychological triggers, because they are particularly difficult to control, lead to additional decre-

ments in disease control. Although exposure to classic triggers such as allergens, irritants, exercise, or infections can be reduced or avoided altogether, psychological triggers are a part and parcel of daily life and may thus often be unavoidable. Their control may be incomplete, possibly because common antiasthmatic medication does not target relevant pathophysiological pathways sufficiently¹⁹ or because this trigger domain could be associated with additional symptoms (e.g., hyperventilation symptoms)²⁶ that can not be controlled by antiasthmatic medication and are thereby associated with a decline in perceived health.²⁷ Other factors could be the association of psychological triggers with anxiety and depression, which are known to compromise asthma control and management.^{28–30}

Table 4 Explained variance in asthma control variables by ATI free report of psychological factors as major triggers: cross-sectionally at pretrial ($n = 97$) and posttrial ($n = 179$) as well as longitudinally from pre- to posttrial ($n = 97$)

Dependent Variable	Free Report of Psychological Triggers			R^2 for Final Model
	ΔR^{2*}	p Value	β Value	
Cross-sectionally at pretrial				
ACQ	0.054	0.010	0.255	0.331
ASQ	0.114	0.001	0.369	0.297
FEV ₁	0.033	0.071	0.198	0.169
Cross-sectionally at posttrial				
ACQ	0.085	0.001	0.299	0.163
ASQ	0.099	0.001	0.323	0.182
FEV ₁	0.000	0.859	−0.014	0.062
Longitudinally pre- to posttrial				
ACQ	0.060	0.013	0.269	0.210
ASQ	0.085	0.003	0.320	0.220
FEV ₁	0.000	0.859	0.021	0.120

* R^2 change in step 4 for free report of psychological factors as major asthma trigger, after controlling for sex, age, race, education level, and British Thoracic Society treatment levels in step 1, free report of animal and pollen allergens in step 2, and free report of physical activity, infection, and air pollution/irritants in step 4.

ACQ = Asthma Control Questionnaire; ASQ = Asthma Symptom Questionnaire; FEV₁ = forced expiratory volume in the 1st second.

Psychological triggers could also be linked to vocal cord dysfunction comorbid with asthma,³¹ thus mimicking asthma symptoms rather than affecting actual airway function. Future studies should assess such potential comorbidities, also including allergic rhinitis and gastroesophageal reflux,³² as potential mediators or alternative sources of symptoms.

Our data enabled us to replicate the studied associations across time points and subsamples, thus showing a certain consistency in associations between psychological triggers and asthma symptoms and control in particular. However, the longitudinal prediction of asthma control did not remain significant when taking initial control levels into account. Thus, beyond the rather stable cross-sectional association between psychological triggers and impaired asthma control, changes in asthma control across the 3- to 6-month period were not additionally predicted by any trigger

factors. Future research needs to explore whether this stability in association with the impairment dimension of asthma control also translates into a substantial and stable association with the exacerbation risk dimension.

Although it is now widely accepted that psychological triggers are relevant in asthma and associations of emotions and stress with airway obstruction and asthma worsening have been established, there is a striking lack of knowledge about possible intervention techniques that might protect from the effects of such triggers.^{33,34} There is evidence that effects of negative affect on airway constriction are mediated by the cholinergic pathway through descending vagal excitation, which would require the use of anticholinergic medication or behavioral intervention techniques counteracting exaggerated vagal activity.³⁵ Other strategies might be needed to address the interaction of psychological factors with exacerbations through allergic/immune pathways.³⁶ Given the elevated comorbidity of asthma with psychiatric disorders, psychotherapy interventions tailored to the specific needs of patients with asthma may also contribute an important treatment modality.³⁷

Among the limitations of our study was the fact that we used a convenience sample, which may have limited its representativeness to patients that are willing to participate in an intervention study. However, it is difficult to conceive how this should have affected the observed associations between perceived triggers and asthma control. Nevertheless, it limited the amount of information available to further explore the role of asthma comorbidities as potential mediators of the asthma trigger—control association. The sample was also smaller measured on epidemiological standards, but it had the advantage of being well characterized through a physician diagnosis and primary care treatment of asthma. The repeated assessment schedule also contributed to the stability of our findings. Although asthma control was measured using a guideline-supported² composite score of self-report and FEV₁, other lung function indicators, such as morning peak flow or peak flow variability, may capture pathophysiology of low asthma control better. However, these were not available in this study. Our observations regarding trigger factors are also limited to the patients' perceptions of these triggers, which may not necessarily correlate with the outcome of a challenge with the actual trigger. Positive correlations have been described between ATI allergic trigger perceptions and skin-prick test results for allergens,^{7,15,16} or for ATI psychological triggers reports and actual airway constriction to emotional stimuli,^{7,35} but the associations are mostly modest. Nevertheless, in practice, perceptions are the first entryway in evaluating patients' disease status and are important determinants of asthma

management.¹² Knowledge about associations between trigger factors and suboptimal asthma control can be helpful in this context. The additional administration of a broader range of laboratory challenges, including irritant inhalation,³⁸ emotion induction,³⁵ and physical activity,³⁹ could assist diagnosis, patient education, and management by validating patients' perception with actual trigger factors of asthma symptoms and airway obstruction.

In conclusion, perceived triggers of asthma can explain considerable portions of the variance in patients' self-reported impairment of asthma control. Of particular relevance are psychological triggers, which are consistently and strongly linked to lower asthma control. Other trigger factors show less consistent associations. Thus, knowledge about patients' psychological triggers may be help identifying those at risk for persistently impaired asthma control.

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