

The Asthma Trigger Inventory: Validation of a Questionnaire for Perceived Triggers of Asthma

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Background: Asthma patients' perceptions of triggers have been explored in a largely unstructured fashion in the past. We therefore developed and validated a questionnaire of commonly perceived asthma triggers. **Methods:** Two hundred forty-seven primary care patients with asthma filled in an asthma trigger survey together with questionnaires on demographics, asthma-relevant information, perceived control of asthma, and general health status. Factor structure of the item pool and psychometric properties of trigger subscales were evaluated. We also investigated the relationship between allergen or psychological trigger reports and allergy skin test response or respiratory impedance during emotional film viewing, respectively. **Results:** Principal component analysis yielded six factors that were thematically associated with psychology, animal allergens, pollen allergens, physical activity, infection, and air pollution/irritants. Subscales showed good internal consistencies and low to moderately positive intercorrelations. Psychological triggers were consistently associated with less favorable health status, a reduced perception of asthma control, and greater medical treatment utilization. Animal allergen scores correlated positively with skin test responses to animal allergens. Respiratory impedance increases during emotional film clips were positively correlated with the psychological trigger subscale. **Conclusion:** The questionnaire is a reliable measure of commonly perceived asthma triggers. Aspects of patients' trigger reports reflect actual reactivity to specific trigger factors. **Key words:** asthma, psychological factors, illness perception, asthma triggers, primary care, allergy skin testing, questionnaire.

ATI = Asthma Trigger Inventory; BTS = British Thoracic Society; PCAQ = Perceived Control of Asthma Questionnaire; SF-36 = Short Form 36 Health Survey.

INTRODUCTION

A variety of factors are known to trigger episodes of airway obstruction in asthma. Among the most frequent triggers are allergens, infections, cold air, physical activity, or air pollution (1). Information on these triggers plays a central role in the diagnosis and management of asthma. In practice, this information is almost always retrieved from patients' self-report in anamnestic interviews before more extensive tests of lung function and atopy are considered. However, despite its importance, little attention has been paid to the reliability and validity of trigger self-reports. In published studies, triggers have typically been identified using single questions (2,3), but this approach may not be sensitive enough to capture the actual extent of individual patients' trigger proneness. Information about asthma triggers is also sometimes embedded in quality-of-life questionnaires (4,5), expert rating systems of illness severity (6), or asthma management inventories (7). However, a comprehensive and psychometrically validated measure of perceived asthma triggers has not yet been developed.

Typically, patients vary with regard to the importance of individual triggers (1), but estimations of the overall impor-

tance of asthma triggers for given populations vary. An overview of earlier literature on classes of allergic, infectious, or psychosocial triggers showed that frequency with which patients report these triggers varies between studies from 4% to 74% (8). Part of this variation is probably the result of the lack of a structured instrument for the assessment of asthma triggers. A reliable identification of the patients' most important triggers is necessary for individualized treatment and management advice (9,10). Predominance of particular trigger types may identify distinct subpopulations of patients with asthma (11,12). Triggers may also vary in their impact on the clinical control of asthma and general health outcomes (13,14). Trigger factors that are less easy to avoid or control such as psychosocial stress, air pollution, or airway infections may put a greater burden on professional asthma care, asthma self-management, and patients' quality of life.

We therefore developed the Asthma Trigger Inventory (ATI), a psychometrically valid instrument for measuring the main categories of patients' self-reports of asthma triggers. Our instrument was specifically designed to include psychosocial triggers, a class of stimuli that is notoriously difficult to capture. The importance of psychosocial factors for asthma onset and exacerbations is increasingly being recognized (15–23) demanding a more refined method for their assessment. A broad range of emotions or stressful states would need to be sampled for a valid assessment of each patient's susceptibility to this trigger class. Because trigger reports might only reflect popular attributions of asthma episodes to life events or "stress" rather than actual changes in the control of asthma, we studied the relationship of trigger self-report with airway responses elicited by emotional stimuli in the laboratory.

METHODS

Patients

Questionnaire data were obtained from 247 patients currently being treated for asthma in two general practice outpatient clinics. Patients had to be 15 to 75 years of age and had to show no indication of chronic obstructive pulmonary disease with respect to lung function test results, prescribed medication, and additional notes in practice files as screened by a nurse

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practitioner or general practitioner. Patients filled out a questionnaire package, including the initial trigger checklist, either in the clinic alone in a separate room or at home. Patients were asked to return the completed questionnaires for use in a research study in a neutral envelope. They were assured that nonparticipation would not affect their regular care and that practitioners or nurses treating them would not have access to information from individual questionnaires. Two-hundred four patients provided sufficient information on the trigger checklist (i.e., missing values on less than 5% of the items—89% of the returned questionnaires, 18.1% of the approached patients). Additional data were used from 43 patients who also underwent skin testing for allergies for participation in a primary care allergen advice study (24). These patients had previously been drawn randomly from the database of one of the participating practices. An additional 24 patients were recruited through general practice for participation in a study on experimental emotion induction using films (25) at a university psychology department; an additional criterion for their selection was nonsmoking status. In addition, 32 patients with asthma who were recruited from the community through advertisement and flyers for participation in an expressive writing study (26) provided questionnaire data on two separate occasions 3 weeks apart. Ethical approval was obtained for all assessments by local ethics committees and patients gave written consent. The data for these studies were collected from 1998 to 2003.

The Asthma Trigger Inventory

The initial version of the ATI consisted of 53 items, including triggers such as allergens, smells and irritants, air pollution, emotions and stress, climate, physical activity and exercise, airway infections, and medication. Triggers were collected ad hoc from initial interviews of patients with asthma taking part in earlier experimental studies of one of the authors (T.R.) and from the literature. Three general practitioners and one nurse practitioner with extensive experience in the treatment of patients with asthma reviewed the list. Patients rated on a 5-point scale (0–4; “never,” “rarely,” “sometimes,” “often,” “always”) how often in their experience the particular trigger was related to their asthma symptoms. In addition, patients were asked to list up to six of their most important asthma triggers and then to rate on a 5-point scale (0–4, “not at all,” “slightly,” “moderately,” “very much,” “completely”) the extent to which the respective trigger affected their everyday life and the degree to which they were able to control or avoid the trigger without bronchodilators. This part of the questionnaire was designed to recognize idiosyncratic trigger patterns and to assess patients’ ability to manage their triggers. Scores for trigger impact and trigger control were obtained by averaging the ratings for the (up to) six triggers.

Additional Measures

Demographic Characteristics and Smoking Status

The following information was collected on a separate questionnaire: gender, age, ethnicity, marital status, education, and smoking history.

History, Disease Manifestation, and Healthcare Use

On the same questionnaire, age at asthma onset, family history of asthma and allergies, childhood diseases (dermatitis, hay fever, chronic bronchitis), seasonal and diurnal patterns of symptoms, asthma-related healthcare use, and medication were reported. Treatment level according to the British Thoracic Society (BTS) (27) was rated using additional information on medication from clinic files. Step 1 in this treatment guideline recommends occasional bronchodilator use; step 2, additional regular inhaled antiinflammatory medication; step 3, additional high doses of inhaled corticosteroids; step 4, additional regular bronchodilators; and step 5, additional regular steroid tablets.

General health status was assessed using the Short Form 36 Health Survey Questionnaire (SF-36) (28) in 187 patients.

The perceived control of asthma questionnaire (PCAQ) (29) was used to assess patients’ perceived control of their asthma and asthma management.

Allergy Skin Testing

Skin testing was performed with ALK UK Soluprick test solutions. In addition to positive (histamine) and negative (saline) controls, seven antigens were administered; among these were grass pollen, tree pollen, house dust

mite, cat dander, and dog dander with relevance to this study. Solutions were applied to the volar aspect of the forearm more than 5 cm above the distal skin crease at the wrist. The ATI scores for pollen and animal allergens were correlated with wheal diameter. We expected a significant positive correlation between ATI pollen scores and skin reactivity to grass and tree pollen, and between the ATI animal score and reactivity to cat and dog dander.

Experimental Emotion Induction Using Film Sequences

Emotional experience was induced experimentally using short (approximately 1.5 to 5 minutes) sequences from commercial movies and film material preevaluated in previous emotion research. Experimental methods and findings have been reported in detail previously (25). Briefly, film sequences preevaluated for eliciting emotions of anxiety, anger, depression, elation, happiness, contentment, and neutral affect were presented to patients in individual sessions. During presentation, respiratory impedance (or oscillatory resistance, R_{os}) was measured using the single-frequency (10 Hz) forced oscillation method (Siemens Siregnost FD5) (30,31). Emotional experience, including the six target emotions, was rated on visual analog scales after each film sequence. Results confirmed the success of the induction of emotional experience and showed an increase in R_{os} during all emotional films compared with the neutral film. A 49-item ATI pilot version was administered before the experiment that included all psychological trigger items of the 53-item version. Airway response during films of negative valence (anxiety, anger, depression) or positive valence (elation, happiness, contentment) was calculated as percentage change from the neutral film. One female patient from the original sample with missing data in the ATI was exchanged for a male patient who had initially been excluded as a result of missing data in the lung function assessments. We expected that patients reporting more frequent psychological triggers would also show a stronger increase in R_{os} during emotional films.

Data Analysis

To explore structure of perceived asthma triggers, the 53 ATI items were submitted to principal component analysis with orthogonal Varimax rotation. The extraction of four to eight factors was explored for plausibility. After item selection, subscale scores were calculated by averaging items. Internal consistencies of subscales were estimated by item-intercorrelations, item-total correlations (correlation between item and total subscale score without individual item), and Cronbach α . Reliabilities were estimated by retest stability using product moment correlations for subscale scores and χ^2 tests for trigger categories of the free response format. Hierarchical multiple linear regressions were calculated to explore whether demographics, asthma and childhood disease history, symptom patterns, and smoking predicted ATI subscale scores and whether subscales predicted healthcare use, health status, and perceived asthma control. Bivariate correlations (Spearman’s rho) were computed to test for the association between ATI subscales and skin prick test responses or respiratory resistance change during films. In line with our dimensional measurement approach, we used wheal size of the skin prick test as a continuous variable rather than dichotomizing patients along an arbitrary criterion. Results are presented as means $\pm$ standard deviation.

RESULTS

Item Reduction

One item, “stress at work,” was excluded as a result of a large number of missing values; additional comments by some patients suggested that this was mostly the result of a lack of relevance because of unemployment or retirement. An orthogonal six-factor solution explaining 54.1% of the variance proved to be most plausible with factors marked by items related to psychological factors (15.1%), air pollution/irritants (11.2%), physical activity (8.3%), animal allergens (7.7%), pollen allergens (6.5%), and infection (5.4%). The “house dust” item showed its highest loading (0.54) on the animal

allergen factor. Further extractions did not yield interpretable factors. Items related to climate were distributed across other factors such as the items “hot climate” (0.50) or “humid air” (0.48) on the pollen allergen factor or “foggy” (0.60) on the air pollution/irritants factor.

Psychometric Properties of Asthma Trigger Inventory Subscales

Six subscales were formed with a total of 32 items (Appendix 1). Psychological factors showed the lowest item means and animal allergens the second lowest (arithmetic means; Table 1). Mean interitem correlations, item-total correlations, and Cronbach α showed that the internal consistencies of subscales were generally high. Subscale intercorrelations were low to moderate ($r(247) = 0.13$ – 0.47 ; Table 2), in particular allergy subscales showed lower correlations with other trigger groups. Both allergy subscales were moderately intercorrelated; thus, properties of an overall allergy subscale including the “house dust” item are also reported. Retest reliabilities were reasonably high for all scales ($r_{tt} = 0.73$ – 0.95). The level of scores did not change significantly from first to second testing.

Individually Relevant Triggers

The six individually most relevant triggers reported in the ATI free response format section were grouped into categories (Fig. 1). Climate, air pollution/irritants, and physical activity were the most frequently mentioned categories and were reported at least as one major trigger by more than half of the patients, whereas approximately one fourth mentioned at least

one psychological trigger. Stability at retest was satisfactory for most larger trigger categories ($\chi^2(1) = 2.70$ – 16.95 , $p = .049$ to $.001$), except for climate-related triggers ($p = .384$) and pollen allergens ($p = .156$). Averaged across all individually relevant triggers, mean trigger impact was rated “moderately” (2.14 ± 0.92) as was trigger control (1.74 ± 0.95). Both scores showed a low to moderate intercorrelation ($r(243) = 0.37$, $p < .001$). Although stability of the trigger impact was acceptable ($r_{tt}(31) = 0.76$, $p < .001$), scores on the trigger control scale showed a lower stability ($r_{tt}(31) = 0.39$, $p = .030$).

Association With Demographics, Asthma History, and Disease Manifestation

Higher education level predicted lower scores on nonallergic ATI trigger subscales and trigger impact (Table 3). Other demographic variables rarely showed significant associations. Membership of nonwhite ethnic groups (16.1%, of that: African, 1.7%; Afro-Caribbean, 7.4%; Asian, 3.7%; other, 3.3%) predicted less pollen allergy. Animal allergy was predicted by earlier age of asthma onset and chronic bronchitis in childhood, whereas pollen allergy was predicted by symptoms predominantly in Spring and Summer and childhood hay fever. Both animal and pollen allergy were predicted by more nighttime symptoms. Current smokers were less likely to report pollen allergy and air pollution triggers.

Association With Healthcare Use, General Health Status, and Perceived Asthma Control

Current medication treatment was with beta-adrenergic or anticholinergic bronchodilators only (rated as BTS step 1) for

TABLE 1. Psychometric Properties of the Asthma Trigger Inventory Trigger Subscales: Item Means, Interitem Correlations, Item-Total Correlations, and Internal Consistencies ($N = 247$)

Trigger Subscale	Number of Items	Mean _i $\pm$ SD _i	r_{ii} (mean)	r_{it} (range)	α
Psychological	10	0.88 ± 0.90	0.60	0.60–0.87	0.94
Allergens (animal)	3	1.36 ± 1.20	0.60	0.48–0.79	0.82
Allergens (pollen)	3	1.47 ± 1.20	0.74	0.75–0.81	0.89
Allergens (general)	7	1.50 ± 0.98	0.44	0.27–0.88	0.84
Physical activity	5	1.91 ± 1.05	0.57	0.59–0.80	0.87
Air pollution/irritants	6	1.60 ± 0.97	0.47	0.46–0.71	0.84
Infection	4	1.99 ± 0.99	0.51	0.40–0.72	0.81

M_i = item mean; SD_i = item standard deviation; r_{ii} = item intercorrelation; r_{it} = item-total correlation; α = Cronbach alpha.

TABLE 2. Bivariate Intercorrelations of Asthma Trigger Inventory Trigger Subscales ($N = 247$) and Retest Reliabilities ($N = 32$; on the diagonal)

	1	2	3	4	5	6	7
1. Psychological factors	0.73	0.47	0.48	0.13	0.21	0.23	0.37
2. Air pollution/irritants		0.95	0.47	0.26	0.40	0.44	0.48
3. Physical activity			0.85	0.21	0.23	0.27	0.45
4. Allergens (animal)				0.82	0.40	0.82	0.20
5. Allergens (pollen)					0.87	0.80	0.32
6. Allergens (general)						0.95	0.33
7. Infection							0.88

Correlation coefficients ≥ 0.13 : $p < .05$, ≥ 0.20 : $p < .001$.

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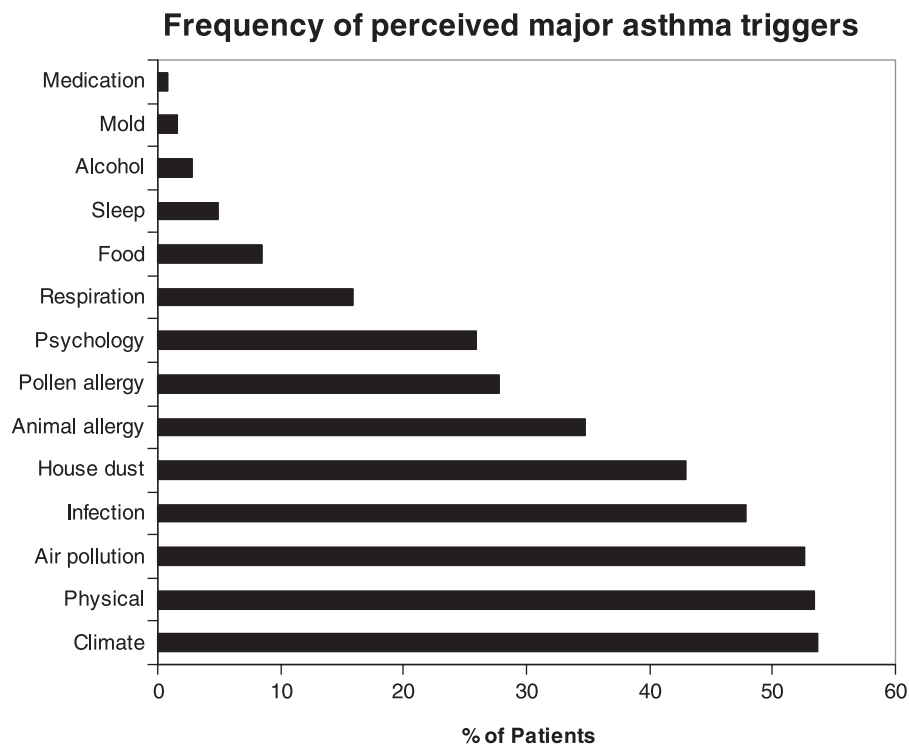


Figure 1. Frequency of main categories of asthma triggers perceived by patients as most relevant ($N = 247$).

TABLE 3. Association Between Asthma Trigger Inventory (ATI) Subscales and Demographics, Clinical History, and Disease Manifestation for Patients With Asthma ($N = 247$)^a

Predictor	Percent or Mean $\pm$ Standard Deviation	Significant for ATI Subscale ^b	t^c	p
Gender, women	47.4%	Psychological factors	1.97	.050
Ethnic origin, not white European	16.1%	Pollen allergens	2.71	.007
Marriage status				
Married/cohabiting	54.3%			
Unmarried	35.4%			
Separated	10.3%			
Higher education (A-levels or degree)	41.5%	Psychological factors	-3.31	.001
		Physical activity	-2.19	.029
		Air pollution	-2.86	.005
		Infection	-3.30	.001
		Trigger impact	-3.19	.001
Age, years	40.5 $\pm$ 14.7	Air pollution	2.21	.028
Age at asthma onset, years	21.7 $\pm$ 17.7	Allergens (animal)	-2.62	.009
Family history asthma or allergy	67.2%			
Childhood disease dermatitis	26.9%			
Hay fever	35.4%	Allergens (pollen)	3.36	.001
Chronic bronchitis	19.1%	Allergens (animal)	2.60	.010
Symptoms predominantly, morning	25.4%			
Night	23.0%	Allergens (animal)	2.11	.036
		Allergens (pollen)	2.01	.046
		Air pollution	2.52	.012
Spring	10.6%	Allergens (pollen)	2.18	.030
Summer	24.8%	Allergens (pollen)	3.67	.001
Winter	28.0%			
Smoking, current smoker	26.4%	Allergens (pollen)	-2.14	.033
		Air pollution	-2.01	.046

^a Results from hierarchical multiple linear regressions analysis with individual ATI subscales as dependent variables and predictors gender, ethnic origin, marriage status, education level, and age in step 1 and either predictors of asthma and childhood disease history or predictors of symptom pattern and smoking in step 2.

^b Significant ($p < .05$) or marginal ($p < .10$) predictors are reported from equations with individual ATI subscales as dependent variables.

^c t test results for beta weights; positive values indicate a positive association between predictor and ATI subscale.

TABLE 4. Asthma Trigger Inventory (ATI) Subscales as Predictors of Healthcare Use and Health Status (SF-36, composite scores)^a

Criterion	Predictors of ATI Subscales ^b	<i>t</i> ^c	<i>p</i>	<i>R</i> ² Change ^d	<i>p</i>	<i>R</i> ² for Total Model
Asthma-related general practitioner visits, previous year (<i>N</i> = 234)	Allergens (pollen)	−2.31	.022	0.095	.001	0.275
	Air pollution	2.53	.012			
Days on oral steroids, previous year (<i>N</i> = 228)	Psychological factors	3.08	.002	0.115	.001	0.216
	Air pollution	−3.39	.001			
	Infection	3.63	.001			
	Trigger impact	1.86	.064	0.032	.013	0.114
	Trigger control	2.76	.006			
Asthma emergency treatment, lifetime (<i>N</i> = 223)	Allergens (animal)	4.68	.001	0.110	.001	0.156
Asthma hospital stays, lifetime (<i>N</i> = 225)	Allergens (animal)	3.75	.001	0.105	.001	
SF-36 composite scores (<i>N</i> = 187)						
Physical composite score	Psychological factors	−4.97	.001	0.208	.001	0.330
	Trigger impact	−1.82	.069	0.028	.008	
	Trigger control	−1.98	.049			
Mental composite score	Psychological factors	−5.03	.001	0.196	.001	0.285
	Trigger impact	−2.18	.030	0.028	.011	
	Psychological factors	−2.20	.029	0.139	.001	
Perceived control of asthma (<i>N</i> = 245)	Allergens (pollen)	−1.75	.081			
	Trigger impact	−1.72	.087			
	Trigger control	2.28	.023	0.038	.005	0.212

^a Results from hierarchical multiple linear regressions analysis after controlling for gender, ethnic origin, marriage status, education level, and age in step 1.

^b Only predictors that are significant ($p < .05$) or marginal ($p < .10$) are reported.

^c *t* test results for beta weights; positive values indicate a positive association ATI subscale (as predictors) and dependent variable.

^d Change in R^2 for the block of variables entered in step 2 (six ATI trigger subscales) or step 3 (trigger impact, trigger control).

34.4% of the patients; 2.8% were treated with systemic steroid medication for more than 100 days (rated as BTS step 5). Medication treatment was consistently related to ATI subscales, because a multivariate analysis of variance for step 1 versus steps 2 to 5 with ATI subscales as dependent variables was significant ($F(8, 234) = 2.55, p = .011$). Univariate tests showed significantly higher nonallergic trigger scores, higher trigger impact, and lower trigger control on steps 2 to 5. Animal allergic triggers showed a robust relationship with emergency and hospital treatments (Table 4). Longer systemic steroid intake was associated with stronger nonallergic triggers and with a higher perceived trigger impact and trigger control at the same time. Interestingly, patients with stronger pollen allergy had fewer practitioner visits, whereas patients with stronger air pollution triggers had more visits. Among the trigger subscales, only psychological factors explained unique variance in the SF-36 physical and mental composite scores in that higher scores were associated with lower health status. Similarly, psychological triggers showed the most consistent relationship with the eight SF-36 subscales (Table 5). Allergy subscales were associated with better health status. ATI trigger subscales typically accounted for 15% to 20% of the variance in aspects of self-reported health status after controlling for demographic variables. Perceived trigger impact or control scales accounted for an additional 2% to 4% of the variance. Stronger psychological factors and pollen allergy as well as stronger trigger impact and less trigger control were associated with lower perceived asthma control. ATI subscales predicted 17.7% of the PCAQ variance (Table 4).

Skin Test Response and Perceived Allergic Asthma Triggers

Patients for additional skin tests were 62.5% women, their mean age was 28.8 ± 6.5 years, and their mean age of asthma onset 11.4 ± 7.8 years. They were mostly treated on BTS levels steps 1 to 3, except for four patients on step 4. Scores of the animal allergen subscale were positively correlated with skin response to cat dander ($r(43) = 0.47, p < .001$) and dog dander ($r(43) = 0.40, p = .007$) allergens. No significant correlations were found between the pollen allergen subscale and grass pollen ($r(43) = 0.25, p > .05$) or tree pollen ($r(43) = -0.02, p > .05$).

Perceived Psychological Asthma Triggers and Airway Response to Emotional Stimulation

Patients participating in the emotional stimulation study were 15 women and nine men with a mean age 35.4 ± 12.0 years and mean age of asthma onset 18.6 ± 13.7 years. BTS treatment level was on steps 1 to 3. The ATI subscale for psychological factors was positively correlated with changes in respiratory resistance to positive ($r(24) = 0.58, p = .003$) and negative emotional stimuli ($r(24) = 0.48, p = .017$). Thus, patients with more frequent experience of psychological asthma triggers also showed greater airway constriction to emotional films.

DISCUSSION

Asthma patients' perception of their triggers has attracted little attention previously, although it is regularly used to

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TABLE 5. Asthma Trigger Inventory (ATI) Subscales as Predictors of Health Status (SF-36 subscales; $N = 187$)^a

Criterion	Predictors of ATI Subscales ^b	t^c	p	R^2 Change ^d	p	R^2 for Total Model
SF-36 subscales						
Physical function	Physical activity	-4.98	.001			
	Allergens (animal)	2.56	.011	0.213	.001	
	Trigger impact	-1.83	.072	0.019	.027	0.571
Role limitation, physical problems	Psychological factors	-2.95	.004			
	Infection	-2.35	.020	0.143	.001	0.248
Role limitation, emotional problems	Psychological factors	-3.68	.001	0.101	.003	0.169
Social functioning	Psychological factors	-4.02	.001	0.216	.001	
	Trigger impact	-2.75	.007	0.038	.009	0.327
Mental health	Psychological factors	-4.61	.001	0.128	.001	0.203
Energy/vitality	Psychological factors	-3.19	.002			
	Allergens (pollen)	2.11	.036			
	Physical activity	-1.69	.095	0.161	.001	
Pain	Trigger impact	-2.08	.039	0.038	.013	0.279
	Psychological factors	-3.65	.001	0.162	.001	
	Trigger control	2.15	.033	0.035	.018	0.264
General health perception	Psychological factors	-2.56	.011			
	Physical activity	-2.08	.039			
	Infection	-2.14	.033	0.181	.001	0.276

^a Results from hierarchical multiple linear regressions analysis after controlling for gender, ethnic origin, marriage status, education level, and age in step 1.

^b Predictors that are significant ($p < .05$) or marginal ($p < .10$) are reported.

^c t test results for beta weights.

^d Change in R^2 for the block of variables entered in step 2 (six ATI trigger subscales) or step 3 (trigger impact, trigger control).

inform decisions regarding treatment and management strategies such as prescribed patterns of inhaler use or costly allergen avoidance measures. It also guides patients' efforts to reduce the burden of this chronic condition on their daily life and thus to improve their quality of life. In research, attempts are sometimes made to identify predominant trigger factors in patient populations (e.g., (8,11,13)). As a reliable and valid questionnaire inventory, the ATI can help in the initial screening of patients for the importance of a number of major trigger classes, to identify the most relevant triggers for an individual patient, and to evaluate the perceived impact of these triggers on the daily life of the patient as well as the perceived control over the triggers.

Correlations between ATI subscales demonstrate that the different classes of triggers are at least partially independent. Although moderate correlations exist among nonallergic trigger subscales for psychology, physical activity, air pollution/irritants, and infection, and also between both allergic trigger subscales, the correlations between subscales across the two main categories of allergic and nonallergic scales are low. Differences between these two trigger classes were also maintained in their relationships with demographics, aspects of disease history and manifestation, and general health measures.

Psychometrically valid information on trigger factors is not always easy to generate from clinical interviews with patients. For example, capturing the importance of more complex factors such as the psychosocial situation requires the exploration of a whole number of potential facets of the patient's experience. A single question on whether "stress brings on asthma" may not identify susceptible individuals with sufficient precision. We tested this approach in our emotion induction study

by embedding a single question on stress-induced asthma in the history and clinical function questionnaire with answer alternatives "yes" ($n = 13$), "no" ($n = 5$), and "only in combination with other triggers" ($n = 6$). The nonparametric statistics (Kruskal-Wallis test) comparing airway responses with positive and negative emotional film clips between these groups remained nonsignificant ($\chi^2 = 2.53$ and 0.15 , $p = .282$ and $.926$, respectively). On the other hand, the significant correlations of the ATI psychological trigger subscales with airway responses to film viewing indeed showed that patients who perceive more frequently that their psychological state is linked to asthma symptoms are also more likely to show stronger bronchoconstriction in an experimental situation with standardized emotion induction procedures. Although patients' airway responses on average remained well below levels typically associated with the perception of dyspnea (32), these findings suggest patients' claims that their asthma is stress-induced may have a physiological basis. Only psychological instruments that capture patients' experience with sufficient thematic depth and psychometric quality will be able to uncover such associations.

The ATI allows more insight into the role and impact various asthma triggers can have on patients' lives. A considerable portion of the variance in measures of health status and healthcare use was explained by trigger perceptions after controlling for major demographical variables. Particularly striking was the strong association of psychological triggers with less favorable general health, a reduced perception of asthma control, and more days on corticosteroids. These findings are compatible with earlier research showing that patients with near fatal asthma attacks are more likely to report psy-

chological stress as an asthma trigger (33) and that patients who experience more fear or panic during asthma exacerbations are more likely have higher doses or longer intake of systemic corticosteroids (34,35). Psychological trigger factors may therefore identify patient subgroups with particularly adverse outcomes in health perception and asthma control. However, because our findings are cross-sectional, they do not inform about the direction of association: adverse outcomes may increase the likelihood of reporting psychological triggers, or experience of psychological triggers may lead to more adverse outcomes.

Both pollen and animal allergic triggers showed a positive association with nighttime symptoms, a finding that can advance knowledge on nocturnal asthma, for which the role of allergic inflammation has been debated (36). Because intensity of medical treatment was not related to allergic triggers, this association was most probably not mediated by greater asthma severity, a typical confound in research on nocturnal asthma. Separate multiple regression analysis using treatment intensity (step1 versus steps 2–5) as an additional predictor did not change these findings profoundly: animal allergens were now only marginally related to nighttime symptoms ($p = .070$), but pollen allergens were more strongly related ($p = .008$). It is also important to note that animal allergies were strongly associated with health-threatening and costly emergencies and hospital stays. A particular focus of primary care prevention strategies on these specific subgroups of patients may be beneficial. Thus, the ATI can help uncover associations of triggers with disease manifestations and healthcare use that have implications for a better understanding and management of asthma.

Self-report information about triggers is based on cause–effect relationships as perceived by the patient and is thus not necessarily identical to objective causes for symptoms. The latter can more precisely be tested by established diagnostic procedures in pulmonary medicine such as exercise testing, specific airway challenge with allergens, or allergy skin testing. The ATI does not attempt to replace such methods; rather, it aims to capture an important aspect of illness perception, which is potentially independent from the somatic manifestation of the illness but can be expected to exert a powerful influence on the patients' illness management and well-being (37). It thereby adds to a biopsychosocial understanding of the patients' illness process (38). From this perspective, a strong relationship between patients' report and actual response to triggers is probably more the exception than the rule. Previous studies have repeatedly demonstrated a dissociation between symptom report and actual lung function in asthma patients (e.g., 39–41). A similar disconnect can be expected between patients' perceptions of asthma triggers or causes and somatic indices of asthma. By the time patients seek treatment, their reports are retrospective attributions of causes for illness episodes and will mainly measure their cognitive concepts of trigger effects. Also, the association of ATI subscales with somatic disease markers may vary depending on the class of triggers as has been observed with allergic triggers in this

study. Although the animal allergy subscale predicted skin test responses, this was not the case for the pollen allergy subscale. These results are consistent with earlier research on patients' predictions of skin test responses (42,43). Learning contingencies between external trigger factors and symptom exacerbations is much easier with distinct objects or events than with a diffuse situation such as changes in air quality resulting from pollen. Similarly, it will be easier to accurately predict from patients' reports their airway response to physical exertion or exercise than to air pollution. Although correlations between trigger self-reports and pathophysiological outcomes can provide some evidence for the construct validity of the ATI subscales, further validation studies of patients' trigger concepts on the self-report level (e.g., ecological momentary assessments of trigger perceptions and avoidance) would be needed.

One factor contributing to the association between perceived and actual triggers is interoceptive ability. Patients with asthma are known to vary considerably in their ability to detect airway obstruction (28,44–46). Subgroups of patients with very low interoceptive abilities may also be at risk for fatal asthma (47) because they lack the appropriate learning history linking trigger experience with perceptions of changes in obstruction. Successful development of interoceptive abilities will require, in addition to afferent information from the organ system, the experience of external causes or triggers and the availability of knowledge to guide the attention and integrate the individual's experience (48). A reliable assessment of patients' asthma trigger perceptions and concepts will be an important element in training of interoceptive abilities and trigger avoidance.

The presented questionnaire has a number of limitations. Only six groups of triggers are assessed, which are among the most common ones according to recent guidelines (1). Triggers that are less frequently experienced by asthmatics such as certain foods, medications, or alcohol do not allow scale construction within the context of a broader survey instrument. More specialized inventories directed at specific patient subsamples such as in occupational asthma (49,50) would be needed. In addition, climate conditions as one major trigger category did not yield an internally consistent subscale. Items from this trigger category form a heterogeneous group with low correlations between questionnaire items. Thus, patients who reported susceptibility to cold air were not more or less likely to also report a role for humid air, dry air, or weather changes. Patients seem to associate some of the climate triggers predominantly with other trigger categories such as "hot climate" or "humid air" with pollen allergens or "foggy" with air pollution. These associations could be partly formed by the experience of temporal contiguity and partly by specific interactions between climate triggers and other trigger classes.

We plan to extend our research assessment and analysis of perceived triggers on trigger hierarchies and interactions. Patients in other studies (13) have reported interaction or synergistic effects, and some have also been demonstrated empirically such as between air pollution and physical activity, respiratory infec-

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tions, or allergens (41–53). The questionnaire can also not feature trigger factors that may be of great importance in asthma but are not perceived by patients sufficiently. This is, for example, the case for “molds,” which also have been shown to be particularly underperceived by allergy patients in other studies (42,43). Similarly, because the focus is on patients’ perception and the resulting schemata, triggers to which patients were never exposed but to which they would potentially be sensitive will also not be covered by the ATI. Finally, the current study does not constitute a representative survey of the relative importance of various asthma trigger categories.

Our main aim was to investigate the structure of asthma trigger perceptions through patients’ self-reports, the construction of psychometrically valid scales, and the subsequent exploration of their potential predictive power with regard to asthma control and general health status of patients. The instrument can thus be recommended for larger-scale epidemiological studies that attempt to uncover evidence for the relative importance of triggers in asthma patient populations.

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APPENDIX 1. Asthma Trigger Inventory

There are many different causes for asthmatic symptoms. Situations causing symptoms can vary considerably from one person to the other. Please indicate for each of the listed causes below how often they are involved when you experience symptoms of asthma. Please base your answers on your *own personal experience*, not on what you think should lead to asthma for the typical patient.

The following things can trigger my asthma alone or in part: (for *each* trigger please circle the number that applies most to you)

	Never	Rarely	Sometimes	Most of the time	Always
1. Having a cold	0	1	2	3	4
2. Cigarette smoke	0	1	2	3	4
3. Running	0	1	2	3	4
4. Being angry	0	1	2	3	4
5. Pollen from trees	0	1	2	3	4
6. Feeling alone	0	1	2	3	4
7. Exhaust fumes	0	1	2	3	4
8. Bicycle riding	0	1	2	3	4
9. Stress at home	0	1	2	3	4
10. Certain intensive odors	0	1	2	3	4
11. Pollen from grass	0	1	2	3	4
12. Feeling tense	0	1	2	3	4
13. Climbing flights of stairs	0	1	2	3	4
14. Depressed mood	0	1	2	3	4
15. Smell of paint	0	1	2	3	4
16. Sport activities	0	1	2	3	4
17. Perfumes	0	1	2	3	4
18. Arguments with people	0	1	2	3	4
19. Flu	0	1	2	3	4
20. Sinus problems	0	1	2	3	4
21. Being excited	0	1	2	3	4
22. Intense worries	0	1	2	3	4
23. Feeling unhappy	0	1	2	3	4
24. Animal hair	0	1	2	3	4
25. Overexertion	0	1	2	3	4
26. Viruses	0	1	2	3	4
27. Feeling weak	0	1	2	3	4
28. Pollen from weeds	0	1	2	3	4
29. Feathers from birds	0	1	2	3	4
30. Sprays	0	1	2	3	4
31. Cats	0	1	2	3	4
32. House dust	0	1	2	3	4

Please make sure you have circled *one* answer for *each* trigger.

Please list below up to six of the strongest triggers of your asthma.

My strongest asthma triggers are:

- 1.....
- 2.....
- 3.....
- 4.....
- 5.....
- 6.....

APPENDIX 1.

Please indicate below how much each of these triggers affects your daily life:

This trigger affects my daily life...

My Strongest Trigger	Not at All	Slightly	Moderately	Very Much	Completely
1.	0	1	2	3	4
2.	0	1	2	3	4
3.	0	1	2	3	4
4.	0	1	2	3	4
5.	0	1	2	3	4
6.	0	1	2	3	4

Please indicate below to what extent you are able to control or avoid each of these triggers in your daily life without medication (bronchodilators, reliever or rescue medication):

I can control this trigger...

My Strongest Trigger	Not at All	Slightly	Moderately	Very Much	Completely
1.	0	1	2	3	4
2.	0	1	2	3	4
3.	0	1	2	3	4
4.	0	1	2	3	4
5.	0	1	2	3	4
6.	0	1	2	3	4

APPENDIX 2. Item Key for the Asthma Trigger Inventory Trigger Subscales

Psychological	Being angry, feeling alone, stress at home, feeling tense, depressed mood, arguments with people, being excited, intense worries, feeling unhappy, feeling weak
Allergens (animal)	Animal hair, feathers from birds, cats
Allergens (pollen)	Pollen from trees, pollen from grass, pollen from weeds
Allergens (general)	Allergens (animal) items, allergens (pollen) items, house dust
Exercise	Running, bicycle riding, climbing flights of stairs, sport activities, overexertion
Air pollution/irritants	Cigarette smoke, exhaust fumes, certain intensive odors, smell of paint, perfumes, sprays
Infection	Having a cold, flu, sinus problems, viruses

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