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Asthma trigger perceptions are associated with work disability

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ABSTRACT

Objective: To study the association between perceptions of various triggers of asthma and employment status.

Methods: A questionnaire was administered to all those adults living in the city of Tampere, Finland, who were entitled to special reimbursement for asthma medication by the Social Insurance Institution (n = 2613). The response rate was 79%. The study population (n = 1657) consisted of individuals who worked full-time (n = 967), were unemployed (n = 197), had all-cause work disability (n = 334), or were retired due to old age (n = 159). Given a list of potential asthma triggers, the respondents were asked how often (never/sometimes/often) the trigger caused or worsened their asthma symptoms during leisure time.

Results: After adjusting for background variables (age, sex, smoking, and professional status), frequency of asthma symptoms, and the use of asthma medication during the last year, any individual trigger identified as asthma-relevant was associated with having work disability (vs. working full-time). The highest odds ratio (OR) was found for vehicle exhaust (OR 5.0, CI 2.2—11.4). We found similar but less consistent associations between asthma trigger perceptions and unemployment. No elevated ORs were found regarding asthma trigger perceptions for old-age retirement.

Conclusions: Perceptions of asthma triggers are associated with all-cause work disability. Our findings suggest that asthmatics have excess trigger perceptions that are not explained by asthma alone. Asthmatics need to be informed that inaccurate trigger perceptions may develop, and how they are induced, because unnecessary trigger avoidance may interfere with work life.

Key words: Asthma; Asthma trigger; Trigger perception; Work disability

1. Introduction

Asthma is a common chronic disease with potential occupational consequences. It has been shown to increase the risk of job change [1], sickness absences [2], all-cause long-term work disability [3,4], and sick leave or disability benefits [5]. Poorer symptom control of the disease associates with work disability outcomes [6]. Patients with worse asthma control are also more likely to be unemployed, as shown by a large population-based study in Europe [7].

Asthma is characterized by variable symptoms of wheeze, shortness of breath, chest tightness and/or cough, and by variable airway limitation [8]. Typically, these variations are triggered by a variety of factors, such as allergens, exercise, viral infections, emotional factors, cold air, irritants, or strong odors, and may lead to an acute onset or worsening of asthma symptoms [8,9]. Exposure to these triggers seems to play a part in poor control of asthma symptoms [10,11]. However, trigger perceptions are not systematically related to asthma control, as some individuals have persistent symptoms without trigger sensitivity while others may have only infrequent symptoms but a striking sensitivity to environmental triggers. In addition, the mechanism of symptoms in asthmatic individuals is not always bronchoconstriction, but comorbidities like laryngeal obstruction may be clinically recognized [12].

In addition to pharmacological treatment, the identification of asthma triggers is often a key element in asthma management aiming at good control of symptoms, normal activity levels, and minimizing the risk of exacerbations. Therefore, patients are educated to recognize and avoid factors that trigger symptoms [13,14]. Individuals who reported that asthma had impacted their daily life also reported making considerable behavioral changes in order to manage exposure to

known asthma triggers [11]. However, evidence of whether allergen and trigger education and avoidance improve asthma control is either limited or inconsistent [9].

Multiple factors contribute to the identification of asthma triggers, and psychological mechanisms are also involved [15]. Individuals vary in their perception of asthma triggers, and both underidentification and overidentification may occur. Asthma triggers that have a phenomenal appearance, such as cats and dogs, are easy to perceive, but the presence of many other potential triggers is inferred from cues such as the smell of diesel exhaust or mold [15,16]. Prior knowledge and beliefs about potential asthma triggers may help to identify triggers that are hard to perceive, but may also lead to inaccurate trigger beliefs and unnecessary avoidance of triggers [15,17]. Concerning allergens, symptom trigger reports only moderately match the results of skin prick tests [18]. Women report more asthma triggers than men [19,20], and some studies have shown higher education levels to be associated with reporting of fewer asthma triggers [18]. Further, smokers report fewer triggers than non-smokers [18,19].

Although asthma induced or triggered by workplace exposures, i.e. occupational asthma and work-exacerbated asthma, and their socioeconomic consequences have been studied previously [21], asthma triggers outside work have received little scientific attention from occupational researchers. However, as patients' perceptions of asthma triggers are important determinants of asthma outcomes, which in turn may increase the risk of adverse occupational outcomes, asthma triggers both at and outside work are of interest. If perceptions of asthma triggers outside work are related to employment status, this would suggest that trigger perceptions should be assessed in asthma management not only to improve daily asthma control but also to support working careers of asthmatic individuals.

The aim of the study was to assess the association between various perceived triggers of asthma and employment status. We studied whether the reporting of leisure time asthma triggers of

individuals outside work life (those with work disability, unemployed or retired) differed to that of full-time workers, and also whether or not the detected differences remained after controlling for more symptomatic asthma and the use of asthma medication.

2. Materials and methods

2.1. Study population

The study was a cross-sectional questionnaire survey among adults with verified asthma. The questionnaire was sent to all adults (aged 20–65 years) with asthma living in the city of Tampere, Finland, entitled to special reimbursement for asthma medication by the Social Insurance Institution (SII) (n = 2613). The cases were identified from the Medication Reimbursement Register of the SII, which covers all permanent residents of the country. To be eligible for the reimbursement for asthma medication, the diagnosis of asthma must fulfill certain criteria that must be documented by the patient's physician and approved by the SII. At the time of the study, the criteria for receiving special reimbursement for asthma medication were: 1) a typical history, clinical features and course of asthma; 2) variable airway limitation shown by at least one of the following: a) a positive bronchodilator reversibility test (an increase in FEV_1 of ≥ 15% and > 200 ml from baseline after β_2-agonist); b) a repeated diurnal variability of ≥ 20% in twice-daily PEF over two weeks; c) a significant increase in lung function (in FEV_1 by ≥ 15% or PEF by ≥ 20%) after four weeks of anti-inflammatory treatment; d) a positive exercise challenge test (a decrease of ≥ 15% in FEV_1 from baseline); and 3) continuing regular use of asthma medication that had lasted for at least six months at the time of the SII decision. All three criteria must be fulfilled. Thus, the study population consisted of individuals with clinically verified asthma, including objectively measured bronchial constriction. Individuals with occupational asthma were not included in the study, as they get

compensation for asthma medication through another insurance system (statutory accident insurance).

The questionnaire with an information letter and an invitation to participate was sent in October 2000 (outside pollen season) and the response rate was 79%. The formation of the study groups is described in more detail in previous reports of the survey [22,23]. In the present study, the study population (n = 1657) consisted of the following four groups, which were formed according to their employment status: (1) working full-time (n = 967), (2) unemployed (n = 197), (3) outside work life due to work disability (including all-cause sickness absence, disability pension, and disability pension applied for but not yet granted) (n = 334), and (4) retired due to old age (n = 159). We excluded those outside work life for other reasons (housewives, students, part-time workers, maternity leave, etc.) from this study because of their small number and the heterogeneity of the groups.

2.2. Background data, symptoms, and medication

The questionnaire included questions on age, sex, smoking, and professional status. We asked those who were on disability pension if asthma was the partial or main cause for this. The frequency of asthma symptoms was elicited by the question: 'How often on the average did you have asthma symptoms during the last year?'. To estimate the long-term use of asthma medication needed to control asthma, we asked the respondents: 'Have you used medication for your asthma during the last year (12 months)?' The response options for these questions can be seen in Table 1.

2.3. Asthma trigger perceptions

The respondents were given a list of potential factors that trigger asthma, which were chosen according to an unsystematic literature search and prior clinical experience. We asked if the factor

in question causes or worsens their asthma symptoms during leisure time. The options were never, sometimes, or often. The triggers included environmental allergens (pollens and animals), irritants/odorants (house dust, tobacco smoke, odors or smells, vehicle exhaust, cleaners or detergents), cold air, physical activity, emotional stress, and foodstuffs (Table 2).

2.4. Statistical analysis

We studied whether the asthma trigger reports of full-time workers differed from those of the three other groups (unemployed, work disability, and retired). Our data set consisted of both continuous and categorical variables. When comparing the differences between the groups, we applied ANOVA with Dunnett´s post-test (variances between the groups were not equal) for a continued variable (age) and Chi-squared tests for categorical variables. After these preliminary studies, we built logistic regression models using unemployed vs. full-time work, work disability vs. full-time work, or retired vs. full-time work as an outcome variable. Whether the inquired asthma trigger worsened or triggered asthma symptoms during leisure time (‘sometimes’ vs. ‘never’ and ‘often’ vs. ‘never’) was used as an independent variable one at a time. Our strategy for building the model was as follows. First, we estimated crude models (Model 1) and then adjusted models for background variables (age, sex, smoking, and professional status) (Model 2), adjusted models for background variables and frequency of asthma symptoms during the last year (data not shown in the tables, because the results did not differ considerably from those of the Model 3), and finally, we adjusted the models with the aforementioned factors and the use of asthma medication during last year (Model 3). The odds ratios (OR) with their 95 % confidence intervals (95 % CI) are presented in the tables. We considered a p-value of $< .05$ statistically significant, and conducted all analyses using SPSS (version 24) software (IBM Corporation, New York).

3. Results

We have reported on the four employment groups' background data, the frequency of asthma symptoms, and the use of asthma medication in our earlier paper [22]. In summary, full-time workers were on average younger, more frequently non-manual workers, they smoked less, had less asthma symptoms and used less asthma medication than those who were unemployed, had work disability or were retired (Table 1).

Full-time workers considered that all the inquired factors caused or triggered their asthma symptoms less often than those with work disability (Table 2). Also, when compared with the unemployed or with those retired due to old age, full-time workers less frequently reported their asthma symptoms as worsening from the triggers, with the exception of pollens and foodstuffs, and animals (no difference between full-time workers and the retired).

Full-time workers reported irritants or odorants (house dust, tobacco smoke, odors or smells, vehicle exhaust, cleaners or detergents), as well as cold air, physical activity, and mental load causing or triggering asthma symptoms less often than all the other groups. All the differences were statistically significant ($p < .001$ for all other comparisons between groups, but $p < .004$ for mental load between full-time workers and the retired) (Table 2).

In the logistic regression models, the identification of any individual trigger as asthma-relevant was associated with having work disability (vs. working full-time) (Table 3). The associations remained statistically significant after adjusting for background variables (age, sex, smoking, and professional status), frequency of asthma symptoms, and the use of asthma medication during the last year. The highest OR was found for vehicle exhaust (OR 5.0, CI 2.2—11.4) and the lowest for tobacco smoke (OR 2.4, CI 1.3—4.4).

Reports of some but not all asthma triggers also increased the risk of being unemployed (Table 4). The risks were lower than those for work disability. After adjustments, an increased risk of unemployment was found in terms of house dust, odors or smells, vehicle exhaust, cleaners or detergents, physical activity, and mental load (ORs = 1.9—2.8).

As regards being retired, we found no elevated risk of any asthma trigger after adjustments (see Supplement Table S1).

Considering a potential for recall bias, we checked whether the results change when adjusting the logistic regression models with asthma symptom frequency during the last month instead of during the last year. The results were similar as the ORs did not differ considerably from the original (see Supplement Table S2).

Among those who were on disability pension (a subgroup of the work disability group), the individuals who reported that asthma was the partial or main cause of their disability pension more often identified triggers as asthma-relevant than those with non-asthma-related work disability, in terms of all other triggers except animal allergens (Table 5).

4. Discussion

In this cross-sectional study among individuals with asthma, we found evidence of an association between asthma trigger perceptions and all-cause work disability. Neither more frequent asthma symptoms in general nor medically less-treated asthma seemed to explain the differences between the trigger perceptions of those with work disability and full-time workers. Similar but less consistent associations were found between asthma trigger perceptions and unemployment. No elevated risks were found regarding asthma trigger perceptions for old-age retirement.

Trigger perceptions were associated with work disability even after adjustment for frequency of asthma symptoms and the use of asthma medication. This suggests that perceptions of trigger-induced symptoms are not always related to bronchoconstriction and that other functional states, such as inducible laryngeal obstruction or mucosal irritation, may be involved. As our study was questionnaire-based, we cannot confirm the exact mechanisms without provocation, lung function tests or other clinical assessments. Our results are compatible with earlier findings that show that spirometric lung function is largely not related to perceived asthma triggers [10,24]. Our results contribute to understanding why trigger avoidance interventions, concerning both allergenic and non-allergenic triggers, have mixed results in terms of asthma symptoms and asthma control [9,13,25,26].

Individuals with asthma commonly report sensory irritation in the eyes, nose, and throat and this might explain the trigger perceptions with no asthmatic component in our study. However, it is difficult for individuals to separate odor perceptions from sensory irritation, and this may result in excessive reporting of sensory irritation due to odor cues [16]. Sensory irritants at sufficiently high concentrations can activate two different sensory systems in the nose: a receptor-mediated trigeminal process that leads to irritant sensations in the mucosa and the release of neuropeptide mediators that affect physiological functions including respiration, and the olfactory system, which induces odor perceptions [27]. When the concentrations are lower, such that they exceed the odor threshold but are below the threshold for sensory irritation, the substance is only sensed by olfaction. Thresholds for sensory irritation can be up to several orders of magnitude higher than the corresponding odor thresholds, depending on the substance [27,28]. In controlled chamber exposure studies, thresholds for sensory irritation have not differed significantly among mild to moderate asthmatics and healthy controls [27,29,30].

In our study, vehicle exhaust increased the risk of work disability the most. The toxicological and exposure data of vehicle exhausts support the primary role of the olfactory route when sensing exhausts. Vehicle exhaust (from diesel or gasoline engines) is a complex mixture of gases and particulate matter, and has a strong, unpleasant odor. It contains several constituents that have the potency to irritate the eyes and airways, such as nitrogen dioxide (NO_2) and aldehydes [31]. In urban environments, most of the vehicle emissions are from diesel engines, and NO_2 has commonly been used as an indicator of diesel exhaust. Studies with controlled human exposure to diesel exhaust for 1–2 hours in chambers have shown that the lowest observed levels causing sensory irritation are 100—300 $\mu g/m^3$ particles and 0.2—1.3 ppm NO_2 [31,32]. Workplace measurements have revealed the highest exhaust exposure levels to be in underground mines and tunnel construction sites (119—231 $\mu g/m^3$ particles and 0.19 ppm NO_2), intermediate levels to be among, for example, vehicle mechanics (23—70 $\mu g/m^3$ particles and 0.02—0.05 ppm NO_2), and the lowest levels to be among outdoor workers and professional drivers (11—26 $\mu g/m^3$ particles and 0.02—0.03 ppm NO_2) [33]. The general population is mainly exposed to vehicle exhaust in streets, yards, and parking halls, and these exposure levels are closest to those of vehicle mechanics and outdoor workers. We can conclude that in everyday life, exposure levels do not usually exceed the threshold for sensory irritation, which leads to the deduction that vehicle exhaust is mainly sensed by olfaction. This view is also supported by a double-blind experimental study, which assessed symptom responses to controlled diesel exhaust exposure at varying concentrations and found that symptom reporting more closely reflected perceived exposure than true exposure [34].

As asthma is known to associate with work disability [2-5], there was good reason to expect that more symptomatic asthma would have explained the more frequent reporting of asthma triggers among those with work disability. Earlier studies have shown asthma trigger perceptions to associate with low health-related quality of life [10,19]. Strong perceptions of non-allergenic

triggers have been associated with less physical and mental well-being [35]. We cannot say to which extent underlying health-related factors, other than asthma, contribute to our results. We did not collect information on comorbidities or general health, but we presume that the health status of those in the work disability group was the poorest of all groups. As regards unemployment, there are also other causes than health-related ones, and those who continue in work life to retirement age are supposed to be the healthiest. The similarity in general health between the retired and current full-time workers provides a conceivable explanation for why no trigger gave elevated risk for comparison between these groups.

Anxiety and depression are common psychiatric comorbidities in asthma [36,37], and depression has been found to increase the risk of work disability among asthmatics [3]. Since 2000, mental disorders have been the leading cause of disability pensions in Finland. Therefore, anxiety and depression were probably highly prevalent in our work disability group, and anxiety in particular might have influenced our results. We observed that reporting of stress as an asthma trigger presented a 3.4-fold increased risk for work disability. Stress is associated with an increased risk of anxiety and depression [38], and it has been shown to play a strong role in asthma exacerbation and suboptimal asthma control [24,39]. Earlier studies have found anxiety and depression to associate with perceptions of asthma triggers, particularly non-allergenic triggers [10], or emotional triggers, such as stress [35]. It may also be the other way around: concerns regarding triggers in the environment may increase anxiety. An asthmatic perceiving a trigger, or the cue for it (like odor), as potentially harmful may initiate cognitive and emotional processes, leading to the interpretation of an uncontrollable health threat [16,40].

Many asthmatics, especially those with non-allergic asthma, report that odors and fragrances cause mucosal or respiratory symptoms, sometimes leading to substantial lifestyle modifications [41,42]. Accordingly, in our study, reports of odors or smells as asthma triggers, as well as cleaners

or detergents, had an elevated risk for work disability and unemployment. Enhanced responsivity to low-dose chemicals is typical for people suffering from idiopathic environmental intolerance (multiple chemical sensitivity) [43], and the condition overlaps to a great extent with asthma [44,45]. In the last decade, research has provided compelling explanations for how environmental triggers seem to cause symptoms in the absence of allergy, irritation or other toxicological effects. These include the presence of trigger cues (e.g. odor), prior expectations and beliefs that lead to a stress response upon exposure, a learning process that pairs potentially harmful environmental stimuli with symptom experiences, and finally, central sensitization. All of these are influenced by individual differences and vulnerabilities [46,47].

Fewer triggers increased the risk of unemployment than those that did so for work disability in our study. Perceptions of allergens (pollens), tobacco smoke, and cold air lost their impact in the models. A common factor to these triggers is that exposure to them is usually not unexpected: they are well known and not considered as an unfamiliar threat. Perceptions of animal allergens, which are relatively easy to control, did not differ between those with asthma-related and non-asthma-related work disability pension, while there was a difference concerning all other triggers. Surprisingly, perceptions of food stuffs triggering asthma symptoms considerably increased the risk of work disability, but not of unemployment. Asthma is not a strong predictor of severe food allergies [48], but non-specific food intolerances [49] and suspicions about harmfulness of food additives are more common [50].

The strength of our study is its homogeneous study population, which consisted of respondents with clinically verified asthma. The study design and an excellent response rate ensured a representative sample of asthmatics in the city of Tampere. Asthma treatment practices are rather uniform in Finland. The national asthma guidelines in Finland have stressed active treatment with inhaled corticosteroids since the early 1990’s [51]. According to a national survey in 2001, over

85% of patients who purchased asthma drugs from pharmacies used inhaled steroids daily [52]. Therefore, in this study, the continuous or seasonal use of asthma medication can be interpreted to be approximate to the use of inhaled corticosteroids.

The study has also some limitations. As the study design was questionnaire based, we lacked clinical data on the patients, for example lung function measurements and allergological tests. Therefore, we had no exact data for assessing asthma control or asthma severity. Instead, we used the frequency of asthma symptoms and the regularity of asthma medication as rough measures. We did not investigate the presence of doctor-diagnosed allergic rhinitis, which can be regarded as another limitation of the study. Concomitant allergic rhinitis may worsen asthma control and thereby it might have an impact on trigger reporting, and sometimes it might be difficult for individuals to differentiate between upper and lower airway symptoms. Because the study design was cross-sectional, no causal conclusions on trigger perceptions and employment status could be drawn, for example, we could not ascertain whether trigger perceptions increased work disability, or vice versa. The study was conducted in 2000, and some aspects of asthma management, environment (e.g. exposure to environmental tobacco smoke), or work life may have changed, although not fundamentally. Finland has for many decades been a stable welfare state, which is one reason for why we regard our results as still valid.

Our study may have important implications for the management of asthma. If all trigger reporting is interpreted as uncontrolled asthma, there is a risk of pharmacological overtreatment. Moreover, the present knowledge regarding pitfalls in trigger identification should be acknowledged in asthma education [15]. Distorted beliefs about asthma triggers may lead to unnecessary trigger avoidance, which in turn may pointlessly interfere with work and other social life [15]. However well-intentioned they might be, alarmist messages may increase the symptom experiences [16,17,52]. In general counseling, asthmatics should be informed that exposure levels

to substances in the everyday environment are often low, well below the sensory irritation thresholds [28], and that trigger perceptions can elicit psychophysiological responses, including bronchoconstriction [40]. Individuals with, for instance, severe allergies need a different approach [53].

It is a novel finding that perceptions of asthma triggers outside work are associated with socioeconomic implications in terms of work disability or unemployment. Further research is needed to evaluate which interventions are efficient to reduce trigger perceptions. Apart from environmental control measures, interventions that change trigger beliefs may improve asthma control and moreover, sustain work careers. Different asthma phenotypes, and the differences between individuals in the perception of asthma triggers, should be taken into account.

5. Conclusions

In conclusion, our study shows that perceptions of triggers as asthma relevant are associated with undesired occupational outcomes, i.e. work disability and, to a lesser degree, unemployment. We found an elevated risk of all the studied triggers in terms of work disability, which may indicate that it is not primarily trigger-specific factors that increase trigger perceptions and contribute to work disability. Our findings suggest that asthmatics have excess trigger perceptions that are not explained by asthma alone. Asthmatics must be informed that inaccurate trigger perceptions may develop, and how they are induced, because unnecessary trigger avoidance may interfere with work life. Also, asthmatics should be helped to differentiate bronchial obstruction from, for instance, laryngeal symptoms, mucosal irritation, and reactions to odors.

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Declarations of interest

The authors have no conflicts of interest related to the present study. KK works as a part-time medical consult at Varma Mutual Pension Insurance Company. This affiliation causes no conflicts of interest as regards this article.

Ethics

This is a questionnaire-based study, in which participation was voluntary. Since there was no intervention, the Finnish legislation does not require ethics committee handling.

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Table 1. Characteristics, frequency of asthma symptoms, and use of asthma medication according to employment status. Data is presented as n (%) unless otherwise stated.

	Full-time work (1) n = 967	**Unemployed (2) n = 197**	**Work disability (3) n = 334**	**Retired (4) n = 159**	**p-value 1 vs. 2**	**p-value 1 vs. 3**	**p-value 1 vs. 4**
Age, mean years (SD)	44.1 (10.2)	46.2 (11.0)	57.9 (8.2)	62.9 (3.8)	0.064	< .001	<.001
Sex					0.007	0.346	0.028
Women	568 (58.7)	136 (69.0)	206 (61.7)	108 (67.9)			
Men	399 (41.3)	61 (31.0)	128 (38.3)	51 (32.1)			
Smoking status					0.004	0.002	< .001
Never smoker	432 (45.0)	70 (36.1)	132 (40.0)	92 (58.2)			
Ex-smoker	217 (22.6)	40 (20.6)	98 (29.7)	38 (24.1)			
Current smoker	155 (16.1)	52 (26.8)	66 (20.0)	20 (12.7)			
Occasional smoker	157 (16.3)	32 (16.5)	34 (10.3)	8 (5.1)			
Professional status					< .001	< .001	0.001
Self-employed	98 (10.2)	10 (5.2)	25 (8.0)	7 (4.6)			
Upper-level non-manual worker	199 (20.7)	11 (5.8)	21 (6.7)	24 (15.9)			
Lower-level non-manual worker	284 (29.5)	50 (26.2)	59 (18.8)	35 (23.2)			
Manual worker	353 (36.7)	113 (59.2)	195 (62.1)	79 (52.3)			
Other	50 (5.2)	14 (7.3)	33 (10.1)	6 (3.8)			
Frequency of asthma symptoms during last year					< .001	< .001	< .001
None	22 (2.7)	2 (1.2)	6 (2.2)	6 (4.9)			
Less than once a week	415 (50.1)	57 (33.7)	58 (21.7)	40 (32.8)			
1–2 times a week	187 (22.6)	41 (24.3)	46 (17.2)	23 (18.9)			
3–4 times a week	84 (10.1)	23 (13.6)	44 (16.5)	16 (13.1)			
Daily or almost daily	121 (14.6)	46 (27.2)	113 (42.3)	37 (30.3)			
Use of asthma medication during last year					0.066	< .001	0.010
None	105 (10.9)	13 (6.6)	19 (5.7)	12 (7.6)			
Irregular	190 (19.7)	39 (19.9)	38 (11.5)	18 (11.4)			
Seasonal (e.g. springtime)	113 (11.7)	15 (7.7)	23 (6.9)	15 (9.5)			
Continuous	556 (57.7)	129 (65.8)	251 (75.8)	113 (71.5)			

SD = standard deviation

Table 2. Asthma triggers according to how often respondent perceived particular factor as causing or worsening their asthma symptoms during leisure time, reported by different employment status groups. Data presented as n (%).

	Full-time work (1) n = 967	**Unemployed (2) n =197**	**Work disability (3) n = 334**	**Retired (4) n = 159**	**p-value 1 vs. 2**	**p-value 1 vs. 3**	**p-value 1 vs. 4**
Allergens							
Pollens					0.118	< .001	0.691
Never	156 (16.8)	30 (16.1)	31 (10.6)	27 (19.7)			
Sometimes	484 (52.1)	84 (45.2)	120 (41.2)	68 (49.64)			
Often	289 (31.1)	72 (38.7)	140 (48.1)	42 (30.7)			
Animals					< .001	0.002	0.466
Never	199 (21.4)	29 (16.1)	59 (20.4)	36 (26.1)			
Sometimes	459 (49.5)	71 (39.4)	115 (39.8)	65 (47.1)			
Often	270 (29.1)	80 (44.4)	115 (39.8)	37 (26.8)			
Irritants/odorants							
House dust					< .001	< .001	< .001
Never	264 (28.5)	31 (17.0)	47 (15.9)	41 (31.1)			
Sometimes	520 (56.2)	96 (52.8)	121 (40.9)	48 (36.4)			
Often	142 (15.3)	55 (30.2)	128 (43.2)	43 (32.6)			
Tobacco smoke					< .001	< .001	< .001
Never	300 (32.4)	44 (23.7)	41 (13.9)	105 (15.8)			
Sometimes	443 (47.8)	83 (44.6)	107 (36.3)	48 (34.8)			
Often	183 (19.8)	59 (31.7)	147 (49.8)	65 (47.1)			
Odors or smells					< .001	< .001	< .001
Never	267 (28.6)	29 (15.8)	28 (9.6)	23 (16.3)			
Sometimes	483 (51.7)	89 (48.6)	124 (42.6)	60 (42.6)			
Often	185 (19.8)	483 (51.7)	139 (47.8)	58 (41.1)			
Vehicle exhaust					< .001	< .001	< .001
Never	305 (33.1)	26 (14.4)	18 (6.1)	21 (14.7)			
Sometimes	468 (50.8)	92 (50.8)	90 (30.6)	52 (36.4)			
Often	148 (16.1)	63 (34.8)	186 (63.3)	70 (49.0)			
Cleaners or detergents					< .001	< .001	< .001
Never	504 (55.4)	65 (37.6)	79 (28.4)	49 (37.7)			
Sometimes	337 (37.0)	71 (41.0)	111 (39.9)	53 (40.8)			
Often	69 (7.6)	37 (21.4)	88 (31.6)	28 (21.5)			
Others							
Cold air					< .001	< .001	< .001
Never	121 (13.0)	10 (5.5)	17 (5.5)	11 (7.7)			
Sometimes	568 (60.8)	76 (41.5)	116 (37.5)	55 (38.5)			
Often	245 (26.2)	97 (53.0)	176 (57.0)	77 (53.8)			
Physical activity					< .001	< .001	< .001
Never	181 (19.3)	13 (7.0)	24 (8.0)	16 (11.5)			
Sometimes	499 (53.3)	97 (52.4)	104 (34.4)	51 (36.7)			
Often	256 (27.4)	75 (40.5)	174 (57.6)	72 (51.8)			
Mental load (stress)					< .001	< .001	0.004
Never	404 (43.8)	44 (24.9)	52 (18.2)	40 (29.8)			
Sometimes	412 (44.7)	87 (49.2)	128 (44.9)	70 (52.2)			
Often	106 (11.5)	46 (26.0)	105 (36.8)	24 (17.9)			
Foodstuffs					0.066	<.001	0.785
Never	575 (63.8)	97 (54.5)	120 (46.7)	78 (61.9)			
Sometimes	276 (30.6)	69 (38.8)	101 (39.3)	39 (31.0)			
Often	51 (5.6)	12 (6.7)	36 (14.0)	9 (7.1)			

Table 3. Odds ratios (OR) with 95% confidence intervals (CI) for work disability (vs. full time work). Background variables used for adjustment included age, sex, smoking, and professional status.

	Model 1 Unadjusted	Model 2 Adjusted for background variables	Model 4 Adjusted for background variables, frequency of asthma symptoms and use of asthma medication during last year
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Allergens			
Pollens			
Never	1.0	1.0	1.0
Sometimes	1.3 (0.8—1.9)	1.4 (0.8—2.4)	1.4 (0.7—2.6)
Often	**2.4 (1.6—3.8)**	**3.7 (2.1—6.7)**	**2.9 (1.5—5.7)**
Animals			
Never	1.0	1.0	1.0
Sometimes	0.8 (0.6—1.2)	1.3 (0.8—2.2)	1.4 (0.8—2.3)
Often	**1.4 (1.0—2.1)**	**3.5 (2.1—5.8)**	**2.6 (1.4—4.7)**
Irritants/odorants			
House dust			
Never	1.0	1.0	1.0
Sometimes	1.3 (0.9—1.9)	1.4 (0.9—2.3)	1.2 (0.7—2.1)
Often	**5.0 (3.4—7.5)**	**5.0 (2.9—8.6)**	**3.7 (2.0—6.8)**
Tobacco smoke			
Never	1.0	1.0	1.0
Sometimes	**1.8 (1.2—2.6)**	1.3 (0.8—2.2)	1.3 (0.7—2.3)
Often	**5.9 (4.0—8.7)**	**3.3 (1.9—5.7)**	**2.4 (1.3—4.4)**
Odors or smells			
Never	1.0	1.0	1.0
Sometimes	**2.4 (1.6—3.8)**	1.6 (0.9—2.9)	1.6 (0.8—3.0)
Often	**7.2 (4.6—11.2)**	**3.4 (1.9—6.3)**	**2.8 (1.4—5.5)**
Vehicle exhaust			
Never	1.0	1.0	1.0
Sometimes	**3.3 (1.9—5.5)**	1.7 (0.9—3.4)	1.7 (0.8—3.9)
Often	**21.3 (12.6—35.9)**	**6.3 (3.2—12.4)**	**5.0 (2.2—11.4)**
Cleaners or detergents			
Never	1.0	1.0	1.0
Sometimes	**2.1 (1.5—2.9)**	**1.6 (1.0—2.4)**	1.2 (0.7—1.9)
Often	**8.1 (5.5—12.1)**	**3.4 (2.0—5.7)**	**2.5 (1.3—4.6)**
Others			
Cold air			
Never	1.0	1.0	1.0
Sometimes	1.5 (0.8—2.5)	1.8 (0.8—3.8)	1.9 (0.7—5.2)
Often	**5.1 (3.0—8.8)**	**3.2 (1.5—6.9)**	**2.6 (1.0—7.1)**
Physical activity			
Never	1.0	1.0	1.0
Sometimes	**1.6 (1.0—2.5)**	1.5 (0.8—2.8)	1.6 (0.8—3.5)
Often	**5.1 (3.2—8.1)**	**3.3 (1.7—6.1)**	**2.5 (1.2—5.5)**
Mental load (stress)			
Never	1.0	1.0	1.0
Sometimes	**2.4 (1.7—3.4)**	**1.7 (1.0—2.7)**	1.6 (0.9—2.8)

Often	**7.7 (5.2—11.4)**	**4.0 (2.3—6.9)**	**3.4 (1.8—6.3)**
Foodstuffs			
Never	1.0	1.0	1.0
Sometimes	**1.8 (1.3—2.4)**	**2.0 (1.3—3.1)**	1.7 (1.1—2.8)
Often	**3.4 (2.1—5.4)**	**4.7 (2.4—9.5)**	**3.9 (1.7—8.9)**

Table 4. Odds ratios (OR) with 95% confidence intervals (CI) for unemployment (vs. full time work). Background variables used for adjustment included age, sex, smoking, and professional status.

	Model 1 Unadjusted	Model 2 Adjusted for background variables	Model 3 Adjusted for background variables, frequency of asthma symptoms and use of asthma medication during last year
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Allergens			
Pollens			
Never	1.0	1.0	1.0
Sometimes	0.9 (0.6—1.4)	0.9 (0.5—1.5)	0.7 (0.4—1.3)
Often	1.3 (0.8—2.1)	1.3 (0.7—2.3)	0.9 (0.4—1.6)
Animals			
Never	1.0	1.0	NA
Sometimes	1.1 (0.7—1.7)	1.3 (0.8—2.3)	
Often	**2.0 (1.3—3.2)**	**2.5 (1.4—4.4)**	
Irritants/odorants			
House dust			
Never	1.0	1.0	1.0
Sometimes	**1.6 (1.0—2.4)**	**1.6 (1.0—2.7)**	**1.9 (1.1—3.5)**
Often	**3.3 (2.0—5.4)**	**2.6 (1.5—4.7)**	**2.2 (1.1—4.4)**
Tobacco smoke			
Never	1.0	1.0	1.0
Sometimes	1.3 (0.9—1.9)	**1.7 (1.0—2.7)**	1.3 (0.8—2.3)
Often	**2.2 (1.4—3.4)**	**2.8 (1.5—5.1)**	1.8 (0.9—3.4)
Odors or smells			
Never	1.0	1.0	1.0
Sometimes	**1.7 (1.1—2.6)**	1.6 (0.9—2.8)	1.6 (0.9—2.9)
Often	**3.2 (2.0—5.2)**	**2.4 (1.3—4.4)**	**1.9 (1.0—3.9)**
Vehicle exhaust			
Never	1.0	1.0	1.0
Sometimes	**2.3 (1.5—3.6)**	**2.4 (1.4—4.1)**	2.2 (1.2—4.0)
Often	**5.0 (3.0—8.2)**	**4.0 (2.1—7.7)**	**2.8 (1.4—5.9)**
Cleaners or detergents			
Never	1.0	1.0	1.0
Sometimes	**1.6 (1.1—2.4)**	1.4 (0.9—2.2)	1.2 (0.8—2.0)
Often	**4.2 (2.6—6.9)**	**3.2 (1.7—5.9)**	**2.4 (1.2—4.9)**
Others			
Cold air			
Never	1.0	1.0	1.0
Sometimes	1.6 (0.8—3.2)	1.4 (0.6—2.9)	0.9 (0.4—2.0)
Often	**4.8 (2.4—9.5)**	**3.4 (1.6—7.3)**	1.9 (0.8—4.4)
Physical activity			
Never	1.0	1.0	1.0
Sometimes	**2.7 (1.5—4.9)**	**2.6 (1.3—5.2)**	**2.1 (1.0—4.5)**
Often	**4.1 (2.2—7.6)**	**3.4 (1.7—6.9)**	**2.4 (1.1—5.3)**
Mental load (stress)			
Never	1.0	1.0	1.0
Sometimes	**1.9 (1.3—2.9)**	1.5 (0.9—2.4)	1.4 (0.8—2.3)
Often	**4.0 (2.5—6.3)**	**3.0 (1.7—5.4)**	**2.2 (1.2—4.2)**

Foodstuffs			
Never	1.0	1.0	1.0
Sometimes	**1.5 (1.1—2.1)**	1.4 (0.9—2.2)	1.4 (0.9—2.2)
Often	1.4 (0.7—2.7)	1.1 (0.5—2.6)	0.7 (0.3—1.9)

NA = not assessed due to small number of observations

Table 5. Asthma triggers according to how often respondent perceived particular factor as causing or worsening their asthma symptoms during leisure time, reported.by those who were on disability pension (n = 254) according to whether or not asthma was the reason for the disability pension. Data presented as n (%).

	"Was asthma the reason for your disability pension?"*		
	No	**Yes, partly or mainly**	**p-value**
	n = 58	**n = 188**	
Allergens			
Pollens			0.002
Never	13 (24.1)	14 (8.5)	
Sometimes	13 (24.1)	73 (44.2)	
Often	28 (51.8)	78 (47.3)	
Animals			0.231
Never	17 (30.9)	32 (19.8)	
Sometimes	18 (32.7)	61 (37.6)	
Often	20 (36.4)	69 (42.6)	
Irritants/odorants			
House dust			< .001
Never	18 (32.7)	21 (12.3)	
Sometimes	21 (38.2)	65 (38.0)	
Often	16 (29.1)	85 (49.7)	
Tobacco smoke			0.027
Never	15 (27.8)	22 (12.8)	
Sometimes	16 (29.6)	52 (30,2)	
Often	23 (42.6)	98 (57.0)	
Odors or smells			< .001
Never	12 (22.6)	12 (7.1)	
Sometimes	24 (45.3)	63 (37.5)	
Often	17 (32.1)	93 (55.4)	
Vehicle exhaust			< .001
Never	8 (15.1)	4 (2.3)	
Sometimes	17 (32.1)	51 (29.5)	
Often	28 (52.8)	118 (68.2)	
Cleaners or detergents			0.007
Never	22 (41.5)	40 (24.8)	
Sometimes	22 (41.5)	58 (36.0)	
Often	9 (17.0)	63 (39.1)	
Others			
Cold air			< .001
Never	5 (9.3)	5 (2.8)	
Sometimes	29 (53.7)	58 (32.4)	
Often	20 (37.0)	116 (64.8)	
Physical activity			0.006
Never	7 (13.0)	8 (4.5)	
Sometimes	24 (44.4)	54 (30.5)	
Often	23 (42.6)	115 (65.0)	
Mental load (stress)			0.002
Never	17 (32.7)	20 (12.2)	
Sometimes	22 (42.3)	78 (47.6)	
Often	13 (25.0)	66 (40.2)	
Foodstuffs			0.028
Never	34 (64.2)	65 (44.2)	
Sometimes	16 (30.2)	59 (40.1)	
Often	3 (5.7)	23 (15.6)	

* Missing data n = 8

Supplementary Table S1. Odds ratios (OR) with 95% confidence intervals (CI) for being retired (vs. full time work). Background variables used for adjustment included age, sex, smoking, and professional status.

	Model 1 Unadjusted	Model 2 Adjusted for background variables	Model 3 Adjusted for background variables, frequency of asthma symptoms and use of asthma medication during last year
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Allergens			
Pollens			
Never	1.0	1.0	1.0
Sometimes	0.8 (0.5—1.3)	0.9 (0.3—2.3)	0.6 (0.2—2.1)
Often	0.8 (0.5—1.4)	1.5 (0.5—4.6)	1.1 (0.3—4.0)
Animals			
Never	1.0	1.0	1.0
Sometimes	0.8 (0.5—1.2)	1.6 (0.6—3.9)	1.5 (0.5—4.7)
Often	0.8 (0.5—1.2)	2.8 (0.9—8.5)	2.0 (0.5—7.6)
Irritants/odorants			
House dust			
Never	1.0	1.0	1.0
Sometimes	0.6 (0.4—0.9)	1.0 (0.4—2.4)	1.4 (0.5—4.5)
Often	2.0 (1.2—3.1)	1.5 (0.5—4.5)	1.6 (0.4—5.9)
Tobacco smoke			
Never	1.0	1.0	1.0
Sometimes	1.3 (0.8—2.2)	0.6 (0.2—2.0)	1.2 (0.3—5.8)
Often	**4.3 (2.6—7.0)**	1.0 (0.3—3.4)	2.0 (0.4—10.6)
Odors or smells			
Never	1.0	1.0	1.0
Sometimes	1.4 (0.9—2.4)	0.7 (0.2—2.2)	0.8 (0.2—3.3)
Often	**3.6 (2.2—6.1)**	1.1 (0.3—3.7)	1.2 (0.2—6.4)
Vehicle exhaust			
Never	1.0	1.0	1.0
Sometimes	1.6 (1.0—2.7)	0.8 (0.3—2.2)	0.7 (0.2—3.0)
Often	**6.9 (4.1—11.6)**	1.4 (0.5—4.4)	1.5 (0.4—6.4)
Cleaners or detergents			
Never	1.0	1.0	1.0
Sometimes	**1.6 (1.1—2.4)**	0.7 (0.3—1.7)	0.7 (0.2—2.0)
Often	**4.2 (2.5—7.1)**	1.1 (0.3—3.9)	1.1 (0.3—4.8)
Others			
Cold air			
Never	1.0	1.0	1.0
Sometimes	1.1 (0.5—2.1)	0.7 (0.2—2.8)	0.2 (0.0—1.2)
Often	**3.5 (1.8—6.7)**	1.7 (0.4—7.4)	0.7 (0.1—5.0)
Physical activity			
Never	1.0	1.0	1.0
Sometimes	1.2 (0.6—2.1)	0.7 (0.2—2.2)	0.6 (0.1—2.7)
Often	**3.2 (1.8—5.6)**	1.2 (0.4—4.2)	1.0 (0.2—5.2)
Mental load (stress)			
Never	1.0	1.0	1.0
Sometimes	**1.7 (1.1—2.6)**	0.6 (0.2—1.6)	0.8 (0.3—2.5)
Often	**2.3 (1.3—4.0)**	1.3 (0.4—4.5)	2.8 (0.6—13.1)
Foodstuffs			

Never	1.0	1.0	1.0
Sometimes	1.0 (0.7—1.6)	0.9 (0.4—2.1)	0.7 (0.2—2.1)
Often	1.3 (0.6—2.7)	0.8 (0.1—5.7)	0.3 (0.0—2.7)

Highlights

- Perceptions of asthma triggers are associated with occupational outcomes in terms of all-cause work disability and, to a lesser degree, unemployment.
- Our findings suggest that asthmatics have excess trigger perceptions that are not explained by asthma alone.
- Asthmatics must be informed that inaccurate trigger perceptions may develop, and how they are induced, because unnecessary trigger avoidance may interfere with work life.