

Work-related exacerbation of asthma among adults treated by pulmonary specialists

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ABSTRACT

The most common chronic occupational lung disease is occupational asthma. This study aimed to assess the prevalence of work-related respiratory symptoms (WRS) in asthmatic adults at pulmonary clinics. A cross-sectional study was performed. Current employed subjects were subdivided into 2 groups by WRS status according to questionnaire mainly based on one developed by the National Institute for Occupational Safety and Health (NIOSH). Subjects' occupation and workplace exposures were evaluated by asthma-specific job exposure matrix (JEM). Thirty-nine of 179 current employed asthmatics had WRS. Subjects with WRS were more likely to have self-reported allergy and exposure to low-molecular-weight antigens (prevalence ratio [PR]: 2.7). The 2 most frequent occupational classes for asthmatics with WRS were trades, transport and equipment operators, and processing and manufacturing. Self-reported allergy, high-risk exposures, and occupations unique to processing, manufacturing, and utilities were estimated to be risk factors of WRS.

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The most common chronic occupational lung disease reported in industrialized countries is occupational asthma.^{1–4} Occupational asthma (OA) is estimated to be the second-most prevalent occupational lung disease in developing countries after pneumoconiosis.⁵ The estimated burden of OA among asthmatics is 2–20%. (1, 4). A recent systematic review by Toren and Blanc concluded that 16.9% of adult-onset asthma is due to occupational exposures.⁶ Furthermore, a quite high attributable risk fraction for asthma due to occupation was found by the European Community Respiratory Health Survey (ERCHS): 10–25%.⁷

Tarlo et al found asthma worsened at work to be 16% among adult-onset asthmatics and 12% of all asthmatics.⁸ Among 301 hospital admitted asthmatics in New York, 31% of patients had work-exacerbated asthma (WEA) in their current job and 71% in any job.³ A study conducted in a general medical practice setting indicated that more than 1 in 10 asthma patients had occupational histories strongly suggestive of occupational attribution.⁹

It has been reported that bakers, chemical workers, and cleaners are at increased risk of asthma.¹⁰ Karjalainen in

an ecologic study in Finland found that occupational factors have significant influence on adult-onset persistent asthma and identified agricultural, manufacturing, and service workers to be at increased risk of asthma.¹¹ In the ONAP (Observatoire National de Asthmes Professionnels Project) 1997 study, the 3 most frequently suspected agents were flour (23.3%), isocyanates (16.6%), and latex (7.5%). At-risk occupations were bakers (23.9%), health care workers (12%), painters (9.1%), and hairdressers (5.2%).¹²

The prevalence of work-related asthma (WRA) in different countries is still an important issue. The American Thoracic Society (ATS) and European Respiratory Society (ERS) have published articles that highlight the importance of evaluating OA prevalence.^{13,14} Although OA remains underrecognized in many countries, this is especially true in developing countries.⁵ Chronic respiratory diseases are estimated to be more prevalent in developing countries with high speed of industrialization. Population-attributable risk of WRA in rapidly developing countries is estimated to be 15% in China, 13% in South Africa, and 6% in Zambia.⁵ To our knowledge,

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there is no published population- or clinical setting-based study among workers or patients with asthma concerning work exacerbation of asthma (WEA) in Iran or the Middle East region. The findings of such studies would be helpful to have crude estimation of work-related respiratory symptoms (WRS). The results also could be useful in conducting more comprehensive studies in clinical settings or population-based studies. Thus, rapidly growing industries with potentially high-risk exposures for WRA in Iran along with a paucity of information about WRA suggests that further investigation in the region is warranted.

The main purpose of the current study was to assess the prevalence of WRA and occupational exposures in working asthmatic adults treated at 2 pulmonary clinics (Masih Daneshvari and Imam Hospitals, Tehran) and to assess which occupations and workplace exposures were associated with WRS.

Methods

Study subjects

A cross-sectional study was conducted in pulmonology clinics at 2 academic referral hospitals in Tehran. Recruitment was conducted throughout all of 2010. Those eligible to take part were patients ≥ 17 years old referred to 1 of the 2 clinics and who were diagnosed with asthma by a pulmonary specialist either previously or at the time they visited the clinic. A total of 339 asthma patients were asked to take part. Informed consent was obtained from all patients before they participated.

Study design

The questionnaire was based mainly on a worker screening questionnaire developed by the National Institute for Occupational Safety and Health (NIOSH) in the United States.¹⁵ The questionnaire had 3 main parts: demographic characteristics, respiratory health assessment in the past 12 months, and occupational information including job titles and tasks in the past 12 months. A trained interviewer (an occupational hygienist) administered the questionnaire to each eligible patient after recruitment. Also, height in meters and weight in kilograms were determined for each participant. These were used to compute the body mass index (BMI), which is body weight divided by height squared.

The focus of the current study was asthma patients who were employed in the last 12 months. These participants were asked about asthma symptoms during the last 12 months, specifically wheezing, chest tightness,

cough, shortness of breath, and asthma attack, and whether these symptoms improved when away from work. A participant was considered to have work-related respiratory symptoms if he reported having at least 2 respiratory symptoms with improvement on days away from work. Currently, employed study participants who reported 0 or only 1 respiratory symptom that improved on days away from work were classified as negative for WRS.

The prevalence of WRS was determined for different categories of characteristics, such as ever smoked tobacco, sex, hospital admission for asthma, allergic status, and self-reported exposure to vapor, dust, gas, or fumes (VDGF). Allergic status was based on self-reported nasal allergies and/or eczema.

Evaluation of occupational exposures

The work history part of the questionnaire asked the participant to provide information about jobs they had in the past 12 months, including job title, tasks completed, and exposures to dusts, gases, and fumes. This information about recent jobs was then used to code the participants' occupations using the Standard Occupational Classification—1991 (SOC-91).¹⁶

Subjects' asthmagenic exposures were assessed using the asthma-specific job exposure matrix (JEM) that Kennedy and colleagues developed, and which was revised in 2008 so that exposure estimates could be assigned using the SOC-91 job codes.¹⁷ The JEM classifies each job as either "exposed" or "not exposed," separately for 18 groups of asthmagenic agents and 3 nonasthmagenic agents. The JEM also combined the asthmagenic agents into 3 categories: high molecular weight, low molecular weight, or mixed exposures.¹⁷

Data analysis

For crude data comparisons, statistical significance was based on the Student's *t* test for continuous variables and chi-square test for categorical variables. Odds ratios can overestimate risk with common outcomes, so prevalence ratios (PRs) were calculated, using a Cox regression model with constant follow-up time for all participants.¹⁸ A base model was fit initially, in which we determined which demographic and health characteristics were associated with WRS. The candidate variables were age, BMI, sex, marriage status, education level, cigarette smoking, and history of allergies. Covariates with a $p \leq .05$ were retained in the base model, to which variables for occupation and workplace exposures were added to assess if they were associated with WRS.

A p value $<.05$ was considered as statistically significant. Data analyses were accomplished using SAS 9.1 software (SAS Institute, Cary, NC, USA).

Results

A total of 339 adult asthmatics (100% of the 339 invited) were recruited in the present study. Among 339 patients, 179 (53%) were employed at the time of their visit in the pulmonology clinic. The 179 employed asthma patients ranged in age from 18 to 80 years, with a mean of 38.8 ($SD = 12.6$), and the overwhelming majority were male ($n = 145$, 81%) and married ($n = 139$, 78%). Many of them had completed a diploma or upper diploma ($n = 95$, 53%) or technical training ($n = 37$, 21%). By health characteristics, the mean BMI was 26 ($SD = 4.6$), and approximately one fourth ($n = 50$, 28%) had ever smoked cigarettes. Mean smoking pack-year was 11.4 ± 18 , 11 ± 20 for participants with WRS ($p = .97$). About half ($n = 103$, 57%) had allergies, which meant they reported a history of nasal allergies ($n = 101$) and/or eczema ($n = 8$). They used inhaled corticosteroids (ICS) ($n = 106$, 59%) more often than the medications prednisolone ($n = 21$, 12%) and bethametasone ($n = 19$, 11%). Substantial minorities reported emergency care ($n = 53$, 30%) or hospital admissions ($n = 30$, 17%) for asthma in the past 2 years.

Thirty-nine employed patients, or 22%, reported at least 2 work-related respiratory symptoms, fulfilling the criteria for WRS. Wheezing was the most commonly reported work-related respiratory symptom ($n = 62$, 35%). The 39 with WRS represented 11% of all 339 adult asthmatics, employed and unemployed, who completed the questionnaire.

The prevalence of WRS varied little by different characteristics of the asthmatic subjects (Table 1). However, patients with self-reported allergy (nasal allergy and/or eczema) did report WRS more often than those without WRS, 30% versus 11%, respectively, $p = .005$. Also, men were more likely to have WRS ($n = 34$, 23%) versus women ($n = 5$, 15%), but this difference was not statistically significant ($p = .15$). Other characteristics, including asthma medications taken and care sought in the past 2 years, did not have a statistically significant association with WRS. Participants with WRS did not take more medications (prednisolone, bethametasone, and inhaled corticosteroids) for treatment of asthma. Moreover, those with WRS had fewer emergency and hospital admissions (Table 1).

Approximately three fourths ($n = 149$) of employed patients reported having exposure to VDGF in their current job. Those with VDGF exposure had a higher

Table 1. Percentage of currently employed asthma patients with work-related respiratory symptoms (WRS), by various characteristics.

Characteristics	N	WRS		p value*
		n	%	
Demographics				
Age (years)				
Low tertile (18–31)	59	14	24%	.58
Middle (32–43)	60	13	22%	.68
High tertile (44–80)	59	11	19%	.53
Sex				
Male	145	34	23%	.15
Female	34	5	15%	
Married				
No	40	10	25%	.57
Yes	139	29	21%	
Education				
Diploma, Upper diploma	95	21	22%	.98
Technical course ^{††}	37	7	19%	.39
Other	47	11	23%	
Health characteristics				
Body mass index				
Low tertile (17–23)	59	10	17%	.30
Middle tertile (24–27)	60	14	23%	.91
High tertile (27.7–41)	59	14	24%	.54
Ever smoke cigarettes				
No	129	28	22%	.98
Yes	50	11	22%	
History of allergies**				
No	76	8	11%	.005
Yes	103	31	30%	
Medications taken for asthma				
Prednisolone				
No	158	34	22%	.81
Yes	21	5	24%	
Bethametasone				
No	160	33	21%	.22
Yes	19	6	32%	
Inhaled corticosteroids				
No	73	18	25%	.26
Yes	106	21	20%	
Care for Asthma				
Emergency admission [†]				
No	126	30	24%	.39
Yes	53	9	17%	
Hospital admission [†]				
No	149	34	23%	.62
Yes	30	5	17%	

* p value based on univariate regression models for WRS.

**History of allergies was positive for anyone who reported having nasal allergies or eczema.

[†]The time frame for emergency care and hospital admissions for asthma was the past 2 years.

^{††}A training technical course about the current job.

prevalence of WRS ($n = 35$, 23%) than those without, but the difference was not statistically significant.

The most frequent occupations of subjects in past 12 months were trades, transport jobs, equipment operators, and related occupations with $n = 62$, followed by sales and service occupations with $n = 35$ (Table 2). About half of the 23 study participants with occupations unique to processing, manufacturing, and utilities had WRS ($11/23 = 48\%$), which was considerably more than the prevalence of 18% ($n = 28$) among the 156 in other occupations ($p = .0003$). None of the other occupations were associated with WRS (Table 2).

Table 2. Prevalence of WRS by occupations of currently employed asthma patients.

Occupational category	N	WRS		p value
		n	%	
Trades, transport, equipment operators, and related	62	12	19%	.67
Processing, manufacturing, and utilities	23	11	48%	.0003
Business, finance, and administrative	33	7	21%	.98
Sales and service	35	5	14%	.27
Primary industry	12	0		—*
Natural and applied sciences	6	0		—*
Social science, education, government service, and religion	5	0		—*
Management	2	0		—*
Art, culture, recreation, and sport	3	1	33%	—*
Health care	1	1	100%	—*

*No statistical calculation was done due to low number of subjects in WRS subgroup.

The asthma-specific JEM identified 58 (32.6%) of the currently employed subjects to have 1 or more high-risk exposures to asthmagenic compounds (Table 3). Exposure to low-molecular-weight compounds in the current job was found to be the most frequent asthmagenic exposure among the asthmatics of the current study. This exposure also had the highest prevalence of WRS with 42% (15/36), which was significantly greater than the prevalence of 17% (24/143) among the other employed participants ($p = .0002$). WRS was somewhat more common for those with mixed exposures (7/21 = 33% versus 32/158 = 20%), but the difference was not statistically significant ($p = .13$). The other notable finding by occupational exposures was for those who had 1 or more high-risk exposures, with a WRS prevalence of 33% (19/58) compared with 17% (20/121) for others ($p = .003$).

Several demographic and health characteristic variables were considered for inclusion in the base regression model, but only history of allergies was associated with WRS at the $p < .05$ level and retained in the model (Table 1). We added different occupation and occupational exposure variables to the base model for WRS to calculate prevalence ratios. Occupations unique to processing, manufacturing, and utilities (odds ratio [OR] = 2.8), exposure to low-molecular-weight antigens (OR =

2.8), and 1 or more high-risk exposures (OR = 2.2) were found to have statistically significant positive associations with WRS (Table 4).

Comment

From a survey of patients from 2 referral pulmonary clinics, we estimated the prevalence of work-related respiratory symptoms to be 11% among all adult asthmatics and 22% in all currently employed asthmatics. There are different reports about prevalence of WEA in similar settings (Table 5).^{8,9,19–24} The reported prevalence of worsening asthma at work in the Tarlo et al study was 16% of all adult-onset employed asthmatic subjects.⁸ A survey by Henneberger et al based on questionnaire self-reports of worsening asthma indicated 25% of participants to have work-exacerbated asthma (Table 5).²¹ To have a better comparison, the most similar studies conducted in clinical settings are reviewed in Table 5. The number of epidemiological studies regarding WEA in clinical settings in developing countries is very small. This warrants conducting population- or clinical setting-based studies to find out more about WEA in the developing world. Consistent with current results in a study of 12 published reports, median

Table 3. Prevalence of WRS by occupational exposures for all currently employed asthma patients.

Exposure assessed by asthma-specific job exposure matrix	N	WRS		p value
		n	%	
High-molecular-weight agents	12	3	25%	.71
Low-molecular-weight agents	36	15	42%	.0002
Mixed-environment exposure	21	7	33%	.13
Accidental peak exposure to irritants	2	0		—*
Combustion particle/fume	22	1	5%	—*
Possible exposure to irritant gases or fumes	2	0		—*
High probability of exposure to environmental tobacco smoke (ETS)	21	4	19%	.83
Low antigen exposure**	37	7	19%	.75
One or more high-risk exposures†	58	19	33%	.003

*No statistical calculation was done due to low number of subjects in WRS subgroup.**Low antigen exposure: May be exposed to “asthmagens” but low probability of enough exposure for OA.

†The high-risk exposures are the first 4 listed in this table.

Table 4. Statistically significant adjusted prevalence ratios for WRS by current occupation and occupational exposures.

Risk factor	Prevalence ratio	95% CI	p value
Processing, manufacturing, and utilities occupations	2.8	1.6–4.8	.0003
Self-reported allergy	2.8	1.4–5.6	.003
Low-molecular-weight agent exposure*	2.8	1.7–4.7	<.0001
Self-reported allergy	2.8	1.4–5.5	.004
One or more high-risk exposures***	2.2	1.3–3.8	.003
Self-reported allergy	2.6	1.3–5.3	.007

*Occupational exposure assessed using an asthma-specific JEM. **The high-risk exposures are the first 4 listed in Table 3.

prevalence of WEA is estimated to be 21%.²⁵ The present study provides crude information about WEA in Iran, and the results warrant conducting more comprehensive studies in the region for prevention and management of WRA. Isolated studies have reported asthma prevalence (not WEA) among different industrial sectors in the developing world: 11% asthma prevalence in indoor duties of Isfahan (Iran), WRS in 53% of 66 carpenters in Mashhad (Iran), work-related wheeze and lung function impairment in 27% of Chinese workers.^{5,26,27}

Multiple factors such as different work sectors, different case definitions, and methods influence reported statistics of OA throughout the world.^{4,10,19} The prevalence of WRS declined somewhat with age (Table 1), and the lower mean age of participants in the current study could possibly account for the somewhat higher WRS symptom prevalence compared with the Tarlo et al study.⁸

The current study found more self-reported allergy (eczema and/or nasal allergy) in participants with work-related respiratory symptoms. Atopy has significant association with some types of OA.¹⁰ Whereas Blanc et al in a report on asthma patients in a general practice setting did not find a significant association between atopic history and work-related asthma, the present study indicated significant correlation.⁹ This may be due to different case definitions. The present study, consistent with the Blanc et al study, found no significant association between marital status, educational level, and WRS (9).

Subjects with WRS had a trend to taking less oral steroids and inhaled steroids and having fewer hospital admission and emergency clinic visits than those without WRS. Along with the present results, Tarlo et al also indicated milder asthma in participants with worsening of asthma at work.⁸

The current study indicated more self-reported exposures to vapor, dust, fume, and gas among subjects with work-attributing symptoms than subjects without work-related respiratory symptoms, but the association was not significant. However, Tarlo et al in a similar setting found more VDGF exposure in patients with worsened asthma due to work.⁸ Mancuso et al in a similar setting

reported worsened asthma by workplace irritants such as dust and chemical smells.²³ Different cultural issues and perceptions of the subjects may influence this relationship.

Current results showed that 32.6% of the subjects have 1 or more high-risk exposures to asthmagenic compounds. Exposure to low-molecular-weight antigens was the most frequent occupational exposure. High-risk occupational exposures, exposure to low-molecular-weight antigens, and occupations unique to manufacture, processing, and utilities had significant prevalence ratio in subjects with WRS. Henneberger et al also reported more prevalence of work-exacerbated asthma among participants with high-risk occupational groups such as construction, mining, manufacturing, and public administration.²¹ Moreover, as Table 2 shows, business, finance, and administrative occupations were more likely to report work-related respiratory symptoms, although they do not have high-risk occupational exposures. One of the possible explanations may be indoor air pollution. As reports show that indoor air pollutants such as gas heaters, environmental tobacco smoke, volatile organic compounds, and mould/dampness could be considered as risk factors for respiratory health and asthma, it may lead to higher report of WRS among office workers in current study, but this possible association needs more detailed investigation.²⁸

One limitation of this study is the potential for bias due to self-reported symptoms, workplace exposures, and occupation. Cross-sectional design is also considered a limitation of the study that warrants conducting comprehensive studies in the future. The small sample sizes for several occupations and exposures (see Tables 2 and 3) meant that it was not possible to evaluate the prevalence of WRS in these subsets of the sample. The questionnaire focused on exposures and symptoms in the past 12 months, so the current study was not able to examine earlier occurrences of WRS.

Participants underwent a clinical evaluation by a pulmonary specialist, so the diagnosis of asthma was likely accurate. The present study questionnaire included questions pertaining to the work relationship of respiratory



Table 5. Prevalence of WEA from studies conducted in the general population or general health care settings.

Reference	Country	Study setting and number of participants (% of eligible)	Criteria for asthma	No. asthma cases	Age (years)	Time frame for WEA	Criteria for WEA (self-reported on questionnaire unless indicated otherwise)	WEA prevalence	
								In all adults with asthma	In working adults with asthma
Current study	Iran	339 asthma cases in pulmonary clinics (100% of eligible)	Asthma dx by pulmonary specialist	339 (179 employed)	17 years or older	Current job	Reported at least 2 respiratory symptoms with improvement on days away from work	11%	22%
Goh (1994) ²⁰	Singapore	802 asthma cases in large primary care clinics (63%)	Asthma dx by medical record	802	20–54	Current	Work environment is asthma trigger	27%	NA
Blanc (1999) ⁹	USA—San Francisco	171 asthma cases in general practice settings (88%)	Asthma dx by medical records	150	18–50	Any labor force participation	Self-report workplace exposure, underlying cause of asthma and likelihood of exposures based on job	66%	NA
Henneberger (2002) ²¹	USA—Colorado	1,461 asthma cases enrolled in HMO (71%)	Asthma rx or care by medical record	1,461	18–44	Current job	Current work environment makes asthma worse	25%	NA
Henneberger (2006) ²²	USA—Massachusetts	598 asthma cases identified in HMO records (61%)	Asthma care and dx by medical record	598 (557 employed)	18–44, mean 33	Last 12 months	Reported at least one of following: asthma symptoms better away from work; used an inhaler or nebulizer more at work; specified an asthma trigger at work	41%	44%
Mancuso (2003) ²³	USA—New York City	Prospective study of 230 persistent asthma cases in primary care practice (39%)	Asthma dx by medical record	102 (employed)	mean 39, 18 years or older	Current job	Asthma made worse by workplace conditions	NA	58%
Saarinén (2003) ²⁴	Finland	1,925 asthma cases in NHI system (74%)	Asthma dx by medical record	969 (employed)	20–65, mean 43	Past month	Asthma symptoms caused or worsened by work at least weekly in past month	NA	20%
Tarlo (2000) ⁸	Canada—Ontario	682 asthma cases in a secondary-referral and tertiary-referral asthma clinic (64%)	Asthma dx by medical records	435 (310 employed)	17 years or older	Current job	Reported asthma was worse at work compared with days away from work	11%	16%

Note. BHR = bronchial hyperresponsiveness; BRFSS = Behavioral Risk Factor Surveillance System; dx = diagnosis; ECRHS = European Community Respiratory Health Survey; ER = emergency room; FU = follow-up; G Pop = general population; HMO = health maintenance organization; JEM = job exposure matrix; NA = not applicable; NHI = national health insurance; SR = self-reported; sx = symptoms.

^aOA determined unlikely when WEA cases were identified.

symptoms, but without a sole emphasis on work as a cause of such symptoms. Moreover, there was no emphasis on any relationship to work in the initial parts of the questionnaire, in which the participant was asked to report on his demographic and respiratory health characteristics. A trained occupational hygienist interviewed the participants and obtained detailed information about occupations and exposures. Occupational coding of the participant's job titles was done using a standard coding system. It has been suggested to combine self-reports with more objective occupational information to avoid the potentially biasing influence of current asthmatic health status on self-reports of occupational exposures.¹ Accordingly, we used an asthma-specific JEM to achieve objective estimates of occupational exposure.

Conclusion

In conclusion, the prevalence of WRS symptoms in the present study (22%) is consistent with previous reports of WEA. Median prevalence WEA is reported to be 21%.²⁵ Self-reported allergy, high-risk exposures, and occupations unique to processing, manufacturing, and utilities were identified as risk factors for WRS. Study results emphasize the need for taking a complete occupational history in adult asthmatics to correctly identify causes of their symptoms and maximize case management.

References

- de Vocht F, Zock J.-P, Kromhout H, et al. Comparison of self-reported occupational exposure with a job exposure matrix in an international community-based study on asthma. *Am J Ind Med.* 2005;47:434–442.
- Ameille J, Pairon J, Bayeux M, et al. Consequences of occupational asthma on employment and financial status: a follow-up study. *Eur Respir J.* 1997;10:55–58.
- Berger Z, Rom WN, Reibman J, et al. Prevalence of Workplace exacerbation of asthma symptoms in an urban working population of asthmatics. *J Occup Environ Med.* 2006;48:833–839.
- Tarlo SM, Chan-Yeung M. Occupational asthma. In: Rosenstock L, Cullen MR, Redlich CA, eds. *Textbook of Clinical Occupational and Environmental Medicine*. 2nd ed. Philadelphia, PA: Elsevier Saunders; 2005:293–306.
- Jeebhay MF, Quirce S. Occupational asthma in the developing and industrialised world: A review [State of the Art Series. Occupational lung disease in high- and low-income countries, edited by M. Chan-Yeung. Number 1 in the series]. *Int J Tuberc Lung Dis.* 2007;11:122–133.
- Toren K, Blanc P. Asthma caused by occupational exposures is common—a systematic analysis of estimates of the population-attributable fraction. *BMC Pulm Med.* 2009;9:7.
- Kogevinas M, Zock J.-P, Jarvis D, et al. Exposure to substances in the workplace and new-onset asthma: an international prospective population-based study (ECRHS-II). *Lancet.* 2007;370:336–341.
- Tarlo SM, Leung K, Broder I, Silverman F, Holness DL. Asthmatic subjects symptomatically worse at work: Prevalence and characterization among a general asthma clinic population. *Chest.* 2000;118:1309–1314.
- Blanc PD, Eisner MD, Israel L, Yelin EH. The association between occupation and asthma in general medical practice. *Chest.* 1999;115:1259–1264.
- Nicholson P, Cullinan P, Burge P, Boyle C. *Occupational Asthma: Prevention, Identification & Management: Systematic Review & Recommendations*. London: British Occupational Health Research Foundation; 2010.
- Karjalainen A, Kurppa K, Martikainen R, Klaukka T, Karjalainen J. Work is related to a substantial portion of adult-onset asthma incidence in the Finnish population. *Am J Respir Crit Care Med.* 2001;164:565–568.
- Kopferschmitt-Kubler MC, Ameille J, Popin E, et al. Occupational asthma in France: a 1-yr report of the Observatoire National de Asthmes Professionnels project. *Eur Respir J.* 2002;19:84–89.
- Tarlo SM, Malo J.-L. An ATS/ERS report: 100 key questions and needs in occupational asthma. *Eur Respir J.* 2006;27:607–614.
- Tarlo SM, Malo J.-L. An Official ATS Proceedings: Asthma in the Workplace. *Proc Am Thor Soc.* 2009;6:339–349.
- Gaughan DM, Kullman GJ, Cummings KJ. Health Hazard Evaluation Report HETA 2007–0073–3089. The Solae Company, Memphis, Tennessee. Report on an Investigation of Asthma and Respiratory Symptoms among Workers at a Soy Processing Plant. August 2009.
- Statistics Canada. Standard Occupational Classification (SOC) 1991. http://www.statcan.gc.ca/sub460jects-sujets/standard-norme/soc-cnp/1991/soc-ctp91_menueng.htm Accessed June 5, 2011.
- Kennedy SM, Le Moual N, Choudat D, Kauffmann F. Development of an asthma specific job exposure matrix and its application in the epidemiological study of genetics and environment in asthma (EGEA). *Occup Environ Med.* 2000;57:635–641.
- Lee J, Tan CS, Chia KS. A practical guide for multivariate analysis of dichotomous outcomes. *Ann Acad Med Singapore.* 2009;38:714–719.
- Le Moual N, Kennedy SM, Kauffmann F. Occupational exposures and asthma in 14,000 adults from the general population. *Am J Epidemiol.* 2004;160:1108–1116.
- Goh L, Ng T, Hong C, Wong M, Koh K, Ling S. Outpatient adult bronchial asthma in Singapore. *Singapore Med J.* 1994;35:190.
- Henneberger PK, Hoffman CD, Magid DJ, Lyons EE. Work-related Exacerbation of Asthma. *Int J Occup Environ Health.* 2002;8:291–296.
- Henneberger PK, Derk SJ, Sama SR, et al. The frequency of workplace exacerbation among health maintenance organisation members with asthma. *Occup Environ Med.* 2006;63:551–557.
- Mancuso CA, Rincon M, Charlson ME. Adverse work outcomes and events attributed to asthma. *Am J Ind Med.* 2003;44:236–245.

24. Saarinen K, Karjalainen A, Martikainen R, et al. Prevalence of work-aggravated symptoms in clinically established asthma. *Eur Respir J*. 2003;22:305–309.
25. Szema AM. Work-exacerbated asthma. *Clin Chest Med*. 2012;33:617–624.
26. Golshan M, Faghihi M, Marandi MM. Indoor women jobs and pulmonary risks in rural areas of Isfahan, Iran, 2000. *Respir Med*. 2002;96:382–388.
27. Boskabady MH, Rezaiyan MK, Navabi I, Shafiei S, Arab SS. Work-related respiratory symptoms and pulmonary function tests in northeast iranian (the city of Mashhad) carpenters. *Clinics*. 2010;65:1003–1007.
28. Viegi G, Simoni M, Scognamiglio A, et al. Indoor air pollution and airway disease [State of the Art]. *Int J Tuberc Lung Dis*. 2004;8:1401–1415.

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