RISK OF ASTHMA SYMPTOMS AMONG WORKERS IN HEALTH CARE SETTINGS

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ABSTRACT

Prevalence of asthma is quite high in health care settings due to exposure to a wide variety of substances, including cleaning products, latex, medicines, ammonia and solvents. In this cross-sectional study, participants completed a validated questionnaire about their occupation, asthma diagnosis, variability of asthma symptoms at and away from work, and exposure to individual substances in the workplace. Work-related asthma symptoms (WRAS) were defined based on a set of criteria. Principal component analysis (PCA) was conducted to classify different substances into exposure patterns. Multivariable logistic regression analysis was used to evaluate the association between self-reported exposures to substances and asthma outcomes among health care workers. PCA revealed two factors: factor 1 (metal dust, metal fumes, solvents, cleaning agents, ammonia, glues) and factor 2 (disinfectants, latex, medicines). Exposure to factor 1 agents was associated with increased risk of WRAS (crude odds ratio (OR) 5.52, 95% confidence intervals (CI) 2.72–11.19), while exposure to factor 2 agents was associated with non-significant lower risk of WRAS (crude OR 0.58, 95% CI 0.3–1.14). Adjusting by confounders such as parent's allergy and history of asthma, or smoking, did not appreciably change the ORs. Some agents were associated with increased risk of WRAS, while the lack of association with the exposure to other set of chemicals may be attributed to a number of factors, including healthy worker effect.
Keywords: chemical exposures, disinfectants, health care, solvents, work-related asthma symptoms.

1 INTRODUCTION

Asthma is a prevalent disease that affects people of all ages and across many countries [1, 2]. Estimates of the disease prevalence in Western countries show a range of 5–10% of the general population [3]. Although genetic background is a factor in the development of asthma, environmental and occupational factors contribute to a substantial proportion of the disease. Reviews from a number of countries worldwide suggest that 10–15% of adult asthma can be attributed to occupational exposures [4, 5]. However, depending on the industry, work-related factors can be responsible for up to one-third of adult asthma cases [6]. Common industries and occupations associated with asthma in both industrialized and developing countries include manufacturing, farming, baking, painting, health care, agriculture and mining [7]. Estimates from the United States have shown that mining (17%), health-related industries (12.5%) and teaching (13%) had been associated with highest prevalence of asthma [8].

Health care workers (HCWs) are exposed to a wide range of substances, some of which have already been identified as causative agents for asthma [9]. Examples of substances used in health care settings include medicines, solvents and latex. Non-medical staff such as maintenance workers, administrative assistants and cleaners can also be exposed to metal dust and fumes, detergents, glues, bleach, ammonia and other materials. Several previous studies showed that either HCWs are at increased risk of occupational asthma or asthma is more common among HCWs [10–14].

In the developing countries, surveillance systems of occupational exposures either do not exist or are poorly implemented, resulting in underestimation of the number of occupation-related diseases and illnesses [15]. In particular, very few studies investigated the prevalence of occupational asthma among HCWs in developing countries [7].

ISSN: 2398-2640 (paper format), ISSN: 2398-2659 (online), http://www.witpress.com/journals
DOI: 10.2495/EI-V1-N2-172-182

The current study estimated the prevalence of asthma-related symptoms among workers in the hospital environment and examined the association of these effects with exposure to several substances. Unlike previous studies, the current study surveyed non-medical staff who may be exposed to distinct group of substances. Diagnosis of occupational asthma is quite difficult in health care settings; therefore, we relied on an outcome that represents an intermediary step in the pathway of occupational asthma development. This outcome is referred to work-related asthma symptoms (WRAS).

2 MATERIALS AND METHODS

2.1 Study population

The study was carried out in a main hospital in Riyadh city; the hospital is located in a medical campus which contains other auxiliary facilities such as auto and elevator repair workshops. Population surveyed in the current study included medical and non-medical staff. The sample of medical staff included nurses, physician/doctor, physical therapist, respiratory therapist and pharmacists. Non-medical staff included drivers, maintenance workers and administrative assistants. The study was approved by the King Abdullah International Medical Research Center. Each participant provided informed consent before they took part in the study.

2.2. Data collection

Interviews were conducted by a trained research assistant using the itemized questionnaire that was based on a previously validated instrument [16]. Questions included socio-economic status indicators (income, home ownership, level of education), profession and smoking. Other questions related to environmental exposures include indoor house environment and house proximity to major highways. Information on occupational exposures included occupation type and duration, nature of job duties, and exposure frequency to substances. The risk of WRAS was determined based on responses to a set of questions reported in an earlier study [16]. Briefly, the questions focus on specific symptoms and their temporality in relation to presence in or being away from the workplace.

2.3. Self-reported exposures

A detailed history of the job held longest by the study participant was collected using the questionnaire. Each participant was asked about frequency of exposure – in their longest held job – to a list of chemicals including medicines, latex, solvents, metal and dust fumes.

2.4. Statistical analysis

The exploratory principal component analysis (PCA) was implemented to identify patterns of exposures substances in the workplace. The number of factors retained was based on the Kaiser criterion (eigenvalues >1). Then patterns of exposures were defined based on individual factor loadings of the different workplace substances. A summary variable of presence or absence (0, 1) of exposure to a given group of chemicals was generated by summing scores of exposures to each of the individual substances in that group. Weighted prevalence analyses of WRAS were performed. Odds ratio (OR) and 95% confidence intervals (CI) of WRAS were calculated in relation to the exposure patterns resulting from PCA. The outcome variable WRAS was compared to the common baseline/reference category (none) using a logistic regression model, adjusted for age, sex, BMI, smoking status, and host-related factors such as mother and father's allergies and sensitivity, and nursery school attendance. All analyses were conducted using SAS Statistical Software Package v 9.4.

3 RESULTS

Table 1 shows major demographic characteristics of the study subject.

Table 2 shows the percentage of subjects within each category of exposures to the different substances. We ordered exposure frequencies from the highest to the lowest of everyday exposures. Exposure to disinfectants was the most prevalent followed by exposure to latex gloves, then floor cleaning chemicals, antibiotics and anaesthetics.

Table 1: Demographic characteristics of the interviewed subjects (n = 285).

Mean age (SD)	30.9 (6.1)
% males	25
Nationality	
Non-Saudi	76%
Job title	
Nurse	54%
Physician/doctor	9%
Respiratory therapist	7%
Pharmacist	9%
Non-medical (cleaner, drivers, painters, auto mechanics, maintenance workers)	21%
Mean BMI (SD)	23.9 (5)
Work-related wheezing	16.2%
Work-related shortness of breath	5.4%
Work-relate asthma symptoms	5.7%
Doctor diagnosed asthma	5.4%

Table 2: Percentage of individuals in each category of exposure frequency ranked from highest to lowest exposure frequency.

Product	**% with exposure frequency**			
	Every day	**At least once a week**	**At least once/month**	**Never**
Disinfectants, sterilizers or alcohol	90.91	5.19	1.3	2.6
Latex or latex gloves	70.93	3.08	3.96	22.03
Floor cleaning agents, bleach, vacuum dust, alkali or formaldehyde	58.26	25.65	6.52	9.57
Anaesthetics, antibiotics, bronchodilators, iodine or nebulized drugs	47.6	9.17	23.58	19.65
Meta dust, insulation dust or printers dust	33.92	12.78	16.3	37

continued

Table 2: Continued

Product	**% with exposure frequency**			
	Every day	**At least once a week**	**At least once/month**	**Never**
Metal fumes, diesel exhaust emission	26.63	23.62	10.05	39.7
Adhesives or glues	7.34	7.91	38.98	45.76
Ammonia, paints, ethylene oxides, acetaldehyde	4.8	4.8	29.26	61.14
Solvents (e.g. toluene, xylene, benzene, paint thinners, tonners etc.).	3.67	5.05	28.9	62.39

Table 3: Eigenvalues of factor analysis.

Factor	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Factor 1	**3.35054**	**1.51261**	**0.3723**	**0.3723**
Factor 2	**1.83793**	**0.87594**	**0.2042**	**0.5765**
Factor 3	0.96199	0.22254	0.1069	0.6834
Factor 4	0.73945	0.15775	0.0822	0.7655
Factor 5	0.58170	0.04854	0.0646	0.8302
Factor 6	0.53316	0.10836	0.0592	0.8894
Factor 7	0.42480	0.03075	0.0472	0.9366
Factor 8	0.39405	0.21768	0.0438	0.9804
Factor 9	0.17637	.	0.0196	1.0000

We conducted PCA to classify exposures into the different patterns or groups. Table 3 shows Eigenvalues for the factors in this survey of exposures. As used by the literature, only Eigenvalues of more than 1 are retained for further analyses. As a result, the first two factors were retained.

Table 4 shows the factor loadings for the different types of exposures in the workplace in the two factors. Exposures to the following types of chemicals: metal dust, or insulation dust or printers dust, metal fumes, or diesel exhaust emission, floor cleaning agents or bleach or vacuum dust, alkali, or formaldehyde, ammonia, or paints, or ethylene oxides, or acetaldehyde, solvents (e.g. toluene, xylene, benzene, paint thinners and tonners), adhesives or glues, were all loaded together in factor 1. However, factor 2 included exposures to the following chemicals: disinfectants or sterilizers, or alcohol, latex or latex gloves, anaesthetics or antibiotics or bronchodilators, iodine, or nebulized drugs.

We then conducted logistic regression to determine the risk of WRAS in relation to these two exposure factors. Subjects with *everyday* exposures to the individual chemicals within factors 1 and 2, respectively, were placed in one group. Table 5 shows the crude and adjusted OR and their 95% CIs. The results show significant increased risk of WRAS with exposure to agents in factor 1 (OR 5.52, 95% CI 2.24–9.73). However, exposure to agents in factor 2 was associated with lower insignificant risk (OR 0.58, 95% CI 0.30–1.14). Adjusting for confounding variables (mother allergy, mother asthma, father allergy, nursery school attendance

Table 4: Factor loadings for the different exposure materials in the two factors.

Substance	Factor 1	Factor 2	Uniqueness
Insulation dust or printers dust	**0.6614**	–0.2964	0.4747
Disinfectants, sterilizers, or alcohol	0.402	**0.6244**	0.4486
Latex or latex gloves	0.449	**0.7053**	0.3009
Metal fumes, metal dust	**0.7516**	–0.2644	0.3652
Floor cleaning agents or bleach or vacuum dust, alkali, or formaldehyde	**0.6784**	0.3873	0.3898
Anaesthetics, antibiotics, bronchodilators, iodine, or nebulized drugs	0.2015	**0.6513**	0.5353
Ammonia, paints, ethylene oxides, or acetaldehyde	**0.6579**	–0.2145	0.5212
Solvents (e.g. toluene, xylene, benzene, paint thinners and tonners).	**0.7363**	–0.286	0.3761
Adhesives or glues	**0.7137**	–0.3016	0.3997

Table 5: Results of logistic regression of the risk of WRAS and exposure to chemicals in the workplace adjusted for other risk factors.

Exposure to factors	Work-related asthma symptoms			ORs and the 95% confidence intervals		
	No	Yes	**Crude OR**	**95% CI**	**Adjusted OR****	**95% CI**
Factor 1*						
No	92	8	1		1.0	–
Yes	31	71	5.52	2.24–9.73	6.35	2.47–14.37
Factor 2*						
No	77	23	1		1.0	–
Yes	85	15	0.58	0.30–1.14	0.56	0.23–1.33

*Factor 1: metal dust, metal fumes, cleaning agents, ammonia, glues; factor 2: disinfectants, latex and medicines.

**Adjusted for gender, mother allergy, mother asthma, father allergy, nursery school attendance and smoking status.

and smoking status) somewhat strengthened the association of exposure to agents in factor 1 (adjusted OR 6.35, 95% CI 2.47–14.37). Adjusting by the same confounders did not change the OR of WRAS for exposures to agents in factor 2 (OR 0.56, 95% CI 0.23–1.33).

4 DISCUSSION

The current results showed high frequency exposures to substances normally encountered in the hospital environment. For example, more than 90% of the interviewed subjects are exposed to disinfectants, sterilizers, or alcohol every day, and about 71% are exposed to floor cleaning agents, bleach vacuum dust, alkali, or formaldehyde. Exposure to agents such as metal dust, metal fumes, cleaning agents, ammonia, solvents and glues was associated with significant increased risk of WRAS (adjusted OR 6.35, 95% CI, 2.47–14.37). Exposure to the other group of substances (disinfectants, latex, medicines) was associated with non-significant lower risk (adjusted OR 0.56, 95% CI, 0.23–1.33).

Exposure to metal fumes and metal dust during welding is associated with respiratory health effects that include chronic bronchitis, lung function abnormalities and occupational asthma [17–19]. Jaakkola et al. (2003) reported that the metal work was the second strongest determinant of asthma among male-dominated occupations [20]. The composition and levels of metals in metal fumes vary depending on the type of metal used and welding method [21]. Those fumes may also contain particulate matter of aerodynamic diameter of <2.5 μm (PM2.5) and zinc oxide particles with an aerodynamic diameter of <0.1 μm (PM0.1) [22]. Chromium and/or nickel and other metals generated during welding of stainless steel have been documented to induce asthma in other occupations [23]. The results of a recent study by Huang et al. (2016) [24] suggested that asthma prevalence in the Chinese adults was positively associated with urinary levels of several metals including Cr, Cu, Se, Mo and Cd. Metal-induced asthma is of the irritant type and is mediated by IgE immunoglobulin release [25].

Many of the cleaning substances commonly used in hospitals are highly volatile and pose respiratory health risks [26]. Examples of such substances include bleach, acetic acid and ammonia. Non-medical staff – mostly cleaners – may be exposed to high levels of detergents and other cleaning products. Bleach is widely used as disinfectant to clean medical instruments and hospital floors. Several studies reported an association between exposure to this agent and asthma or asthma symptoms [27–33]. Similarly, exposure to ammonia was linked to work-related asthma among HCWs [26, 34] and in occupational domestic cleaning [35]. Formalin is used in hospitals for a variety of purposes such as disinfection, staining and fixing of tissues. It has been linked to asthma or asthma symptoms for medical staff [34].

Nursing and other health professionals conduct tasks that involve exposure to adhesive compounds, glues and/or solvents [36]. In the same study exposure to adhesives, glues and/or solvents was associated with a two-fold increase in the odds of reported asthma, but not after adjustment for covariates. However, factor analysis in the current study revealed that solvents loaded into factor 1 agents, which also included metal dust, metal fumes, cleaning agents, ammonia and glues. These agents were probably encountered in some non-medical occupations in health care facilities. The current study was carried out in major medical complex that has its own maintenance units such as auto and elevator repair, reconstruction and refurbishing. We interviewed drivers, administrative assistants and maintenance workers (e.g. auto mechanics). They probably defined exposures to factor 1 agents. Exposure to solvents in hospitals can also occur in cleaners [37], painters and auto mechanics. Unintentional solvent exposure among medical and non-medical staff can also occur during accidents in hospitals [38].

Current results showed that exposure to substances in factor 2 (latex, disinfectants and medications) was associated with somewhat lower risk of WRAS. These exposures commonly occur among medical staff such as nurses, physicians and laboratory technicians. A recent survey of 182,825 adults in 35 states in the US Health Care Worker Survey [10] estimated higher prevalence ratios (PR) of asthma attacks among HCWs (PR = 1.23, 95% CI 1.03–1.46). In addition, several other studies reported increased risk for both asthma and work-related asthma among HCWs [11–14]. Nevertheless, some other studies have not observed an increase in asthma risk for specific jobs such as nursing [39–41]. Studies assessing exposures to individual risk factors such as latex, sensitizing agents and disinfectants suggested increased risk. Latex was found to be an occupational risk factor for asthma among health care professionals in numerous studies [9, 42–44]. However, the introduction of latex-free gloves after 2000 in many health care institutions reduced the risk of asthma and allergy significantly [43]. Use of disinfectants [43, 45], areosoled medications [43], anaesthetics [46] and several other medications [47] has also been linked to occupational asthma. A number of explanations can be offered on the current results of lack of association between the agents in factor 2 and WRAS. First, underreporting of occupational exposures may contribute to the lack of association. Donnay et al. [48] observed substantial underestimation of self-reported exposure among hospital workers for exposures to cleaning/disinfecting agents. Two estimates of exposures were available in that study: self-report and expert assessment. Underestimation of self-reported exposure was observed for some agents compared to that resulting from expert assessment. Other reports also cited underestimation of exposures to asthma risk factors among health care professionals [49]. Furthermore, reliance on self-reporting for exposures may cause misclassification bias as those with and those without asthma may recall their exposures differently. Another possible explanation for the observed lack of association is that health care professionals (especially those with asthma or asthma symptoms) are more educated and aware of the risk of asthma. They may use precautions to protect against latex and medication allergies such as the use of masks. It is also possible that proper ventilation in hospitals reduces exposure to allergens and asthmagens compared to workplaces for agents in factor 1. Healthy worker effect may also partly explain these results as some workers may change their jobs when they experience recurrent asthma symptoms or exacerbations of asthma.

Current results and results of other cross-sectional studies described above only suggested (and did not confirm) an association between exposure to a specific agent in health care settings and the risk of asthma. The majority of the agents which were linked to occupational asthma or asthma symptoms in health care settings are of low molecular weight type [9]. These agents are irritants but induce other asthma symptoms, such as chest tightness, with a latent period (may be after the shift ends). In addition, the highly complex and varied exposure to volatile substances in the hospital environment complicates establishing a link between a specific agent and the asthma. It was observed that jobs with multiple exposures are common. Zoc et al. (2009) [50] showed that 25% of the study population of the European Community Respiratory Health Survey had four or more exposures according to assessments using job exposure matrix (JEM). In that same study, there was no association between exposure to low molecular weight agents and asthma. Determination of the culprit exposure agent is challenging unless self-reporting of exposure is compared with other means such as using JEM indices [49]. Even assessing exposures based on broad job categorization using JEM may result in either over- or underestimation of exposures. Individuals in the same job category may experience quite different exposure profiles. For example, exposure frequency and intensity to strong asthmagens such as cleaning and sterilizing products, latex or formaldehyde were different among nurses in the different health departments [51]. Furthermore, Mirabel et al. [52] observed no overall increased risk of asthma among nurses but found an elevated risk among nurses who reported certain occupational exposures such as ammonia or bleach.

Major limitations of the current study is that cross-sectional design did not allow to confirm whether WRAS was caused by persistent and cumulative exposure rather than being sparse response to short-term exposure to allergens. Another limitation is that the use of self-reported exposures may have resulted in recall bias and subsequent exposure misclassification. This study also lacked detailed information on job history, long-term exposure or exposure intensity. However, unlike some of the previous studies which assessed asthma risk in different job titles, we assessed actual exposures to the actual agents that induce or exacerbate asthma. Job titles in some cases do not reflect specific roles and occupational tasks that could increase the risk of asthma or WRAS. Another strength is that the current questionnaire assessed the temporality of the respiratory symptoms and their relation to being in or way from work thus allowing to define work-relatedness of asthma symptoms.

5 CONCLUSIONS

In conclusion, our results on exposures to factor 1 agents are consistent with the large body of literature reporting increased risk of asthma in certain job exposures such as cleaning agents and metal fumes. Lack of association with exposures to other substances such latex, medications or disinfectants may reflect complexity of exposures in these jobs, or the awareness of risk factors of asthma among HCWs. The current results showing increased risk of exposure to cleaning agents may have public health implications due to widespread use of cleaning agent in homes. Protective measures (e.g. proper ventilation and wearing masks) should be strongly implemented, especially among non-medical staff.

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