Occupational exposures and asthma among nursing professionals

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ABSTRACT

Objectives: To identify occupational exposure risk factors associated with the development of new-onset asthma in nurses.

Methods: A cross-sectional survey was administered to a sample of licensed Texas nurses (response rate 70%) and compared to three other healthcare professional groups. Nursing professionals were defined based on self-reported longest held job. Outcome variables were physician-diagnosed new-onset asthma after entry into the healthcare profession and symptoms associated with bronchial hyper-responsiveness (BHR). Occupational exposures were ascertained through a job-exposure matrix, grouped into four categories: cleaning-related tasks, use of powdered latex gloves, administration of aerosolised medications, and tasks involving adhesive compounds, glues and/or solvents.

Results: After adjustment for age, sex, ethnicity, atopy, smoking, body mass index and seniority, reported asthma was significantly greater among nursing professionals involved in medical instrument cleaning (OR = 1.67, 95% CI 1.06 to 2.62) and exposure to general cleaning products and disinfectants (OR = 1.72, 95% CI 1.00 to 2.94). Use of powdered latex gloves during 1992–2000 was associated with 1.6 times (95% CI 1.01 to 2.50) the odds of reported asthma. In univariate analysis, exposure to adhesives, glues and/or solvents was associated with a twofold increase in the odds of reported asthma, but not after adjustment for covariates. Similarly, the odds of BHR-related symptoms were significantly greater among nursing professionals exposed to general cleaning products and disinfectants (OR = 1.57, 95% CI 1.11 to 2.21) and adhesives, glues and/or solvents used in patient care (OR = 1.51, 95% CI 1.08 to 2.12).

Conclusion: Among nursing professionals, workplace exposures to cleaning products and disinfectants increase the risk of new-onset asthma.

According to the 2000 National Sample Survey of Registered Nurses (NSSRN), in the United States there are approximately 2.7 million registered nurses (RNs; the largest nursing occupation group), who are predominantly employed in hospitals and spend a majority of their time in direct patient care activities.[1] The nursing professions consist of several occupational groups, including RNs, licensed practical nurses (LPN), licensed vocational nurses (LVN), nurses' aides, nurse practitioners and nurse educators. Nurses perform a number of patient care activities, including drawing blood, mixing and administering medications, providing wound care and respiratory care, cleaning surgical and non-surgical instruments, mopping floors, assisting with invasive and other medical procedures, and assisting with anaesthesia.[2 3] These activities carry with them a potential for exposure to occupational hazards that may pose serious health concerns, including risk for asthma.

Asthma has increased worldwide[4] and in the USA there are an estimated 20 million people with this condition.[5] Nurses play a critical role in the management of asthma in patients; unfortunately, little attention is paid to their own risk for asthma as a result of their profession.

In two recently published large population-based studies from Europe, the prevalence of asthma among nursing professionals was reported to be 4.8%[6] and 6.0%,[7] respectively. Nursing professionals were found to have more than twice the risk of asthma (OR = 2.22, 95% CI 1.25 to 3.96) as compared to a reference group of professional, clerical and administrative occupations.[6] We recently reported a prevalence of 7.3% for asthma with onset after entry into the profession, among Texas nursing professionals with an active licence, the highest in a survey that also included physicians as well as respiratory and occupational therapists.[8] In this study we further evaluate occupational exposures, assigned based on a job-exposure matrix (JEM), associated with the development of new-onset asthma after entering the nursing professions.

METHODS

Study population

A detailed description of our study methods has been previously published.[8] Briefly, a cross-sectional state-wide asthma survey was conducted in representative samples of four groups of Texas licensed healthcare professionals, using a previously validated questionnaire.[9] The four groups (n = 3650) consisted of physicians (n = 862), respiratory therapists (n = 879), occupational therapists (n = 968) and nurses (n = 941). The overall response rate to the survey was 66%; the response rate among nurses was 70%. For the present study, 16 participants were removed because of missing essential information regarding job history. This analysis therefore includes observations from 3634 respondents.

Dependent variables

The primary binary outcome variable was "reported asthma", defined as new-onset asthma, appearing after entry into the healthcare profession. This variable was constructed from information obtained from three questions in the survey: "Have you ever had asthma?", "If Yes, has your asthma been confirmed by a doctor?" and "If Yes, at what age was your asthma confirmed by a

doctor?''. The age of asthma diagnosis was then compared to the number of years in the health profession to determine the temporal relationship between asthma and entry into the profession.

A secondary outcome variable, the presence of bronchial hyper-responsiveness-related symptoms (BHR-related symptoms), was based on a combination of eight questions on asthma and allergy symptoms that had exhibited the best combination of sensitivity and specificity when compared to non-specific bronchial challenge testing with methacholine.[9]

Independent variables

There were nine main occupational exposure variables, grouped into four categories: cleaning-related (patient care cleaning, instrument cleaning, and cleaning of general building surfaces), use of powdered latex gloves (before 1992, 1992–2000 and after 2000), administration of aerosolised medications, and use of adhesives/removers (used in patient care or on general surfaces). Use of powdered latex gloves was categorised a priori into three time periods to reflect periods of peak use following passage of the 1992 OSHA bloodborne pathogens standard.[10] Exposures were classified based on an externally developed JEM previously developed by our group.[8] Briefly, data on potential occupational asthmagens were collected from multiple sources including a literature review and data derived from the 1981–1983 National Occupational Exposure Survey,[11] then updated through a series of hospital walk-through surveys conducted by a multidisciplinary team of industrial hygienists and occupational physicians. Three industrial hygienists (as a group), another industrial hygienist and an occupational physician independently assigned an exposure level to each cell of the matrix with 0 = high certainty/probability that the majority of the workers in a cell are not exposed at least once a week, 1 = low certainty/probability of exposure at least once a week, and 2 = high certainty/probability of exposure at least once a week. Discrepancies were resolved by consensus. For the purpose of this analysis we dichotomised the exposure to 0 = no probability of exposure and 1 or 2 = low/high probability of exposure.

Effect modifying variable

In the questionnaire[9] we included a job history section collecting detailed information on the longest held and the current (at the time of survey) occupations. For this analysis we used longest held occupation to categorise participants into nursing healthcare professions which included RNs, LVNs, nurse aides and nurse practitioners (n = 448) and a comparison group of ''other'' healthcare professionals, which included physicians, occupational therapists, respiratory therapists and other occupations (n = 3186). One-way interaction terms with the main occupational exposure categories were then constructed and included in the statistical models.

Confounding factors

Potential confounding variables included in the model were age, sex, ethnicity (Hispanic vs non-Hispanic), atopy status, smoking status (non-smokers, current smokers and ex-smokers), body mass index (BMI; classified into normal, overweight and obese based on self-reported height and weight) and seniority (four quartiles). As previously described, atopy was defined on the basis of responses to previously validated questions on allergy to animals, dust mites and non-specific dust.[9]

Statistical analyses

Simple descriptive statistics were performed by stratifying on nurse status; χ^2 analysis was used to compare independent variables between the nursing group and the comparison group of other healthcare professionals. Associations between the two asthma-related outcome variables and the main exposure variables for nursing professionals were examined using binary logistic regression analysis. Odds ratios (OR) and their corresponding 95% confidence intervals (95% CI) were calculated by first including an interaction term of ''nursing professionals×exposure of interest'' in a logistic model and then calculating the interaction term odds ratios by exponentiating the sum of the regression coefficients of the effect modifier (nursing professionals), main exposure of interest and their interaction term:

$$e^{\beta_1+\beta_2+\beta_1*\beta_2}$$

In situations where the interaction term contained zero values, we calculated the odds ratios (and their corresponding 95% confidence intervals) under a multiplicative model assumption by taking

$$e^{\beta_1+\beta_2}$$

All models were adjusted for the potential confounding effects of age, sex, ethnicity, atopy, smoking, BMI and seniority. Analyses were performed with Stata statistical software v 10.0 (Stata, College Station, TX).

RESULTS

A total of 448 study participants were classified as nursing professionals based on self-reported longest held occupation. Of these, 394 were RNs, 25 LVNs, 15 nurse aides and 14 nurse practitioners (table 1). The majority of nursing professionals reported working in a clinical setting for their longest held job, whereas the majority of other healthcare professionals reported working in non-clinical settings (table 1).

Table 2 presents the general characteristics of the study population based on self-reported longest held occupation. Nursing professionals, as expected, were predominantly female and only 11% were Hispanic. Prevalence of current smoking (12.6% vs 8.7%; p = 0.025) and obesity (BMI≥30) (28% vs 20%; p = 0.001) were significantly higher among nurses as compared to the comparison group. Average seniority at work for nursing professionals was 23.9 (SD 11.3) years (median, 24 years) as compared to 18.6 (SD 11.8; p<0.001) years among other professionals (median, 16 years). The prevalence of reported asthma was significantly higher among the nurses (9.8% vs

Table 1 Distribution of study population by workplace setting

	Clinical settings (n = 1256)*	Non-clinical settings (n = 2378)†
Nursing professionals	396	52
Registered nurses	350	44
Nurse practitioners	14	0
Licensed vocational nurse	21	4
Nurse aides	11	4
Other healthcare professionals	860	2326

*Clinical setting includes hospitals, private practice, outpatient clinic, nursing home, public school, home health and dental office.
†Non-clinical setting includes health department, health insurance agency, research, medical sales, academia and others.

4.8%; p<0.001), although the prevalence of BHR-related symptoms was not significantly different among the two groups (31.3% vs 27.4%; p = 0.119). Among the nursing professionals, RNs had the highest prevalence of reported asthma (10.2%), followed by LVNs (8.0%) and nurse practitioners/nurse aides (6.9%; p<0.001). BHR-related symptoms were more prevalent, albeit non-significantly, among LVNs (36.8%) as compared to RNs (30.9%) and nurse practitioners (32.0%; p = 0.430). There were no significant differences related to atopy.

Table 3 presents unadjusted and adjusted odds ratio estimates for reported asthma among nursing professionals and associations with occupational exposures. The odds of reported asthma among the nurses were significantly higher for medical instrument cleaning (adjusted OR = 1.67, 95% CI 1.06 to 2.62) and exposure to general building cleaning products and disinfectants (adjusted OR = 1.72, 95% CI 1.00 to 2.94). Nursing professionals exposed to powdered latex gloves before 1992 and during 1992–2000 had more than twice the odds of reported asthma in the univariate analysis. The odds ratio diminished in magnitude after adjusting for covariates, to 1.68 and 1.59 for the two time periods, respectively. After 2000, no significant associations were observed as regards the use of powdered latex gloves. Significantly elevated univariate odds ratios for reported asthma among nursing professionals were observed in relation to exposure to aerosolised medication and adhesives, adhesive removers or solvents used in patient care (table 3).

The odds of BHR-related symptoms among nursing professionals were 1.57 times (95% CI 1.11 to 2.21) greater for exposure to cleaning products and disinfectants applied to general building surfaces. Similar to reported asthma, significantly elevated univariate odds were observed for exposure to aerosolised medications and adhesives, adhesive removers or solvents used in patient care and/or on general surfaces; after adjusting, significant associations remained for adhesives used in patient care (table 4).

Table 2 Descriptive characteristics of the study population

	Nursing professionals (n = 448)	Other health care professionals (n = 3186)
Variables	**n (%)**	**n (%)**
Age in years (mean, SD)	48.6 (10.7)	44.9 (12.0)
Less than 30	18 (4.1)	311 (10.0)
30 to less than 45	145 (33.0)	1360 (43.6)
45 to less than 60	213 (48.5)	1121 (35.9)
60 and above	63 (14.4)	327 (10.5)
Sex		
Male	39 (8.8)	1114 (35.5)
Female	403 (91.2)	2028 (64.5)
Ethnicity		
Non-Hispanic	380 (89.2)	2624 (85.4)
Hispanic	46 (10.8)	449 (14.6)
Atopy		
No	356 (83.4)	2540 (83.5)
Yes	71 (16.6)	502 (16.5)
Smoking status		
Non-smoker	282 (63.7)	2101 (66.7)
Current smoker	56 (12.6)	273 (8.7)
Ex-smoker	105 (23.7)	777 (24.7)
Body mass index		
Normal (<25.0)	176 (40.3)	1429 (46.0)
Overweight (25.0–29.9)	140 (32.0)	1061 (34.1)
Obese (30 and above)	121 (27.7)	620 (19.9)
Seniority		
First quartile (mean 6.6 years)	62 (14.0)	977 (31.1)
Second quartile (mean 13.8 years)	95 (21.4)	714 (22.7)
Third quartile (mean 22.5 years)	121 (27.3)	775 (24.6)
Fourth quartile (mean 36.2 years)	165 (37.3)	681 (21.6)
Reported asthma		
No	404 (90.2)	3032 (95.2)
Yes	44 (9.8)	154 (4.8)
BHR-related symptoms		
No	255 (68.7)	1896 (72.6)
Yes	116 (31.3)	715 (27.4)

BHR, bronchial hyper-responsiveness.

DISCUSSION

This study identified that nursing professionals, in comparison to other healthcare professionals, have an increased risk of developing new-onset asthma or BHR-related symptoms due to chemicals and compounds used during patient care activities, medical instrument cleaning/disinfection and general cleaning.

Cleaning products and disinfectants

Cleaning products and disinfectants are commonly used in both occupational and non-occupational settings. During our walk-through survey of hospitals we identified several chemical products, in departments and areas predominantly run by nurses and nursing aides, known to be potentially strong respiratory irritants or sensitisers. These included topical cleansers and antiseptics applied to patient skin, glutaraldehyde for cold sterilisation of medical instruments, and all-purpose general cleaners, including bleach. Rosenman *et al*[12] using surveillance data from the Sentinel Event Notification Systems for Occupational Risks (SENSOR) Program, reported that 12% of work-related asthma cases were related to the use of cleaning products. RNs, vocational nurses and nursing aides formed the second largest occupational group, after janitors, where exposure to cleaning products was associated with

Table 3 Unadjusted and adjusted logistic regression analysis of reported asthma*

	Unadjusted analysis	Adjusted analysis†
JEM-based exposures	**OR (95% CI)**	**OR (95% CI)**
Cleaning related		
Patient care cleaning and disinfection	1.76 (0.41 to 7.62)	2.73 (0.34 to 21.81)
Instrument cleaning and disinfection	2.57 (1.73 to 3.83)	1.67 (1.06 to 2.62)
Building surfaces cleaning and disinfection	2.50 (1.61 to 3.89)	1.72 (1.00 to 2.94)
Latex use		
Use of powdered latex gloves before 1992	2.59 (1.66 to 4.04)	1.68 (1.02 to 2.76)
Use of powdered latex gloves 1992–2000	2.45 (1.64 to 3.67)	1.59 (1.01 to 2.50)
Use of powdered latex gloves after 2000	1.21 (0.35 to 4.16)	0.80 (0.22 to 2.84)
Exposure to aerosolised medication	2.48 (1.67 to 3.68)	1.50 (0.95 to 2.37)
Adhesives/solvents		
Patient care	2.21 (1.43 to 3.41)	1.36 (0.82 to 2.26)
On surfaces	1.73 (0.95 to 2.17)	1.23 (0.62 to 2.44)

*Reported asthma is defined as "physician-diagnosed asthma after entry into the health profession".
†Adjusted for potential confounding effects of age, sex, ethnicity, atopy, smoking, body mass index and seniority.
JEM, job-exposure matrix.

Table 4 Unadjusted and adjusted logistic regression analysis of BHR-related symptoms

	Unadjusted analysis	Adjusted analysis*
JEM-based exposures	**OR (95% CI)**	**OR (95% CI)**
Cleaning related		
Patient care cleaning and disinfection	0.62 (0.28 to 1.40)	0.69 (0.26 to 1.83)
Instrument cleaning and disinfection	1.31 (1.00 to 1.70)	1.27 (0.94 to 1.73)
Building surfaces cleaning and disinfection	1.94 (1.46 to 2.58)	1.57 (1.11 to 2.21)
Latex use		
Use of powdered latex gloves before 1992	0.96 (0.73 to 1.26)	1.18 (0.86 to 1.64)
Use of powdered latex gloves 1992–2000	1.20 (0.92 to 1.56)	1.24 (0.91 to 1.69)
Use of powdered latex gloves after 2000	0.94 (0.53 to 1.64)	1.01 (0.52 to 1.95)
Exposure to aerosolised medication	1.31 (1.01 to 1.71)	1.25 (0.92 to 1.70)
Adhesives/solvents		
Patient care	1.78 (1.34 to 2.37)	1.51 (1.08 to 2.12)
On surfaces	1.96 (1.39 to 2.77)	1.37 (0.91 to 2.06)

*Adjusted for potential confounding effects of age, sex, ethnicity, atopy, smoking, body mass index and seniority.
JEM, job-exposure matrix.

work-related asthma. Pechter *et al*,[13] using data from the same project, reported a 16% prevalence of work-related asthma among healthcare workers. Nurses with work-related asthma formed the largest healthcare worker group and reported frequent exposures to cleaning products and disinfectants, including quaternary ammonium compounds, bleach, ammonia, floor strippers, glutaraldehyde and formaldehyde, all of which, at sufficient concentrations, are established respiratory irritants or sensitisers. Glutaraldehyde was responsible for 6% of occupational asthma cases reported to a surveillance registry in the UK.[14] Recently, Mirabelli and colleagues,[7] utilising data from the European Community Respiratory Health Survey (ECRHS II), collected prospectively from 10 European countries, analysed follow-up data on 332 nurses and 2481 professional and/or administrative workers, initially free from asthma symptoms in the early 1990s (ECRHS I). Nurses who reported using ammonia and/or bleach were found to have a greater than twofold risk of new-onset asthma as compared to referents (relative risk 2.16, 95% CI 1.03 to 4.53). A significantly increased odds of association between instrument cleaning and reported asthma, and significantly elevated odds of reported asthma and asthma-like symptoms among nurses exposed to surface cleaning products and disinfectants observed in our study add support to the concern over these exposures in healthcare settings.

Powdered latex glove use

The prevalence of allergy to latex among healthcare professionals has varied widely in different studies and at different time periods, ranging from as high as 31% among nurses[15] to as low as 3% among general hospital workers.[16] In this study, the use of powdered latex gloves among nurses before 1992 and between 1992 and 2000 was associated with a greater than twofold increase in risk of reported asthma in the univariate analysis. The odds ratio diminished but remained significantly elevated for these time periods after adjustment for potential confounding factors, and then resolved after 2000. The adverse occupational health effects of latex allergy among healthcare workers are well established; fortunately, there is evidence that this is coming under control in industrialised nations.[7 13 17 18]

Adhesives/solvents/gases

We found an almost twofold increased odds of reported asthma and BHR-related symptoms in the univariate analysis, among nursing professionals exposed to adhesives, adhesive removers and/or solvents, although results were attenuated after adjusting for confounders but remain significant for adhesives used in patient care and BHR-related symptoms. Nurses, especially those working in surgical or intensive care units, are regularly exposed to adhesives and adhesive removers during routine patient care activities. During our original walk-through surveys of hospitals, several adhesives and adhesive removers were identified, containing chemicals including dimethyl ether, dipropylene glycol methyl ether and isoparaffinic hydrocarbons (all respiratory irritants). Some of the products containing these chemicals were available as sprays, which increase the potential for aerosolisation.[19 20] To our knowledge, exposure to these types of compounds has not been previously linked to asthma among nursing professionals and, hence, warrants further evaluation.

The major strength of this study is that it used data from a large representative sample of healthcare workers. Exposure assessment was based on an externally developed JEM which should minimise the chances of differential exposure misclassification. Use of longest held occupation, as opposed to current or last held occupation, is a better predictor of workers' cumulative exposure.[21] The main outcome of interest, reported asthma, was defined based on information from a previously validated questionnaire.[9] We included nursing professionals as interaction terms in the logistic regression models instead of limiting the analysis to nurse subgroups alone. This approach allowed us to make use of the full sample size and avoid potential problems of collinearity between JEM-assigned task-based exposures and professional groups. The main weakness lies in its cross-sectional nature, which precludes cause and effect interpretation of study results. Nursing professionals include several subgroups and it is likely that certain exposures may vary among these subgroups. However, the number of nursing professionals, other than RNs, was too small to carry out further analysis. Lastly, in the absence of personal quantitative exposure measurements, generally not practical or feasible in large population-based studies, it is difficult to assess the validity of the exposure assessment metrics.

CONCLUSION

This study found that occupational exposure to cleaning substances, pre-2000 use of powdered latex gloves and use of adhesives/solvents are related to reported asthma or asthma-related symptoms among nursing professionals. The results support adopting an integrated approach towards reducing workplace exposures among nursing professionals. The substitution of powdered latex gloves with less allergenic alternatives appears to have reduced the risk of asthma.[22 23] Substituting cleaning agents with environmentally friendly "green chemicals" and using appropriate personal care protection could also help minimise occupational exposures in this professional group. Further studies are needed to evaluate the risk posed by the use of adhesives and solvents among nursing professionals.

Main messages

- Exposure to medical instrument cleaning and general cleaning products and disinfectants is associated with new-onset asthma and bronchial hyper-responsiveness symptoms among nursing professionals.
- Use of powdered latex gloves, especially before 2000, is also associated with onset of asthma in nurses.
- Nurses may also be at increased risk of bronchial hyper-responsiveness symptoms if exposed to adhesives, glues and/or solvents at work.

Policy implications

- Reducing exposure to cleaning products and disinfectants by substituting them with "green chemicals" or using better personal protective measures is warranted.
- The new association found in this study between the use of adhesives/solvents and new-onset asthma or bronchial hyper-responsiveness symptoms deserves further research.

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