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Cleaning Tasks and Products and Asthma Among Healthcare Professionals

Jenil Patel, PhD[1,2], **David Gimeno Ruiz de Porras, PhD**[3,4,5], **Laura E. Mitchell, PhD**[6], **Arch Carson, MD**[1], **Lawrence W. Whitehead, PhD**[1], **Inkyu Han, PhD**[7], **Lisa Pompeii, PhD**[8], **Sadie Conway, PhD**[9], **Jan-Paul Zock, PhD**[10], **Paul K. Henneberger, DSc**[11], **Riddhi Patel, MPH**[6], **Joy De Los Reyes, MPH**[12], **George L. Delclos, MD**[1,4,5]

[1]Southwest Center for Occupational and Environmental Health, Department of Epidemiology, Human Genetics and Environmental Sciences, The University of Texas Health Science Center at Houston (UTHealth Houston) School of Public Health, Houston, TX, USA.

[2]Center for Pediatric Population Health, Department of Epidemiology, Human Genetics and Environmental Sciences, School of Public Health, The University of Texas Health Science Center at Houston (UTHealth Houston), Dallas, TX, USA

[3]Southwest Center for Occupational and Environmental Health, Department of Epidemiology, Human Genetics and Environmental Sciences, School of Public Health in San Antonio, The University of Texas Health Science Center at Houston (UTHealth Houston), San Antonio, TX, USA.

[4]Center for Research in Occupational Health, Universitat Pompeu Fabra, Barcelona, Spain.

[5]CIBER Epidemiología y Salud Pública, Madrid, Spain.

[6]Department of Epidemiology, Human Genetics and Environmental Sciences, The University of Texas Health Science Center at Houston (UTHealth Houston) School of Public Health, Houston, TX, USA.

[7]Department of Epidemiology and Biostatistics, Temple University College of Public Health, Philadelphia, PA, USA

[8]Research in Patient Services, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, USA

[9]Smith Scientific LLC, Houston, TX, USA

Corresponding Author: David Gimeno Ruiz de Porras, PhD, The University of Texas Health Science Center at Houston, School of Public Health, 7411 John Smith Dr. Suite 1122, San Antonio, TX 78229. Phone: 210-276-9011; david.gimeno@uth.tmc.edu.

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The study adheres to STROBE Guidelines for observational studies (See Supplementary Digital Content for checklist)

[10]Center for Research in Environmental Epidemiology (CREAL), Barcelona, Spain.

[11]Respiratory Health Division, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Morgantown, WV, USA.

[12]Department of Biostatistics and Data Science, The University of Texas Health Science Center at Houston (UTHealth Houston) School of Public Health, Houston, TX, USA.

Abstract

Objective: Healthcare workers (HCWs) are at risk for work-related asthma, which may be affected by changes in cleaning practices. We examined associations of cleaning tasks and products with work-related asthma in HCWs in 2016, comparing them to prior results from 2003.

Methods: We estimated asthma prevalence by professional group, and explored associations of self-reported asthma with job-exposure matrix-based cleaning tasks/products in a representative Texas sample of 9914 physicians, nurses, respiratory/occupational therapists, and nurse aides. .

Results: Response rate was 34.8%(n=2,421). The weighted prevalences of physician-diagnosed(15.3%), work-exacerbated (4.1%), and new-onset asthma(NOA) (6.7%), and bronchial hyperresponsiveness symptoms(31.1%) were similar to 2003. NOA was associated with building surface cleaning(OR=1.91; 95%CI:1.10–3.33), use of orthophthalaldehyde(OR=1.77; 95%CI:1.15–2.72), bleach/quaternary compounds(OR=1.91; 95%CI:1.10–3.33), and sprays(OR=1.97; 95%CI:1.12–3.47).

Conclusion: Prevalence of asthma/BHR appears unchanged, whereas associations of NOA with exposures to surface cleaning remained, and decreased for instrument cleaning.

Keywords

asthma; cleaning products; health care; occupational risk factors

INTRODUCTION

Approximately 8% of U.S. adults have asthma (1,2). Among these, about 15% to 25% of cases are considered work-related asthma (WRA), which includes asthma exacerbated or induced *de novo* by inhalation exposures in the workplace (3). At least 2.25 million people in the U.S. aged 15–65 years are at risk for WRA (4,5), and the annual economic impact of WRA is estimated at $6 billion (6,7). Not all occupations have the same risk of WRA, with healthcare workers (HCWs) known to be at high risk (8,9). Among HCWs, nurses, nurse aids, and housekeeping personnel are high-risk occupations for WRA (6,10,11,12,13).

Asthma triggers in HCWs include cleaning products, disinfectants, and medications (14,15). A 2003 study of asthma in Texas HCWs found significant associations with exposures such as medical instrument cleaning, cleaning of surfaces, and use of powdered latex gloves in the 1992–2000 period (8,16). Recent studies highlighted the importance of cleaning and disinfection as a risk factor for WRA (10,11,12,15,17,18). Known factors include the type of tasks (e.g., cleaning of general building surfaces or medical instrument cold sterilization) (8,18), product use (e.g., decalcifying agents, toilet cleaners) (19,20), application method (e.g., sprays, which can volatilize chemicals that are usually fairly non-volatile) (21,22,23), and work setting (e.g., operating rooms, where exposures are among the highest in healthcare settings) (24,25), along with the use of respiratory protection. High-level disinfectants (HLDs), such as glutaraldehyde, peracetic acid, or orthophtalaldehyde (OPA), are used daily in healthcare environments, along with disinfectants such as alcohol and bleach, often used as sprays (26,27). This literature called for more research on infection control and prevention practices in HCWs, particularly among nurses, who have the highest asthma risk.

Over the past two decades, and in light of the COVID-19 pandemic, there have been major changes in the nature and frequency of cleaning and disinfection products, with a greater emphasis on automation of practices and increased use of protective equipment (8,28,29,30,31,32,33,34,35). A greater focus on controlling hospital-acquired infections has led to detailed cleaning and disinfection guidelines, with concurrent changes in environmental policies and regulations that may have unintended consequences on HCWs (31,34). However, a recent report found no change in the percentage of WRA cases associated with cleaning agents, underscoring the need to increase the knowledge of potential cleaning hazards (9). A literature review on cleaning agents in healthcare settings emphasized that larger, more contemporary population-based studies of HCWs exposed to cleaning agents are needed (34,36, 37,38,39).

To assess the current prevalence of WRA among HCWs and whether changes in cleaning products exposure and tasks affected the prevalence, we conducted a population-based study of Texas HCWs, and compared the findings to the 2003 study among the same target population.

METHODS

Survey Population

Five healthcare occupations were identified from their respective state licensing boards or certification organizations (40,41,42,43,44,45) and targeted for a statewide cross-sectional confidential mail survey: physicians (n=61,661), nurses (n=361,719), respiratory therapists (RTs, n=13,223), occupational therapists (OTs, n=12,556), and certified nurse aides (CNAs, n=108,718). Inclusion criteria were (a) age ≥18 years and (b) having an active Texas license or certification in 2016. The sample size calculations for the first four groups were similar to the 2003 study, requiring a sample for each group of 1,400 participants (total=5,600) to ensure α=0.05 and β=0.20, an expected response rate of at least 50%, and an expected proportion of eligible respondents of 90% (44). Nurses may practice in various settings, have consistently been identified as being at risk for asthma, and prior studies are limited on characterizing their work habits and environments, so we oversampled nurses, mailing 3,200 surveys (RNs=1,600, LVNs=800, and APRN=800). Given historically low response rates of physicians to mail surveys (46), we also oversampled them to ensure a sufficient number of physicians in the analysis (n=400 additional surveys for a total of 1,800). Since CNAs were recruited in a stand-alone pilot study (13), their sample size (n=1,057) calculations followed a method for a single-group cross-sectional study (45) based on α=0.05 and a 3% margin of error. With a 50% expected response rate, 2,114 surveys were mailed to CNAs.

The combined target population of HCWs included 9,914 surveys mailed between 10/2016 and 02/2017, following Dillman's five-wave approach to survey administration (47). Like in 2003, a $1 incentive was provided with each survey. Informed consent was in the form of an introduction letter, and survey completion implied consent to participate. Participants could return the hard copy questionnaire by mail or complete it online. The Committee for Protection of Human Subjects at UTHealth School of Public Health approved the study.

The overall response rate was 34.8% (n=3,444): 41.0% for OTs, 40.2% for nurses, 37.9% for RTs, 34.1% for physicians, and 21.1% for CNAs. For comparability across analyses, we created an analytical sample (n=2,421 respondents without missing data) (Table 1). Compared to this sample, the excluded respondents with missing data (n=905) were slightly older (50.4 vs. 48.8 years), had fewer Non-Hispanic Whites (48.9% vs. 59.6%), fewer physicians (9.2% vs. 11.8%) and nurses (53.1% vs. 69.7%), and more CNAs (34.0% vs. 13.5%), a lower prevalence of new-onset asthma (5.9% vs. 6.7%), higher prevalence of bronchial hyperresponsiveness (40.1% vs. 31.1%), and fewer HCWs using powdered latex gloves in 1992–2000 (66.6% vs. 71.6%).

Data Collection

Asthma Risk Factor Job Exposure Matrix—Occupational exposures were determined using an asthma risk factor Job Exposure Matrix (JEM) designed for HCWs. Originally developed and used in 2003, this JEM was updated for the 2016 study by a multidisciplinary team of physicians, industrial hygienists, and epidemiologists who conducted walk-throughs and focus groups at three tertiary hospitals, two nursing homes, and two outpatient clinics in Houston. The updated JEM included: a) the 2003 exposure categories; b) new exposure categories reflecting specific tasks (e.g., endoscopy) and environments (e.g., intensive care units); c) broader nursing professions (e.g., nurse aides); and d) broader practice settings to include areas within and outside hospitals (e.g., outpatient clinics).

The JEM-derived exposures were classified into two categories: (a) tasks or practices: patient care cleaning and disinfection, medical instrument cleaning, and building surface cleaning (including sprays), and (b) products or compounds classified into cleaning agents, including glutaraldehyde, OPA, enzymatic cleaners, bleach, quaternary ammonium compounds, sprays, and powdered latex glove use.

This updated JEM was then coded by a group of experienced industrial hygienists, occupational physicians, toxicologists, and occupational health professionals working in healthcare settings, both hospitals and outpatient clinics. "Exposed" was defined as the probability that a HCW in a given cell was exposed to the task or product at least once per week: a code of '0' indicated a high probability of no exposure, a '1' a low probability of exposure, and a '2' a high probability of exposure. Each coder independently assigned codes to the entire JEM, followed by a team review to identify disagreements, resolved by consensus. Based on their job title and practice setting, the coded JEM was applied to respondents' current and longest-held job as HCW.

Survey Instrument—As in 2003, in 2016, we asked about demographics, occupational history, and health. In 2016 we added new questions on exposures and occupational history to characterize better exacerbated or occupational asthma. The questionnaire was pilot tested in a small group of Houston HCWs for timing, ease of use, and comprehensibility. The final questionnaire was available in two formats, an online version and a paper-based version compatible with direct data entry with the HP Teleform™ (Version 11, Sunnyvale, CA) software, which recognizes and digitizes handwriting on a scanned paper-based survey.

Study Variables

Four self-reported asthma outcomes were defined: (a) physician-diagnosed asthma (PDA), (b) new onset PDA (NOA), (c) work-exacerbated asthma (WEA), and (d) bronchial hyperresponsiveness (BHR) symptoms. PDA was defined as a 'Yes' to: '*Have you ever had asthma?*' and '*If yes, has it been confirmed by a doctor?*'. NOA was defined as PDA after entry into the health profession by comparing the age at which the asthma diagnosis was made to the number of years as HCW. WEA was defined among respondents with a history of PDA as a 'Yes' to: *'Have you had an attack/episode while you were at work in the last 12 months?*' and '*If Yes, do you know what triggered that last attack/episode?*'.

The presence or absence of BHR symptoms was determined based on a previously validated 8-item predictor of PC_{20} (provocative concentration of methacholine causing a 20% fall in FEV_1)(48) assessing these symptoms: occurrence of trouble breathing, wheezing, or whistling in the chest, attacks of shortness of breath, nocturnal cough attacks, chest tightness attacks, itchy/watery eyes or a feeling of chest tightness when near animals, feathers, or dust, and itchy or watery eyes when near trees, grass, flowers, or pollen. Respondents who left the eight items blank were set to missing (n=4). A continuous score (from 0 to 1) was created and dichotomized based on the published cutoff, where >0.5 indicates the presence of BHR. Next, two scenarios were created for respondents with at least one nonmissing item: (1) a best scenario coding all missing symptoms as absent, and (2) a worst scenario coding those symptoms as present. We set to missing respondents who obtained a different score in both scenarios (n=26), and kept the scores for those respondents whose score (either ≤0.5 or >0.5) under both scenarios was the same.

The main independent variables were occupational exposures as defined by the JEM. In the coded JEM, the number of occupation–practice setting combinations coded "1" (low probability) for exposure was very small for almost all exposures and considered too small for meaningful analyses. Thus, occupational exposure variables were dichotomized by collapsing codes "1" and "2" into a single "exposed" category, with "0" reflecting the nonexposed groups. JEM codes for the longest held job were used because the majority (55.6%) of respondents indicated that their current job was their longest-held job. If the longest-held job was outside healthcare, the JEM codes from the current job were used. Also, the questionnaire asked a yes/no question on having ever been involved in a chemical spill or gas release at work.

Covariates included age, sex, race/ethnicity, professional group, years as an HCW (10-year groups), smoking status (never, current, or former), and obesity (body mass index [kg/m2]⩾30). Atopy was determined based on a history of allergies to animals, dust, or dust mites (8). Of the 220 respondents missing age, we imputed it for 139 of them based on their nonmissing number of years as HCW and the average number of years at which the profession typically starts (e.g., 26 years for physicians, 22 years for nurses, RTs and OTs, and 16 years for CNAs).

Statistical Analysis

Being a complex survey dataset, we applied survey weights with proportions based on census data on healthcare professionals. Post-stratification weights were calculated to obtain prevalence estimates that were representative of the population size for each professional group. We calculated unweighted counts and weighted prevalence of PDA, NOA, WEA, and BHR. Multivariate regression models were built following Hosmer and Lemeshow's covariate selection strategy (49). Separate regression models were built for each class of exposure tasks and products since initial strong collinearity ($r \geq 0.70$) was found among occupational exposures, mainly within instrument cleaning (glutaraldehyde, endoscopy, OPA), building surface cleaning (sprays with quaternary compounds and bleach), and latex glove use (among all time axes).

We used logistic regression models to estimate the associations (odds ratio, OR, and corresponding 95% confidence interval, 95%CI) between each independent variable and the outcomes. Variables with a p<0.25 in the univariate analyses (i.e., age, gender, race, atopy, obesity, smoking, and job seniority) were entered into the multiple regression models. We assessed interactions of patient care cleaners with smoking, race, obesity, and seniority, but none were statistically significant. Hosmer-Lemeshow's goodness-of-fit tests for survey data (50) indicated good model fit (p>0.05). Stata's *svy* package for weighted data was used for the analyses (51,52).

Finally, we adhered to STROBE Guidelines in the completion of this study.

RESULTS

Table 1 shows descriptive statistics for the analytic (n=2,421) and excluded (n=905) samples. The majority of the analytical sample was middle age (48.8 years old), female (83.2%), Non-Hispanic white (59.6%), and never-smokers (74.7%). The prevalence of obesity was 27.9%, and the prevalence of atopy was 15.4%. The sample was evenly distributed by job seniority (20%−25% in each group). Most participants were nurses (69.7%), followed by CNAs (13.5%), physicians (11.8%), and RTs or OTs (both with 2.5%)

The overall weighted prevalence for PDA, NOA, WEA, and BHR symptoms was 15.3%, 6.7%, 4.1%, and 31.1%, respectively. There were differences by profession (p<0.01) in the prevalence of NOA: 8.0% in OTs, 7.6% in nurses, 6.3% in RTs, 4.9% in physicians, and 3.4% in CNAs. BHR symptoms also varied by profession (p=0.02): 38.3% in OTs, 36.3% in RTs, 34.7% in nurses, 30.5% in CNAs, and 27.6% in physicians. There were no statistically significant differences for PDA, and the sample for WEA was too small to stratify by profession.

In the unadjusted models (Table 2), NOA was associated with age (OR=1.03; 95%CI 1.02–1.04), inversely associated with race, particularly among non-Hispanic blacks (OR=0.35; 95%CI: 0.15–0.82) as compared to non-Hispanic whites, atopy (OR=2.47; 95%CI: 1.57–

3.88), and job seniority, with the odds of NOA increasing with advancing age (ORs ranging from 5.48 to 11.39). BHR symptoms were associated with gender (OR=1.68; 95%CI: 1.28–2.20, female vs. male) and atopy (OR=6.75; 95%CI: 5.00–9.11).

Regarding cleaning tasks and products (Table 3), the use of OPA (OR=2.07; 95%CI: 1.38–3.10), bleach and quaternary compounds (OR=1.89; 95%CI: 1.16–3.09, for each), sprays (OR=1.92; 95%CI: 1.17–3.15), and powdered latex glove after 2000 (OR=0.25; 95%CI: 0.09–0.69) were associated with NOA. After adjusting for age, gender, race, atopy, obesity, smoking status, and years on the job, statistically significant associations remained for NOA with the use of OPA for instrument cleaning (OR=1.77; 95%CI: 1.15–2.72), bleach and quaternary ammonium compounds used to clean building surfaces (OR=1.91; 95%CI: 1.10–3.33 for both), use of sprays in building surface cleaning (OR=1.97; 95%CI: 1.12–3.47), and use of latex gloves from 2001 to 2006 (OR=0.25; 95%CI: 0.09–0.73), and 2007 onwards (OR=0.26; 95%CI: 0.09–0.76). For BHR, only an inverse association with patient care cleaners was found (OR=0.64; 95%CI: 0.44–0.92).

Compared with 2003 (Table 4), the overall prevalence of NOA remained high (6.6% in 2003, 6.7% in 2016), and the BHR prevalence increased from 27.4% to 31.1%. Disregarding statistical significance, the associations between NOA and patient care cleaners, surface cleaners, use of powdered latex gloves, and spill at the workplace were essentially unchanged, except for a weakening of the association with patient care cleaners and instrument cleaning (1.60 to 0.66 for patient care cleaners, 2.22 to 1.36 for instrument cleaners).

DISCUSSION

The overall prevalence of NOA (6.7%) and BHR symptoms (31.1%) among HCWs remained high, or were slightly higher, in 2016 as compared to 2003 (6.6% and 27.4%, respectively). Some associations with cleaning tasks and products changed, while others remained the same (8). The association of NOA with patient care cleaners and with instrument cleaning and disinfection of medical instruments decreased substantially (40% to 60%), exposure to powdered latex appeared even more controlled (OR<1), but exposure to cleaning of building surfaces remained unchanged (ORs around 2). Importantly, BHR symptoms which, in 2003, were associated with cleaning of building surfaces and acute exposures to chemical spills, had no elevated odds for any cleaning-related exposures in 2016.

The decrease in what was previously a greater than two-fold risk for NOA associated with medical instrument cleaning is encouraging. This likely reflects the widespread use of enclosed, automated disinfection procedures for endoscopes in recent years (i.e., Automated Endoscope Reprocessors or AERs) (53, 54). AERs have evolved over the past 15 years, incorporating several functions, including leak testing, cleaning, and post-cleaning rinse, followed by high-level disinfection, a second rinse, and drying, all previously done manually. Over this period, glutaraldehyde, the main cold sterilant used to disinfect medical instruments and which had been repeatedly identified as a sensitizer capable of inducing asthma (55,56,57,58), was steadily replaced by OPA. Being less volatile than glutaraldehyde, OPA was expected to affect the respiratory system less (59). However, although glutaraldehyde was not a significant risk factor in our study, we did observe a two-fold increase in the odds of NOA associated with OPA. This is consistent with recent reports of OPA-associated acute respiratory symptoms and skin sensitization (60,61). Although used primarily for AER-based medical instrument disinfection, OPA is also used in other situations, some of which may entail a greater risk of direct exposure, such as electrocardiographic probes or cryosurgical equipment (59). OPA is also used in cleaning the container systems, removing and rinsing soaked instruments, their disposal, and other maintenance procedures for AERs (59). Hence, more research on OPA appears warranted.

The persistent association of NOA with cleaning general building surfaces, at a magnitude similar to 2003, is concerning. We also examined the associations between common tasks and cleaning products, which was not done in 2003. The increased association with bleach may be due to a resurgence in the use of bleach in the U.S. as part of intensified attempts to control hospital-acquired infections, particularly those associated with *Clostridium difficile* (62,63,64,65). Reports of asthma associated with exposure to quaternary ammonium compounds surfaced 18 years ago (66) but have continued to appear (67,68,69,70). Previous studies have described the frequent use of cleaning sprays as an asthma risk factor (23,71). The disappearance of the negative association of NOA with powdered latex glove use observed in 2003 continues, likely reflecting the widespread substitution of latex by non-latex products, as well as improvements in the manufacturing use of less allergenic lightly powdered or non-powdered latex gloves (72,73,74,75,76). Although latex glove use has dramatically decreased in clinical settings, there are still some settings where hypoallergenic non-powdered (or lightly powdered) latex gloves may still be in use. In our 2003 study, we found that many latex control programs had been implemented in the mid to late 1990s, such that we found a marked decrease in the risk of allergy associated with latex glove use after 2000. When we again examined this association, the magnitude of the association was similar to that in 2003, probably indicating that controls for latex allergy have remained effective in the subsequent time period.

Finally, that BHR symptoms do not appear related to occupational exposures to cleaning products and chemicals is also encouraging. This may be due to increased awareness, more standardized procedures for prompt prevention, detection, and control of chemical spills, better training of personnel, and the use of appropriate personal protective equipment per newer OSHA guidelines (77).

Healthcare settings are committed to regularly cleaning and disinfecting their facilities to prevent spreading disease and infection. But during the COVID-19 pandemic, particularly in its early phases when the risk of getting the SARS-CoV-2 virus from a contaminated surface was thought to be high, the frequency of cleaning and disinfection of surfaces intensified to reduce virus exposure from surface contact. This overall increase in the extent, frequency, and intensity of use of disinfectants, particularly bleach-based ones, not only in healthcare facilities but also in households may have exacerbated the effect of cleaning on asthma. Later, it was determined that COVID-19 spread mainly through the air, but it is unclear if cleaning practices and use of products have returned to pre-pandemic levels. At the same time, that effect may have been buffered by the widespread use of tight-fitting respirators such as the N95 masks to reduce exposure to virus aerosols. However, N95 masks do not protect from chemical odors, gases, or vapors. Although there is likely a bi-directional association of cleaning products and practices with asthma, more research is needed to establish which direction predominates.

Our study strengths are the sampling and weighting strategy, which produced a statewide representative sample of five HCWs groups. This makes results generalizable to similar workers in the U.S. and other countries. Comparisons should be made cautiously since cleaning and disinfection products may vary by country or even in healthcare environments within a country. Likewise, the job duties ascribed to specific HCWs groups, for example, nurses or therapists, may be different than in the U.S. Adding CNAs, a previously unstudied group, is a strength and allows comparison to other nursing professionals in the current study. Finally, preserving the same study design, sampling strategy, and execution as in the 2003 study allows meaningful time comparisons.

Our study also had limitations. The overall lower response rate (about 39% for the four occupational groups included in 2003, that is, all but CNAs) than in 2003 (66%) may reflect a well-described general trend toward declining response rates in epidemiological surveys (78,79,80). However, the final number of responses in the analytical sample (n=2,347) was comparable to the 2003 study (n=2,738), and we used statistical weights to increase sample representativity. Also, the excluded sample differed somewhat from the analytical sample in a few demographic characteristics (i.e., a bit older, fewer Whites, and more nurses) and asthma-related measures (less NOA, more BHR). Still, a potential selection effect is unlikely since most of these differences were small, we oversampled nurses, and, as discussed above, our results on asthma are coherent and consistent with other research.

In summary, the prevalence of NOA and BHR symptoms in 2016 was similar to 2003. The association of NOA with exposures to building surface cleaning remained, decreased for instrument cleaning, and improved for powdered latex glove use. Partly, these changes may be attributable to technological changes in disinfection procedures and the decline in the use of some disinfectants. However, the increased association with exposure to OPA and the continued association with cleaning building surfaces should be monitored, along with using alternative products and practices (e.g., less use of bleach and aerosols). Overall, improving exposure controls and clinical asthma management could help decrease the asthma burden among HCWs.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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SMART Learning Outcomes

- Evaluate changes in asthma prevalence among Texas healthcare workers (HCWs) from 2003 to 2016, focusing on physician-diagnosed, work-exacerbated, and new-onset asthma.
- Calculate and compare weighted asthma prevalence rates within a sample of 2,421 HCWs, utilizing statistical analysis to assess temporal trends.
- Utilize self-reported data and statistical methods to discern shifts in asthma prevalence, contributing to an improved understanding of HCWs' respiratory health risks.

Table 1.

Descriptive characteristics[a] of the analytical sample and the excluded sample of Texas healthcare workers, 2016. (N=3,326)

Characteristics	Analytical sample (n = 2,421)	Excluded sample (n=905)	p-value[b]
Age (in years) [mean ± SE]	48.8 ± 0.36	50.4 ± 0.60	<0.001
Sex [n (%)]			<0.01
Women	1,852 (83.2)	657 (88.0)	
Men	569 (16.8)	147 (12.0)	
Race [n (%)]			<0.001
Non-Hispanic white	1450 (59.6)	362 (48.9)	
Hispanic	434 (17.5)	133 (22.6)	
Non-Hispanic black	265 (12.9)	100 (17.7)	
Others	272 (10.0)	74 (10.8)	
Atopy [n (%)]	388 (15.4)	146 (18.2)	0.13
Obesity [n (%)]			0.01
(BMI ≥ 30 kg/m^2)	630 (27.9)	233 (34.1)	
Smoking [n (%)]			0.04
Never smokers	1,830 (74.7)	613 (74.7)	
Current smokers	111 (5.4)	54 (8.2)	
Former smokers	480 (19.8)	148 (17.1)	
Job seniority (in years) [n (%)]			0.02
0–10 years	634 (26.6)	207 (24.5)	
11–20 years	655 (26.0)	222 (24.9)	
21–30 years	543 (21.0)	171 (17.7)	
≥31 years	589 (26.4)	300 (32.9)	
Profession [n (%)]			<0.001
Physicians	430 (11.8)	139 (9.2)	
Nurses	947 (69.7)	298 (53.1)	
Respiratory Therapists	399 (2.5)	133 (2.0)	
Occupational Therapists	442 (2.5)	119 (1.6)	
Certified Nurse Aides	203 (13.5)	211 (34.0)	
Asthma-related conditions [n (%)]			

Characteristics	Analytical sample (n = 2,421)	Excluded sample (n=905)	p-value[b]
Physician-Diagnosed Asthma (PDA)	389 (15.3)	140 (17.8)	0.17
New-Onset Asthma (among PDA)	157 (6.7)	49 (5.9)	0.53
Work-Exacerbated Asthma (among PDA)	16 (4.1)	8 (0.9)	0.33
BHR[c] symptoms	775 (31.1)	279 (40.1)	<0.001
Cleaning-related tasks and products (post-2003) [n (%)]	2,121 (90.0)	625 (86.6)	0.04
Patient cleaning & disinfection			
Instrument cleaning	716 (28.9)	182 (28.3)	0.79
Endoscopy	700 (27.8)	185 (29.3)	0.53
Glutaraldehyde	950 (45.8)	232 (41.4)	0.11
Orthophthalaldehyde	475 (10.2)	118 (11.5)	0.44
Enzymatic cleaners			
Building surface cleaning	1,763 (75.6)	461 (77.4)	0.40
Bleach	1,763 (75.6)	461 (77.4)	0.40
Quaternary ammonium compounds	1,781 (77.0)	461 (77.6)	0.76
Sprays	0	0	--
Stripping/waxing/buffing			
Powdered latex gloves [n (%)]			
Pre-1992	1,762 (84.2)	463 (84.9)	0.69
1992–2000	1,502 (71.6)	374 (66.6)	0.04
2001–2006	215 (5.9)	53 (5.3)	0.43
2007 onwards	214 (5.9)	53 (5.3)	0.48
Aerosolized medications (post-2003) [n (%)]	1,131 (58.3)	260 (48.9)	<0.001
Spill at work	93 (4.3)	21 (3.3)	0.37

[a] From weighted sample;

[b] P-values of chi-squared test for differences in proportions and of *t* test for mean differences;

[c] Bronchial-hyperresponsiveness.

Table 2.

Unadjusted[a] associations (odds ratios [OR] and 95% confidence intervals [CI]) of sample demographic and job-related characteristics with asthma-related conditions among Texas healthcare workers, 2016 (n=2,421).

	New Onset Asthma	BHR Symptoms[b]
Characteristics[c]	OR (95% CI)	OR (95% CI)
Age [continuous]	**1.03 (1.02–1.04)**	1.00 (0.99–1.01)
Sex		
Men	Ref	Ref
Women	1.72 (0.98–3.03)*	**1.68 (1.28–2.20)**
Race (Non-Hispanic White)	Ref	Ref
Hispanic	0.58 (0.32–1.05)*	0.79 (0.59–1.07)*
Non-Hispanic Black	**0.35 (0.15–0.82)**	0.66 (0.46–0.94)*
Others	0.59 (0.28–1.27)*	1.03 (0.73–1.46)
Atopy	**2.47 (1.57–3.88)**	**6.75 (5.00–9.11)**
Obesity	1.37 (0.90–2.11)*	
Smoking (Non-Smokers)	Ref	Ref
Current Smokers	0.83 (0.30–2.30)	1.22 (0.76–1.98)
Former Smokers	1.14 (0.69–1.89)	1.33 (1.02–1.74)*
Job seniority (0–9 years)	Ref	Ref
10–16 years	**5.48 (2.07–14.48)**	1.15 (0.85–1.55)
17–26 years	**8.60 (3.30–22.39)**	1.27 (0.93–1.74)
≥27 years	**11.39 (4.50–28.87)**	1.10 (0.81–1.49)

Bold = $p < 0.05$.

* $p \leq 0.25$.

[a] From weighted logistic regression models;

[b] Bronchial-hyperresponsiveness;

[c] All from the self-reported questionnaire, except cleaning agents and latex use, which were assessed with the job-exposure matrix;

[d] Quaternary Ammonium Compounds.

Table 3.

Crude and adjusted[a] associations (odds ratios [OR] and 95% confidence intervals [CI]) of cleaning tasks and products with asthma-related conditions among Texas healthcare workers (n=2,421).

	New Onset Asthma		BHR Symptoms[b]	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Cleaning-related tasks				
Patient care cleaning & disinfection	**0.56 (0.32–0.98)**	0.66 (0.37–1.17)	**0.63 (0.44–0.88)**	**0.64 (0.44–0.92)**
Instrument cleaning				
Endoscopy	1.34 (0.87–2.06)	1.36 (0.86–2.15)	0.92 (0.72–1.17)	0.98 (0.76–1.28)
Building surface cleaning				
Sprays	**1.92 (1.16–3.15)**	**1.97 (1.12–3.47)**	0.86 (0.68–1.09)	0.86 (0.62–1.20)
Cleaning-related products				
Instrument cleaning				
Glutaraldehyde	1.29 (0.83–1.99)	1.24 (0.78–1.95)	1.04 (0.81–1.32)	1.03 (0.79–1.34)
Orthophthalaldehyde	**2.07 (1.38–3.10)**	**1.77 (1.15–2.72)**	0.93 (0.75–1.16)	0.90 (0.71–1.14)
Enzymatic cleaners	1.51 (0.86–2.67)	1.42 (0.79–2.54)	1.23 (0.89–1.71)	1.21 (0.84–1.75)
Building surface cleaning				
Bleach	**1.89 (1.16–3.09)**	**1.91 (1.10–3.33)**	0.87 (0.69–1.10)	0.78 (0.60–1.02)
Quaternary ammonium compounds	**1.89 (1.16–3.09)**	**1.91 (1.10–3.33)**	0.87 (0.69–1.10)	0.78 (0.60–1.02)
Sprays	**1.92 (1.17–3.15)**	**1.97 (1.12–3.47)**	0.86 (0.68–1.09)	0.79 (0.61–1.04)
Powdered latex glove use				
Pre-1992	1.55 (0.86–2.80)	1.41 (0.77–2.58)	0.84 (0.64–1.11)	0.90 (0.65–1.23)
1992 – 2000	1.42 (0.90–2.23)	1.20 (0.75–1.91)	1.03 (0.81–1.29)	1.00 (0.78–1.29)
2001 – 2006	**0.25 (0.09–0.69)**	**0.25 (0.09–0.73)**	**0.69 (0.49–0.96**)	0.88 (0.61–1.28)
2007 onwards	**0.25 (0.09–0.70)**	**0.26 (0.09–0.76**)	0.70 (0.50–0.97)	0.90 (0.62–1.31)
Spill at work	1.40 (0.60–3.31)	0.94 (0.37–2.37)	**1.91 (1.17–3.13)**	1.72 (0.99–3.00)

Bold indicates p<0.05.

[a]From weighted logistic regression models adjusted for age, gender, race, atopy, obesity, smoking, and job seniority;

[b]Bronchial-hyperresponsiveness.

The similar odds ratios for bleach and quats are because of similar codes that were entered in the Job-Exposure Matrix

Table 4.

Comparison between 2003 and 2016 of prevalence (Prev.) and adjusted[b] associations (odds ratios [OR] and 95% confidence intervals [CI]) between cleaning-related tasks and products with asthma-related conditions among Texas healthcare workers.

	New Onset Asthma		BHR[a] Symptoms	
	2003 Study (n=2,738)	**2016 Study (n=2,421)**	**2003 Study (n=2,738)**	**2016 Study (n=2,421)**
	Prev. = 6.6%	**Prev. = 6.7%**	**Prev. = 27.4%**	**Prev. = 31.1%**
	OR (95%CI)	**OR (95%CI)**	**OR (95%CI)**	**OR (95%CI)**
Cleaning-related products				
Patient care cleaners	1.60 (0.18–14.16)	0.66 (0.37–1.17)	0.79 (0.35–1.78)	**0.64 (0.44–0.92)**
Instrument cleaning	**2.22 (1.34–3.67)**	1.36 (0.86–2.15)	1.26 (0.95–1.67)	0.98 (0.76–1.28)
Surface cleaners	**2.02 (1.20–3.40)**	**1.97 (1.12–3.47)**	**1.63 (1.21–2.19)**	0.78 (0.60–1.02)
Latex 2000–2006	0.42 (0.13–1.29)	**0.25 (0.09–0.73)**	0.61 (0.34–1.11)	0.88 (0.61–1.28)
Latex 2007 and later	NA	**0.26 (0.09–0.76)**	NA	0.90 (0.62–1.31)
Spill at work	1.23 (0.53–2.87)	0.94 (0.37–2.37)	**2.02 (1.28–3.21)**	1.72 (0.99–3.00)

Bold indicates $p<0.05$.

[a] Bronchial hyperresponsiveness;

[b] Adjusted for age, gender, race, atopy, obesity, smoking, and number of years as healthcare professional.