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Acute Symptoms Associated with Chemical Exposures and Safe Work Practices Among Hospital and Campus Cleaning Workers: A Pilot Study

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Abstract

Background—Cleaning workers are regularly exposed to cleaning products containing hazardous chemicals. This study investigated acute symptoms associated with chemical exposures among cleaning workers and their safe work practices.

Methods—This cross-sectional study included 183 cleaning workers employed in an academic medical center and affiliated health sciences campuses in Northern California. Data on respiratory, eye, skin, neurological, and gastrointestinal symptoms and occupational factors were collected by in-person interviews or self-administered questionnaires.

Results—Chemical-related symptoms (several times monthly or more often) were more common among workers who performed patient-area cleaning (44%) than hospital-custodians (36%) or campus-custodians (28%). After controlling for age, sex, and job title, symptoms were associated with exposure to carpet cleaners (OR=2.98, 95% CI 1.28–6.92), spray products (OR=2.82, 95% CI 1.16–6.82), solvents (OR=2.71, 95% CI 1.20–6.15), and multi-purpose cleaners (OR=2.58, 95% CI 1.13–6.92). Except for gloves, regular use of personal protective equipment was infrequent.

Conclusions—Study findings suggest a need for additional interventions such as use of less toxic products to reduce health risks among cleaning workers.

Keywords

cleaners; cleaning; chemical exposure; healthcare; safe work practice

INTRODUCTION

Cleaning workers are regularly exposed to chemical products used in cleaning tasks. Cleaning products contain various chemical ingredients such as detergents, disinfectants, surfactants, solvents, corrosion inhibitors, fragrances and preservatives. Some of these chemicals are classified as corrosives, irritants, sensitizers, carcinogens, or neurotoxic agents

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[Wolkoff, et al. 1998, Zock 2005]. Regular and frequent exposure to cleaning products without adequate protection puts cleaning workers at risk of acute and chronic adverse health effects from hazardous chemicals.

Cleaning workers rank among the top 20 occupations with the highest rates of occupational injuries and illnesses in the United States. Four percent of their injuries and illnesses are attributed to exposure to harmful substances or environments [Bureau of Labor Statistics 2010]. Irritation of the eyes, skin, and respiratory tract, allergy, and chemical burns have been identified as common acute health and safety problems among cleaning workers [Alamgir and Yu 2008, Arif, et al. 2008, Charles, et al. 2009, Lynde, et al. 2009, Nielsen and Bach 1999, Sarri, et al. 1991]. A Danish study of 1,011 female cleaning workers in nursing homes, schools, and offices reported that the annual symptom prevalence was 46% for nose or throat symptoms, 31% for eye symptoms, with an asthma prevalence of 8% [Nielsen and Bach 1999]. A Canadian study found that the prevalence of skin rash was significantly higher among male professional cleaning workers than other building workers (21% vs. 11%) [Lynde, et al. 2009]. Two other studies reported a prevalence of hand dermatitis of 12–15% among hospital cleaning workers [Gawkrodger, et al. 1986, Hansen 1983, Lynde, et al. 2009]. In addition, epidemiological studies have found elevated risks of asthma among cleaning workers and significant associations between asthma and exposure to cleaning products [Jaakkola and Jaakkola 2006, Karjalainen, et al. 2002, Reinisch, et al. 2001, Rosenman, et al. 2003, Vizcaya, et al. 2011, Zock, et al. 2001, Zock, et al. 2007, Zock, et al. 2010].

Among the types of cleaning products, disinfectants are recognized as among the most hazardous. Disinfectants include active ingredients such as chlorine-releasing compounds, alcohols, aldehydes, and quaternary ammonium compounds [Wolkoff, et al. 1998, Zock 2005]. Disinfectants used on environmental surfaces are regulated by the Environmental Protection Agency. In healthcare, disinfecting activities are essential for infection control in certain settings, and therefore cleaning workers in healthcare may have increased risk of disinfectant exposure than workers in other settings. Among various occupational groups in healthcare settings, cleaning workers have been identified as an occupation at higher risk of chemical-associated injuries or illnesses [Centers for Disease Control and Prevention (CDC) 2010, Weaver, et al. 1993].

Information is limited on the extent of chemical exposure and associated acute health problems among cleaning workers in healthcare. This study was conducted to investigate the prevalence of and risk factors for acute health symptoms associated with chemical exposures and safe work practices among cleaning workers in hospital and affiliated settings.

METHODS

Study Setting and Participants

This cross-sectional study recruited a convenience sample of cleaning workers employed at a university medical center and affiliated health sciences campuses in Northern California. Cleaning workers were defined as employees who perform janitorial, cleaning, or housekeeping services regardless of job title. The medical center (called “hospital”

afterwards) has about 7,000 employees and 690 patient beds in two locations. As of December 2010, the Hospitality Service Department had 280 employees, which consisted of 122 (44%) patient support assistants (PSAs) who assist patient transport and perform cleaning of patient rooms and clinical areas (e.g., operating room), and 133 (48%) custodians who perform cleaning of other nonclinical or public areas (e.g., hallway, restroom, or waiting room). The remaining employees had supervisory or other job responsibilities (8%). The university health sciences campus (called “campus” afterwards) is affiliated with the hospital, but has a separate management system for cleaning services. A total of 128 custodians were employed by the campus. The study setting has adopted certified green products for most cleaning agents. A variety of cleaners, degreasers, finishers, sealers, and polishes were used and included chemicals such as ethanolamines, glycol ethers (2-butoxyethanol, ethylene glycol ethylhexyl ether, dipropylene glycol methyl ether), alcohols (benzyl alcohol, ethyl alcohol, isopropyl alcohol), and d-limonene.

The cleaning service departments’ managers helped the investigators’ access to the workers. The investigators attended monthly staff meetings and other events (e.g., staff stretching exercise time) to provide study information and recruit participants. As the majority of the workers spoke Chinese or Spanish as their first language, all study information was provided in three languages (English, Chinese, and Spanish). The study flyers were placed on cleaning department bulletin boards and in hospital employee lounges. Eligible participants were cleaning workers who were employed for at least one month and could speak, read, and understand English, Chinese, or Spanish. Supervisors who performed cleaning as a partial job responsibility were also included. A $25 gift card was given to each participant after completing the questionnaire. The study was approved by the Committee on Human Research of the University of California at San Francisco.

Data Collection and Instruments

This study collected data using a questionnaire in English, Chinese, or Spanish. The English questionnaire was developed initially and reviewed by two occupational health experts and one cleaning service manager. The questionnaire was pilot tested with four hospital cleaning workers and minor modifications were made to improve clarity in wording and format. Chinese and Spanish versions were developed through translation and back-translation processes by independent bilingual persons. The principal investigator compared the back-translated versions and the original English version. For a few discrepancies identified, translations were corrected and finalized with consultation with a third bilingual person. The initial data collection method was face-to-face interviews conducted by trained bilingual interviewers. A self-administration method was subsequently added to facilitate participant recruitment.

The study questionnaire included items about demographics (age, sex, race/ethnicity, country of birth, and education), health conditions (e.g., asthma, contact dermatitis, other comorbidities, and perceived general health), job information (job title, job tenure, full-time status, and shift), chemical exposure, safe work practices and health symptoms associated with chemical exposure.

Chemical exposure items were adapted from studies by Zock and colleagues [2001] and Nielsen and Bach [1999]. We asked how many days in the usual work week the worker performed the cleaning task (e.g., floor polishing, window or mirror cleaning, or discharge cleaning of in-patient rooms) and used the cleaning product (e.g., bleach, solvents, polishers, or glass cleaners). For those who had any frequency of exposure to the task or product, the duration of exposure per day was assessed on a 5-point scale (<0.5 hours, 0.5–1 hour, >1–2 hours, >2–4 hours, >4 hours).

Safe work practices were assessed by chemical safety behavior and use of personal protective equipment (PPE). Chemical safety behavior was asked by an 8-item measure developed by the investigators based on a reference by the California Division of Occupational Safety and Health (Cal/OSHA) [2005]. Respondents answered how often they engaged in the behavior on a 5-point scale (never, rarely, sometimes, most of the time, all the time). As for PPE use, respondents were asked to indicate how often in the past 30 days they wore gloves, long-sleeve clothing, rubber apron, safety glasses or goggles, face shield, and surgical mask while handling chemicals on a 5-point scale (never, rarely, sometimes, most of the time, all the time).

For chemical-related health symptoms (16 items), we asked how often in the past 12 months the respondent had symptoms involving the respiratory tract, eye, skin, nervous and gastrointestinal systems which were associated with the use of chemicals to perform cleaning tasks. Symptom items (see Table 2) were selected based on the Respiratory Sensitizers Surveillance Questionnaire developed by Cal/OSHA (http://www.dir.ca.gov/dosh/doshreg/5179Meetings.html) and related literature [Brevard et al. 2003]. The questions were asked using a 5-point scale (daily, several times weekly, several times monthly, several times yearly, never in the past 12 months). Those who reported symptoms were further asked about whether they sought medical care, missed work due to the symptoms, and reported the condition to the supervisor.

Data Analysis

Data entry and analysis were performed using the statistical programs STATA version 11.2 (StataCorp, College Station, TX) and SAS version 9.2 (SAS Institute, Cary, NC). Data from pilot testing were excluded from the data analysis. All data were double entered by different individuals and the two datasets were compared to identify and correct entry errors. Descriptive statistics were used to summarize chemical-related symptoms and other study variables. To examine associations of symptoms with relevant study variables, symptom cases were defined as those who reported any chemical-related symptoms experienced “several times monthly or more often” (hereafter referred to as “at least monthly”). Demographic and job characteristics and health conditions were compared between symptom cases and non-cases using chi-square or Fisher’s exact tests. As for chemical exposure variables, we found that the numbers of workers who had no exposure were too small (<2–10%) to serve as the reference group for several items (e.g., mixing chemical solutions, dusting, mopping, disinfectants). Hence we categorized chemical exposure into no/low, medium, and high exposures by tertile split of the calculated product of exposure frequency (days/week) and duration category (hours/day). For some chemical exposure

items (e.g., waxing floors, stripping floors, carpet cleaners), most respondents (66–84%) reported no exposure and the approach of using tertiles were considered to be inappropriate. Hence, these variables were dichotomized into no exposure and any exposure. Multiple logistic regressions were conducted to examine associations between chemical-related symptoms and job or chemical exposure variables. Odds ratios (ORs) and 95% Confidence Intervals (CIs) were calculated.

RESULTS

Characteristics of Participants

A total of 183 cleaning workers (142 hospital workers and 41 campus workers) participated in this study (Table 1). This sample represented 45% of all cleaning workers in the study setting. The sample included 68 PSAs (37%), 64 hospital custodians (35%), 39 campus custodians (21%), and 12 supervisors (7%). The mean age of the participants was 48.0 years old (SD 9.9, range 20–73) and the mean job tenure was 8.1 years (median 6.3, range 0.3–33.4). The majority was female (56%), Asian (65%), foreign-born (86%), and had an educational level of high school or lower (72%). Most participants were full-time workers (96%) and worked on shifts other than days (57%). For hospital custodians and PSAs, the proportion of female and Asian workers were significantly higher among study participants than among nonparticipants ($p<0.05$) [data not shown]. The majority (54%) perceived their general health status as excellent or very good. A history of asthma or contact dermatitis was reported by 22 workers (12%); of these, 4 workers (18%) reported having both conditions.

Chemical-related Symptoms

Table 1 shows chemical-related symptom experiences (at least monthly) by demographic and job characteristics and health conditions. Female workers were significantly more likely to experience symptoms than male workers (45% vs. 25%, $p=0.004$); significance remained after adjustment for age and job title (OR=2.13, 95% CIs 1.07–4.23). Age was not significantly associated with symptoms, but the proportion of workers with symptoms tended to decrease with increasing age. A history of asthma was reported by 17 workers (9%); nine workers were currently taking a medication for asthma and one out of 11 workers who were diagnosed with asthma at 18 ages or order reported that it was related to her previous job. Workers with a history of asthma or contact dermatitis were significantly more likely to experience chemical-related symptoms than workers without such conditions (asthma: 65% vs. 33%, $p=0.010$; contact dermatitis: 78% vs. 34%, $p=.012$). In further analyses, a significant association was found between respiratory symptoms and asthma history (59% with asthma history vs. 28% without asthma history; $p=0.008$), but not between skin symptoms and contact dermatitis (22% with the history vs. 5% without the history; $p=0.094$). A significant association was found between experiences of respiratory symptoms and skin symptoms with Fisher's exact test ($p=0.004$) [data not shown].

Table 2 provides detailed data on symptom experiences related to chemical exposure. The 12-month prevalence of any chemical-related symptoms was 56% (13% daily, 8% several times weekly, 15% several times monthly, and 20% several times a year). Of the participants, 31% reported having experienced respiratory symptoms at least monthly: stuffy,

itchy or runny nose (19%) was the most common respiratory symptom, with shortness of breath and wheezing reported by 7% and 4%, respectively. Symptoms occurring at least monthly were reported for ocular (15%), neurological (13%), dermal (6%), and gastrointestinal (3%) systems.

Among103 workers who experienced chemical-related symptoms, 35 (34%) saw a healthcare provider due to the symptom, 27 (26%) reported the symptom to their supervisors, and 15 (15%) missed work. Hispanic workers were significantly more likely to see healthcare providers than Asian or Black workers (54% vs. 26% or 13%, respectively; p=0.006). Symptom reporting to supervisors was significantly less common among female workers than among male workers (19% vs. 42%; p=0.013) and among Asian workers than among other workers (14% vs. 49%; p=0.0002).

Job Exposures and Chemical-related Symptoms

Table 3 shows chemical-related symptoms and respiratory symptoms by job location, job title and selected work areas. Chemical-related symptoms were more common among hospital workers (39%) than among campus workers (27%). PSAs had the highest symptom prevalence (44%). After adjustment for age and sex, hospital custodians and PSAs had 19–43% increased odds of experiencing chemical-related symptoms compared to campus custodians, although this finding was not statistically significant. Chemical-related symptoms were significantly associated with working on in-patient floors (OR=2.55, 95% CI 1.28–5.08) and intensive care units (OR=2.53, 95% CI 1.15–5.55). For respiratory symptoms, overall findings showed similar patterns with slightly weaker associations compared to the findings on chemical-related symptoms, and statistical significance was found only for working on in-patient floors (OR=2.37. 95% CI 1.18–4.75).

Table 4 shows multivariable analyses on the associations of chemical-related symptoms and respiratory symptoms with job tasks and cleaning products. After adjustment for age, sex, and job title, chemical-related symptoms were significantly associated with tasks using spray products (OR=2.82, 95% CI 1.16–6.82 for medium exposure) and with high exposure to liquid multi-use cleaners (OR=2.58, 95% CI 1.13–5.89), solvents or stain removers (OR=2.71, 95% CI 1.20–6.15), carpet cleaners (OR=2.98, 95% CI 1.28–6.92) and products that smell like lemon or orange (OR=2.16, 95% CI 1.03–4.51). For respiratory symptoms, significant associations were found with medium exposure to tasks using spray products (OR=3.16, 95% CI 1.24–8.04) and high exposures to liquid multi-use cleaners (OR=2.35, 95% CI 1.02–5.43) and carpet cleaners (OR=2.33, 95% CI 1.00–5.43).

Safe Work Practices and Chemical-related Symptoms

Table 5 shows safe work practices among cleaning workers by job location and symptoms. More than 80% of participants reported that they complied with all chemical safety practices all the time or most of the time. Almost all participants (98%) reported wearing gloves all the time or most of the time whereas regular use of other PPE was uncommon (e.g., safety glass/goggle 28% and face shield 16%). Hospital workers were significantly more likely to wear a safety glass/goggle (X^2=14.39, p=0.0001), face shield (X^2=9.95, p=0.0016), and surgical mask (X^2=11.48, p=0.0007) than campus workers. No symptoms were significantly

associated with regular wearing of safety glass/goggle, long-sleeve clothing, or surgical mask and ventilating the cleaning space (Table 6).

DISCUSSION

Hospital cleaning workers perform cleaning tasks in settings where infection control is crucial, but may be at risk of adverse health effects from frequent exposure to cleaning and disinfecting products. This study investigated acute symptoms associated with chemical exposure among cleaning workers in an academic medical center and affiliated health sciences campuses. Our study showed that chemical-related symptoms, particularly respiratory symptoms, were relatively common among cleaning workers while regular use of PPE, except for gloves, was infrequent. Symptoms were more common among hospital cleaning workers than among campus custodians.

The annual prevalence of any chemical symptoms was 56% among cleaning workers, most commonly nasal irritation and cough. The prevalence of respiratory symptoms (48%) was similar to the prevalence (46%) from a Danish study of female cleaning workers in nursing homes, schools and offices [Nielsen and Bach 1999]. Our study also found that reported symptoms were relatively frequent among cleaning workers, with about one-third of workers experiencing respiratory symptoms at least monthly. Cleaning products contain volatile chemicals, and acute and chronic inhalation exposures pose respiratory health risks including asthma [Bello, et al. 2009, Jaakkola and Jaakkola 2006, Vizcaya, et al. 2011, Zock, et al. 2010]. In our study, most workers (81%) reported ventilating the cleaning space always or most of the time and about one third reported regularly wearing a surgical mask. No associations were found between regular ventilation and surgical mask use and respiratory symptoms.

Symptoms of eye irritation were the second most commonly reported among cleaning workers in this study, and the annual prevalence (32%) was similar to the report (31%) by Nielsen and Bach [1999]. A surveillance report by CDC [2010] showed that ocular symptoms were the most common disinfectant-related injury or illness in healthcare workers, often due to splashes without eye protection. Our study found that only 28% of participants reported regular use of safety glasses or goggles. Although we did not find a significant association, workers reporting frequent eye symptoms tended to wear eye protection more often than workers reporting infrequent or no symptoms. Lombardi et al. [2009] reported that use of protective eyewear among workers was influenced by perceptions of hazards and risks, enforcement and reinforcement, and barriers such as lack of comfort and fogging/scratching of the eyewear.

Our study identified that working on in-patient floors and intensive care units were significantly associated with increased symptoms. We found no association between using disinfectants and reported symptoms, but bleach showed non-significantly increased ORs (1.24 and 1.62) with medium and high exposures. Symptoms were significantly associated with spray products, multi-use cleaners, solvents, carpet cleaners, and products with smell like lemon or orange (these products potentially contain limonene). Spray products and solvents can increase the risk of inhalation exposure [Bello, et al. 2009], and these products

were found to be associated with increased risks of asthma in other studies [Zock, et al. 2001, Zock, et al. 2007]. A study of domestic and professional cleaners [Arif, et al. 2008] showed that more than 70% of products used by the workers were identified as respiratory irritants and sensitizers.

In controlling chemical hazards, elimination or substitution with less toxic products is the most effective, first-line approach. It should be noted that the study setting has replaced most cleaning products with green products, which contain less hazardous chemicals for human health and environmental impacts. For example, carcinogens, mutagens, reproductive toxins, asthmagens, skin sensitizers, and chemicals causing skin corrosion or serious eye damage may not be included in any product that obtains certification under certain criteria [Green Seal Inc., 2012]. Although mostly green certified products were used in the study setting, symptoms of acute irritation were nevertheless common among workers in our study.

Symptom perception and reporting can be influenced by sex and cultural factors [Barsky, et al. 2001, Callister, et al. 2003, Rahim-Williams, et al. 2012]. Our study observed interesting findings for sex. While female workers were more likely to experience symptoms than male workers, male workers were more likely to report the symptoms to their supervisors than female workers. We further analyzed for sex by controlling for significant variables of work area, task, or products as well as age and job title, and sex was still significant in all of the analyses [data not shown]. Higher incidence or prevalence of work-related injuries, illnesses, or symptoms in female workers was reported by other studies of various occupational groups [Alterman, et al. 2008; Barbosa, et al. 2013; Buchanan, et al. 2010; Kasner, et al. 2012]. Alamgir and Yu [2008] also reported a significantly higher incidence rate of work-related injuries among female cleaners in healthcare, but no significant difference was found for irritation or allergy. With regard to our findings of less symptom reporting to supervisors among female workers, little information is available in the literature. Some gender associated sociocultural aspects may play a role in communication or relationships with supervisors, but further research is needed to validate and better understand this finding.

In our study, participants were predominantly non-white, foreign-born workers (65% Asian). Symptom prevalence was not significantly different by either race/ethnicity or immigration status, but we found that symptom reporting to supervisors was significantly less among Asian workers than among non-Asian workers. As Asian workers are usually a small racial group in US studies, it is difficult to find a study to compare our findings. In a study of hotel room cleaners, Premji and Krause [2010] compared the prevalence of work-related pain and reporting to management by ethnicity and immigration status and found a significantly higher prevalence among Hispanic workers but no differences in pain reporting to management. Ethnic disparities in work-related injuries or pain have also been reported by other studies [Alterman, et al. 2008; Buchanan, et al. 2009, Friedman and Forst 2008, Tak, et al. 2010].

Our study has the following methodological strengths. We were able to increase the participation of immigrant workers by conducting the survey and interviews in three different languages. Also, two-thirds of the data were collected by in-person

interview, and trained interviewers provided additional explanation as needed and improved data completeness. We, however, found a significant difference in symptom reporting between the two methods in further analysis [data not shown]: symptom cases were significantly more among interviewed subjects than among those who self-administered the questionnaire. This finding is different from other studies [Rhodes et al. 1995; Steketee et al. 1996], which observed greater reporting of urinary symptoms or obsessive compulsive symptoms in self-administered methods than in interviews. In another study of binge eating, the two methods showed the opposite direction in reporting depending on the subjects' diagnosis [Birgegard et al. 2014]. Further evaluation is needed identify the impact of the methods on our study findings.

Our study has several limitations. First, causality cannot be established in the associations observed in this study due to the cross-sectional design. Second, our findings might have been affected by selection bias due to a low response rate (about 46%) and healthy worker survivor effect. The participants are not likely to be representative of all cleaning workers in the study setting. Female and Asian workers were overrepresented in the sample of hospital workers. Workers who experienced more severe symptoms or had low tolerance to chemical exposures might have left their job. Lower symptom prevalence rates among older workers may suggest healthy worker survivor bias, which leads to the underestimation of the true prevalence. Third, this study relied on self-reported data, which are subject to reporting bias from social desirability or recall bias. As for exposure to cleaning products, some researchers have reported underestimation by self-reports or differences between self-reports and job exposure matrix among general hospital workers [Delclos, et al. 2009, Donnay, et al. 2011]. Compared to general hospital workers, cleaning workers might be more knowledgeable about cleaning products as they currently use them for their main job activities. Therefore, recall bias in answering job activities and chemical exposure in usual work week may be of less concern in this study. For safe work practices and reported symptoms, we cannot exclude potential misclassification due to reporting bias. Our approach of defining cases as those who had symptoms at least monthly, however, may provide more conservative estimations in the examined associations. Fourth, the small sample size in this study limited the statistical power to detect true associations. Finally, our findings from the small convenience sample cannot be generalized to the cleaning worker population.

CONCLUSIONS

Work-related health symptoms can affect the well-being, work performance, and quality of work life of workers. Acute health problems associated with chemical exposure among cleaning workers have not been well described. This study identified that chemical-related symptoms of irritation were frequent among cleaning workers, especially hospital workers who clean patient areas. Use of PPE except for gloves was not part of regular safety practices among cleaning workers. The study findings suggest the need for interventions to reduce hazardous chemical exposure and indicate areas needed to be targeted for injury and illness prevention programs for cleaning workers. The US Occupational Safety and Health Administration and the National Institute for Occupational Safety and Health [2013] recommend that occupational exposures and health risks from cleaning products should be

reduced by selecting the least hazardous products, utilizing modern cleaning equipment that minimizes chemical use, maintaining and operating proper ventilation systems, complying with safe work practices and using adequate PPE. Future research studies employing longitudinal design, a larger sample size, objective exposure assessment and diaries of work activities and symptoms are suggested to better quantify the extent of chemical exposure and associated health effects. Furthermore, effective intervention programs should be developed and implemented to improve safe work practices and reduce adverse health outcomes for cleaning workers.

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TABLE 1.

Chemical-Related Symptom Experiences (Several Times Monthly or More Often) by Personal and Job Characteristics and Health Conditions

Variable	Total, N=183 (100%)	Chemical-related symptoms		P-value
		Yes n=66 (36%)	No n=117 (64%)	
Demographic characteristics				
Sex				
Male	81 (44.3)	20 (24.7)	61 (75.3)	**0.004**
Female	102 (55.7)	46 (45.1)	56 (54.9)	
Age (year)				
<30	11 (6.0)	7 (63.6)	4 (36.4)	0.211
30–39	22 (12.0)	9 (40.9)	13 (59.1)	
40–49	57 (31.1)	21 (36.8)	36 (63.2)	
50–59	76 (41.5)	24 (31.6)	52 (68.4)	
≥60	17 (9.3)	3 (21.4)	11 (78.6)	
Race/ethnicity				
Hispanic	37 (20.2)	15 (40.5)	22 (59.5)	0.932
Asian	119 (65.0)	42 (35.3)	77 (64.7)	
African American	21 (11.5)	7 (33.3)	14 (66.7)	
Other	6 (3.3)	9 (33.3)	18 (66.7)	
Country of birth				
United States	26 (14.3)	10 (38.5)	16 (61.5)	0.752
Other	156 (85.7)	55 (35.3)	101 (64.7)	
Education				
Elementary	13 (7.1)	6 (46.2)	7 (53.9)	0.482
High school	118 (64.5)	39 (33.1)	79 (67.0)	
College (≥ 1year)	52 (28.4)	21 (40.4)	31 (59.6)	
Job characteristics				
Job tenure (years)				
< 1	8 (4.4)	3 (37.5)	5 (62.5)	0.886
1–4	47 (25.7)	15 (31.9)	32 (68.1)	
5–9	67 (36.6)	24 (35.8)	43 (64.2)	
≥10	61 (33.3)	24 (39.3)	37 (60.7)	
Work status				
Full-time	176 (96.2)	61 (34.7)	115 (65.3)	0.100
Part-time or per-diem	7 (3.8)	5 (71.4)	2 (28.6)	
Work shift				
Day	78 (42.6)	32 (41.0)	46 (59.0)	0.229
Other	105 (57.4)	34 (32.4)	71 (67.6)	
Health conditions				
Perceived general health				
Excellent or very good	99 (54.1)	35 (35.4)	64 (64.7)	0.826

Variable	Total, N=183 (100%)	Chemical-related symptoms		P-value
		Yes n=66 (36%)	No n=117 (64%)	
Good	62 (33.9)	24 (38.7)	38 (61.3)	
Fair or poor	22 (12.0)	7 (31.8)	15 (68.2)	
Asthma				
Yes	17 (9.3)	11 (64.7)	6 (35.3)	**0.010**
No	166 (90.7)	55 (33.1)	111 (66.9)	
Contact dermatitis				
Yes	9 (4.9)	7 (77.8)	2 (22.2)	**0.012**
No	174 (95.1)	59 (33.9)	115 (66.1)	
Allergy				
Yes	52 (28.4)	22 (42.3)	30 (57.7)	0.268
No	131 (71.6)	44 (33.6)	87 (66.4)	

TABLE 2.

Symptom Experiences Related to Chemical Exposure among Cleaning Workers (N=183)

	Daily	Several times weekly	Several times monthly	Several times yearly	Never in the past 12 months
Symptoms	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Respiratory	15 (8.2)	17 (9.3)	24 (13.1)	32 (17.5)	95 (51.9)
Stuffy, itchy, or runny nose	7 (3.8)	13 (7.1)	15 (8.2)	31 (17.0)	117 (63.9)
Burning in nose or throat	5 (2.7)	2 (1.1)	7 (3.8)	22 (12.0)	147 (80.3)
Cough	3 (1.7)	7 (3.8)	9 (4.9)	32 (17.5)	132 (72.1)
Phlegm from chest	3 (1.6)	1 (0.6)	7 (3.8)	15 (8.2)	157 (85.8)
Chest tightness	1 (0.6)	2 (1.1)	8 (4.4)	11 (6.0)	161 (88.0)
Shortness of breath	3 (1.6)	3 (1.6)	6 (3.3)	14 (7.7)	157 (85.8)
Wheezing	3 (1.6)	2 (1.1)	2 (1.1)	7 (3.8)	169 (92.4)
Ocular	8 (4.4)	4 (2.2)	16 (8.7)	31 (16.9)	124 (67.8)
Watery, itchy, or burning eyes	4 (2.2)	5 (2.7)	15 (8.2)	25 (13.7)	134 (73.2)
Red eyes	5 (2.8)	1 (0.6)	5 (2.7)	21 (11.5)	150 (82.4)
Blurred or distorted vision	1 (0.6)	1 (0.6)	1 (0.6)	8 (4.4)	172 (94.0)
Dermal	5 (2.7)	2 (1.1)	4 (2.2)	24 (13.1)	148 (80.9)
Itchy or burning skin	3 (1.6)	1 (0.6)	4 (2.2)	22 (12.0)	153 (83.6)
Rash	4 (2.2)	3 (1.6)	0 (0)	14 (7.7)	162 (88.5)
Neurological	5 (2.7)	9 (4.9)	8 (4.4)	30 (16.4)	131 (71.6)
Headache	5 (2.7)	9 (4.9)	8 (4.4)	26 (14.2)	135 (73.8)
Dizziness or lightheadedness	2 (1.1)	4 (2.2)	2 (1.1)	13 (7.1)	162 (88.5)
Gastrointestinal	0 (0)	2 (1.1)	4 (2.2)	10 (5.5)	167 (91.3)
Nausea	0 (0)	2 (1.1)	4 (2.2)	10 (5.5)	167 (91.3)
Vomiting	0 (0)	0 (0)	0 (0)	5 (2.7)	178 (97.3)
Any symptom	24 (13.1)	15 (8.2)	27 (14.8)	37 (20.2)	80 (43.7)

TABLE 3.

Age and Sex Adjusted Associations Between Chemical-related Symptoms (Several Times Monthly or More Often) and Job Location, Job Title, and Area of Work Assignment Among Cleaning Workers (N=183)

	Chemical-related Symptoms			Respiratory Symptoms Only		
Variable	**Yes**	**No**	**OR (95% CIs)**	**Yes**	**No**	**OR (95% CIs)**
Job location						
Campus	11 (26.8)	30 (73.2)	1.00	11 (26.8)	30 (73.2)	1.00
Hospital	55 (38.7)	87 (61.3)	1.29 (0.57–2.91)	45 (31.7)	97 (68.3)	0.96 (0.42–2.18)
Job title						
Custodian, campus	11 (28.2)	28 (71.8)	1.00	11 (28.2)	28 (71.8)	1.00
Custodian, hospital	23 (35.9)	41 (64.1)	1.19 (0.48–2.94)	20 (31.3)	44 (68.7)	1.01 (0.40–2.50)
Patient support assistant, hospital	30 (44.1)	38 (55.9)	1.43 (0.58–3.53)	25 (36.8)	43 (63.2)	1.10 (0.44–2.75)
Supervisor, campus or hospital	2 (16.7)	10 (83.3)	0.49 (0.09–2.72)	0 (0)	12 (100)	-
Select area of work assignment *						
In-patient floor	29 (51.8)	27 (48.2)	**2.55 (1.28–5.08)**	25 (44.6)	31 (55.4)	**2.37 (1.18–4.75)**
Intensive care units	20 (54.1)	17 (46.0)	**2.53 (1.15–5.55)**	16 (43.2)	21 (56.8)	1.92 (0.87–4.22)
Out-patient clinics	17 (44.7)	21 (55.3)	2.04 (0.94–4.41)	13 (34.2)	25 (65.8)	1.55 (0.70–3.43)
Operating rooms	13 (32.5)	27 (67.5)	0.71 (0.32–1.56)	9 (22.5)	31 (77.5)	0.50 (0.21–1.21)
Non-surgical procedure rooms	16 (50.0)	16 (50.0)	2.05 (0.93–4.55)	13 (40.6)	19 (59.4)	1.76 (0.78–3.94)
Emergency department	6 (33.3)	12 (66.7)	1.04 (0.36–3.04)	5 (27.8)	13 (72.2)	0.98 (0.32–3.00)
Post-anesthesia care unit	3 (50.0)	3 (50.0)	2.46 (0.46–13.0)	3 (50.0)	3 (50.0)	3.07 (0.58–16.2)
Clinical or medical laboratories	21 (39.6)	32 (60.4)	1.57 (0.78–3.16)	18 (34.0)	35 (66.0)	1.56 (0.76–3.18)

* Categories are not mutually exclusive. More than one area can be assigned to workers. Those who do not work in the area were used as the reference group in the analysis.

TABLE 4.

Associations between Chemical-related Symptoms (Several Times Monthly or More Often) and Job Exposure[a] Among Cleaning Workers (N=183): Odds Ratios (95% CIs) Adjusted for Age, Sex, and Job Title (Reference=No/Low Exposure)

Variable	Chemical-related Symptoms		Respiratory Symptoms Only	
	Medium exposure	High exposure	Medium exposure	High exposure
Work Task				
Mixing or diluting cleaning solutions	0.85 (0.35–2.06)	1.04 (0.40–2.72)	0.78 (0.31–1.92)	0.92 (0.34–2.52)
Cleaning equipment after use	1.87 (0.72–4.88)	0.88 (0.31–2.47)	1.79 (0.65–4.92)	0.86 (0.28–2.61)
Dusting, sweeping, vacuuming	0.50 (0.17–1.43)	1.59 (0.69–3.67)	0.62 (0.20–1.91)	2.05 (0.84–5.05)
Mopping, wet cleaning, damp wiping	1.36 (0.52–3.61)	1.62 (0.58–4.55)	2.30 (0.74–7.17)	3.11 (0.94–10.3)
Buffing, polishing, waxing floors[b]	-	1.54 (0.67–3.52)	-	1.72 (0.73–4.06)
Stripping floors[b]	-	2.02 (0.81–5.01)	-	2.48 (0.96–6.45)
Cleaning windows or mirrors	1.13 (0.47–2.69)	1.17 (0.47–2.86)	1.51 (0.59–3.89)	1.57 (0.60–4.12)
Cleaning toilet bowls or sinks	1.37 (0.60–3.14)	1.56 (0.68–3.59)	1.71 (0.72–4.01)	1.96 (0.82–4.69)
Cleaning furniture	1.38 (0.59–3.20)	0.98 (0.42–2.27)	1.07 (0.44–2.61)	1.03 (0.43–2.44)
Cleaning tasks using sprays	**2.82 (1.16–6.82)**	1.79 (0.81–3.96)	**3.16 (1.24–8.04)**	1.98 (0.87–4.51)
Regular cleaning of patient rooms in use[b]	-	1.62 (0.68–3.83)	-	1.49 (0.60–3.71)
Discharge cleaning of patient rooms[b]	-	1.77 (0.74–4.25)	-	1.98 (0.77–5.11)
Cleaning isolation rooms[b]	-	1.10 (0.49–2.46)	-	1.19 (0.51–2.79)
Cleaning Product				
Liquid multi-use cleaning products	1.09 (0.49–2.43)	**2.58 (1.13–5.89)**	0.83 (0.35–1.95)	**2.35 (1.02–5.43)**
Polishes, waxes[b]	-	1.23 (0.57–2.65)	-	1.26 (0.57–2.79)
Disinfectants	1.00 (0.43–2.32)	0.80 (0.33–1.90)	0.67 (0.28–1.62)	0.72 (0.30–1.74)
Bleach	1.24 (0.55–2.80)	1.62 (0.71–3.72)	1.29 (0.55–3.04)	1.68 (0.70–4.01)
Solvents, stain removers	1.92 (0.84–4.39)	**2.71 (1.20–6.15)**	1.38 (0.59–3.23)	2.29 (0.99–5.26)
Glass cleaning products	1.77 (0.76–4.15)	2.01 (0.89–4.53)	1.34 (0.55–3.27)	1.96 (0.85–4.54)
Products for mopping the floor	0.94 (0.41–2.15)	1.45 (0.60–3.50)	0.75 (0.32–1.76)	1.06 (0.43–2.59)
Products for cleaning carpets[b]	-	**2.98 (1.28–6.92)**	-	**2.33 (1.00–5.43)**

Variable	Chemical-related Symptoms		Respiratory Symptoms Only	
	Medium exposure	High exposure	Medium exposure	High exposure
Furniture sprays[b]	-	1.78 (0.78–4.07)	-	1.50 (0.63–3.56)
Products that smell like lemon or orange[b]	-	**2.16 (1.03–4.51)**	-	2.04 (0.96–4.33)
Products combined immediately before use[b]	-	1.29 (0.53–3.11)	-	0.59–3.69)

[a] No/Low, medium, or high exposures were categorized by tertile split of the frequency of exposure (days per week X hours per day)

[b] As most cases (66% to 84%) had no exposure to the task or product, the variables were dichotomized. High exposure indicates having any exposure.

TABLE 5.

Safe Work Practices Among Cleaning Workers

Variable	% Compliance: All the time or most of the time[a]				
	All (N=183)	Job location		Chemical-related symptoms	
		Hospital (n=142)	Campus (n=41)	Yes (n=66)	No (n=117)
Chemical safety behavior					
I follow safety rules at work	97.8	97.9	97.6	96.9	98.3
When I use a new cleaning product, I read the label of the product	91.2	90.7	92.7	87.9	93.0
I follow the directions of cleaning products	96.2	96.5	95.1	93.9	97.4
I do not mix cleaning products to make them stronger[b]	87.6	86.0	92.7	87.9	87.4
I do not use concentrated products without diluting them to make them stronger[b]	90.5	88.4	97.6	93.9	88.5
I wash my hands before eating, drinking or smoking	99.5	99.3	100	100	99.2
When I get chemicals on my skin, I wash my skin immediately	98.9	98.6	100	100	98.3
When I use chemicals to clean an area, I ventilate the space with any available methods	80.8	80.2	82.9	80.0	81.3
Use of PPE while handling chemicals					
Gloves	98.4	98.6	97.6	100	97.4
Surgical Mask	37.2	43.7	14.6	39.4	35.9
Safety goggle or glass	28.4	35.2	4.9	31.8	26.5
Long sleeve clothing	26.2	27.5	22.0	30.3	23.9
Face shield	15.9	20.4	0	16.7	15.4
Rubber apron	3.3	3.5	2.4	4.6	2.6

[a] Answer categories also included never, rarely, and sometimes.

[b] The original wording in the questionnaire was in a reverse direction.

TABLE 6.

Associations Between Safe Work Practice and Chemical-related Symptoms (Several Times Monthly or More Often) Among Cleaning Workers (N=183)

Variable	Chemical-related symptoms		OR (95% CIs) adjusted for age, sex, and job title
	Yes	No	
Safety glass or goggle	**Ocular**		
All the time/most of the time	12 (23.1)	40 (76.9)	1.41 (0.52–3.80)
Never/rarely/sometimes	16 (12.2)	115 (87.8)	
Long sleeve clothing	**Dermal**		
All the time/most of the time	3 (6.3)	45 (93.8)	1.10 (0.27–4.53)
Never/rarely/sometimes	8 (5.9)	127 (94.1)	
Surgical mask	**Respiratory or neurological**		
All the time/most of the time	24 (35.3)	44 (64.7)	1.08 (0.53–2.20)
Never/rarely/sometimes	37 (32.2)	78 (63.9)	
Ventilate the space when using chemicals	**Respiratory or neurological**		
All the time/most of the time	48 (33.6)	95 (66.4)	0.77 (0.33–1.76)
Never/rarely/sometimes	12 (35.3)	22 (64.7)	