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Major Article

Health problems and disinfectant product exposure among staff at a large multispecialty hospital

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Background: Hospital staff expressed health concerns after a surface disinfectant product containing hydrogen peroxide, peracetic acid, and acetic acid was introduced. We sought to determine if this product posed a health hazard.

Methods: An interviewer-administered questionnaire on work and health characteristics was completed by 163 current staff. Symptoms that improved away from work were considered work-related. Forty-nine air samples were taken for hydrogen peroxide, peracetic acid, and acetic acid. Prevalence ratios (PRs) were calculated using Poisson regression, and standardized morbidity ratios (SMRs) were calculated using nationally representative data.

Results: Product users reported higher prevalence of work-related wheeze and watery eyes than non-users ($P < .05$). Workers in the department with the highest air measurements had significantly higher prevalence of watery eyes (PR, 2.88; 95% confidence interval [CI], 1.18-7.05) than those in departments with lower air measurements, and they also had a >3-fold excess of current asthma (SMR, 3.47; 95% CI, 1.48-8.13) compared with the U.S. population.

Conclusions: This disinfectant product was associated with mucous membrane and respiratory health effects. Risks of mucous membrane irritation and asthma in health care workers should be considered in development of disinfection protocols to protect patients from hospital-acquired infections. Identification of optimal protocols that reduce worker exposures while maintaining patient safety is needed.

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Health care–associated infections (HAIs) remain a significant challenge to health care facilities in the United States. On any given day, approximately 1 in 25 hospital patients has at least 1 HAI.[1] One of the most significant challenges to preventing HAIs is *Clostridium difficile* bacteria, which has replaced methicillin-resistant *Staphylococcus aureus* as the most common cause of HAI.[2] Hospitalized patients acquire *C difficile* by ingesting spores transmitted from other patients through health care workers or from contact with contaminated surfaces in hospital rooms.[3,4] Eliminating *C difficile* spores in the hospital environment requires the use of disinfectants that are sporicidal. Sporicides that are effective at reducing the environmental burden of *C difficile* may also contain chemicals that cause health effects for cleaning staff and other hospital workers.

Several studies have identified cleaning as an occupational risk factor for asthma among health care workers.[5-8] There are a number of chemicals in cleaning and disinfecting products that can cause or exacerbate asthma because of their sensitizing or irritant properties, including quaternary ammonium compounds, ethanolamines, chlorhexidine, glutaraldehyde, ortho-phthalaldehyde, hexachlorophene, and chloramine-T.[9-17] In addition, dermatitis and other adverse skin effects have been reported among hospital cleaning workers.[18] However, some health care workers may underestimate their exposure or may lack knowledge of product components.[19] There is no national surveillance of health effects related to cleaning and disinfection product use. In 4 states with occupational health surveillance, a total of 401 acute illnesses associated with work-related antimicrobial pesticide exposures in health care facilities were reported during 2002-2007. The most commonly reported health effects were eye irritation (55%), headaches or other neurologic symptoms (32%),

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Conflicts of interest: None to report.

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respiratory symptoms (30%), and skin problems (24%). Among these reports, environmental service staff (EVS), who are largely responsible for cleaning and disinfection in health care facilities, was the most common occupation reporting health effects at 24%.[20]

In January 2015, the Centers for Disease Control and Prevention's National Institute for Occupational Safety and Health (NIOSH) was notified through their Health Hazard Evaluation program of eye, respiratory, and skin problems among hospital EVS staff thought to be related to disinfectant use in a hospital. The hospital had introduced a new disinfectant product containing hydrogen peroxide, peracetic acid, and acetic acid in March 2014 to mitigate HAIs. We conducted a health hazard evaluation to assess if this disinfectant posed a health hazard to EVS and other hospital staff.

METHODS

An interviewer-administered questionnaire was offered to all EVS staff and an equal number of non-EVS staff on duty during the days of our visits. Non-EVS staff were recruited from the same departments of the hospital where EVS staff were located. Questions addressed self-reported respiratory and dermatologic symptoms, asthma and other diagnoses, smoking history, work history and practices, and demographic information. Participants ever having asthma were defined as those who were ever told by a physician or health care provider that they had asthma. Current asthma was defined as physician-diagnosed asthma that was still present. Some of these questions were taken from the Third National Health and Nutrition Examination Survey[21] and the European Community Respiratory Health Survey.[22] Asthma-like symptoms were defined as a response of yes to any of the following questions[22]:

1. Are you currently taking any medicine (including inhalers, aerosols, or tablets) for asthma?
2. Have you had wheezing or whistling in your chest at any time in the last 12 months?
3. Have you woken up with a feeling of tightness in your chest at any time in the last 12 months?
4. Have you been woken by an attack of asthma at any time in the last 12 months?

Symptoms that improved when the employees were away from work, either on their days off or when they were on vacation, were considered work-related.

We collected 49 full-shift air samples from the breathing zones of EVS staff while they performed their regular cleaning duties. Details of the air sampling and air sample results are reported in Hawley et al.[23] All air samples were analyzed for the 3 chemicals found in the disinfectant: hydrogen peroxide, peracetic acid, and acetic acid.

Statistical analyses were conducted using SAS software version 9.3 (SAS Institute, Cary, NC). Statistically significant differences between demographic characteristics, symptoms, and diagnoses were assessed using Student t test for continuous variables and χ^2 test for categorical variables. We used Fisher exact test when cell sizes were <5. We considered results to be statistically significant when $P \leq .05$ using a 2-sided test, and 95% confidence intervals were calculated.

Incidence densities of self-reported adult-onset asthma diagnosed by a physician before and after hire at the hospital were estimated using birth date, hire date, and diagnosis date. Asthma incidence density before hire was calculated by adding the number of adult-onset asthma diagnoses that occurred before hire and dividing by the sum of participants' years at risk before hire. Asthma incidence density after hire was calculated by adding the number of adult-onset asthma diagnoses that occurred after hire and dividing by the sum of participants' time at risk after hire. An incidence density ratio was calculated using Poisson regression.

We compared the observed prevalence of shortness of breath, cough, wheeze, watery eyes, and doctor-diagnosed asthma among participants to expected values for the general U.S. adult population obtained from the Third National Health and Nutrition Examination Survey. For these comparisons, we calculated standardized morbidity ratios (SMRs) using indirect standardization for race (white, black, or Mexican-American), sex, age (17-39 years or ≥40 years), and cigarette smoking status (ever vs never smoker).[21]

Among the participants who worked in a department where air sampling was performed, we evaluated associations between symptoms and department-level air measurements by calculating prevalence ratios using Poisson regression. Concentrations of hydrogen peroxide, peracetic acid, and acetic acid from personal air samples were used in the American Conference of Governmental Industrial Hygienists' (ACGIH) additive mixture formula. We used this formula to categorize departments by their total mixture of hydrogen peroxide, peracetic acid, and acetic acid.[24] This formula takes the measured parts per million (ppm) concentrations of hydrogen peroxide and acetic acid and divides them by their established Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) and NIOSH recommended exposure limits (RELs) of 1 ppm for hydrogen peroxide and 10 ppm for acetic acid. Measured ppm concentrations of peracetic acid were divided by the occupational exposure limits proposed by multiple researchers, of 0.2 ppm.[25-27] Hydrogen peroxide [HP], peracetic acid [PAA], and acetic acid [AA] represent the measured full-shift time weighted average. ACGIH mixture formula results <1 are considered to be below the threshold limit value where adverse effects may occur.

$$ACGIH\ Mixture\ Formula = \frac{[HP]}{1\ ppm} + \frac{[PAA]}{0.2\ ppm} + \frac{[AA]}{10\ ppm}$$

The mixture values derived from the formula were averaged using arithmetic means calculated by the hospital department where the survey participant was assigned. Based on this department-level value of the ACGIH mixture formula, 9 departments were categorized into tertiles of low (≤0.075), medium (>0.075 to ≤0.190), and high (>0.190) exposure categories. Prevalence ratios were calculated by comparing the single department with the highest ACGIH value, departments in the high category, and departments in the medium category to departments in the low category.

RESULTS

A total of 163 current employees, including 78% (n = 79/101) of EVS staff who were working on the days of the survey, completed the questionnaire. Five EVS staff refused to participate. Hospital supervisors and charge nurses assisted in pulling non-EVS staff from their duties to participate in the survey. As a result, there were no non-EVS staff who refused to participate. Non-EVS staff included nursing staff (n = 27); other patient care staff (n = 25), such as patient care technicians, respiratory therapists, and nursing assistants; administrative staff (n = 13), such as business managers and unit clerks; and other hospital staff (n = 19), such as cooks, dietitians, and laboratory staff. Table 1 describes the demographic and work characteristics of questionnaire participants.

EVS staff represented 48% (n = 79/163) of questionnaire participants. EVS and Non-EVS staff were similar regarding age, tenure, and smoking status. Men were significantly ($P < .05$) more represented among EVS staff than non-EVS staff, representing roughly half (49%, n = 39/79) of EVS participants. Most non-EVS staff were white (85%, n = 71/84), whereas most EVS staff were black (59%, n = 47/79). Differences in race were statistically significant ($P < .05$) (Table 1).

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