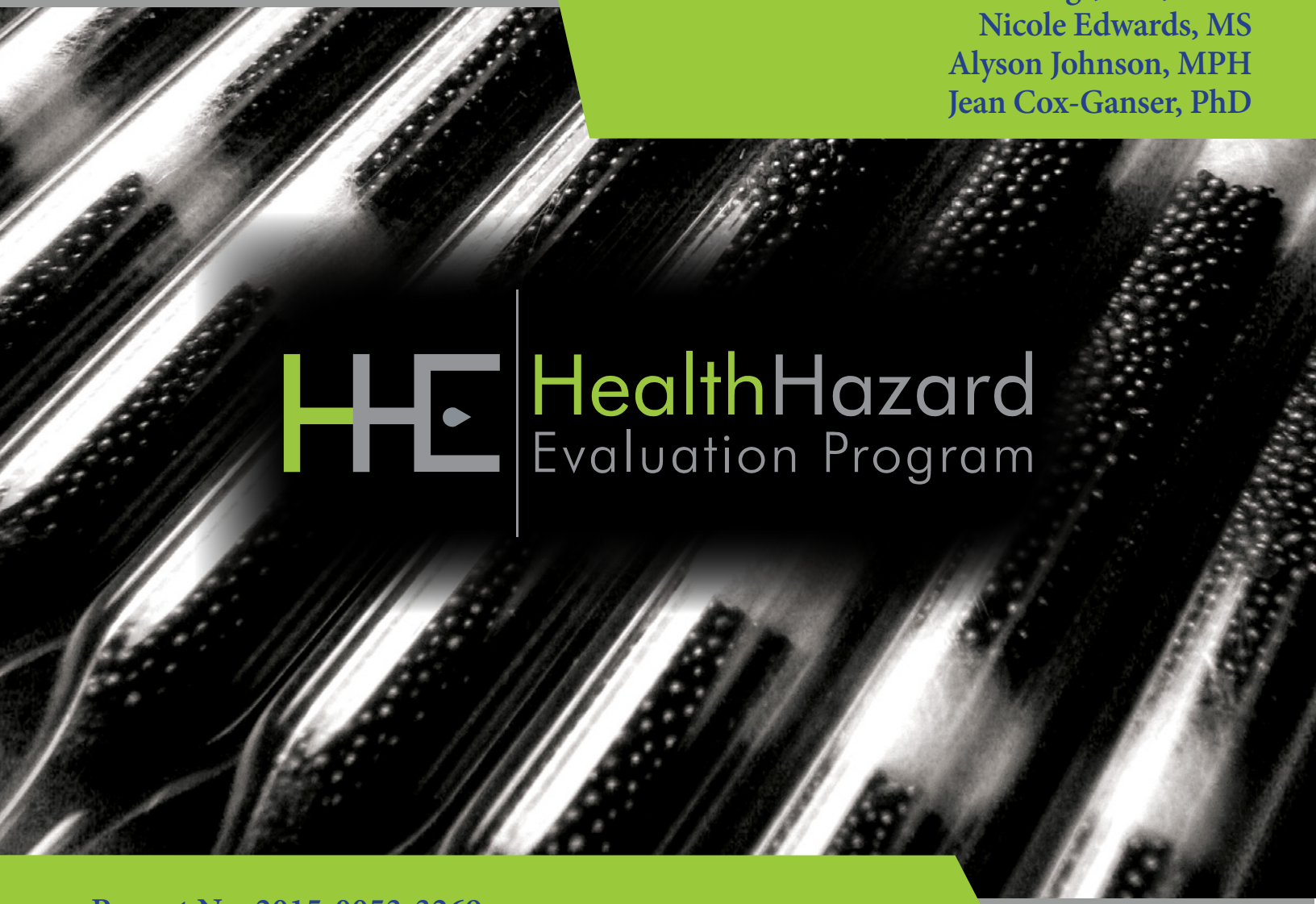
Evaluation of exposure to a new cleaning and disinfection product and symptoms in hospital employees

Brie Hawley, MS, PhD
Megan Casey, RN, BSN, MPH
Kristin Cummings, MD, MPH
Nicole Edwards, MS
Alyson Johnson, MPH
Jean Cox-Ganser, PhD



HHE Health Hazard Evaluation Program

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Contents

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation.

Highlights of this Evaluation

The Health Hazard Evaluation Program received a confidential employee request for the National Institute for Occupational Safety and Health to conduct a health hazard evaluation at a hospital. The request cited concerns about exposure of hospital employees to the sporicidal disinfectant, OxyCide, and described symptoms experienced by employees. Employee symptoms noted in the health hazard evaluation request included burning eyes, nose, and throat; runny nose; cough; headache; dizziness; nausea; nose bleeds; asthma exacerbation; skin burns; and rashes.

What We Did

- We visited the hospital in April 2015 to observe cleaning staff while they performed their regular cleaning duties and to talk with them about cleaning product use and any related health concerns.
- We collected 11 bulk samples of the diluted OxyCide in April 2015.
- We discussed the process for recording work-related injuries and illnesses with representatives from occupational health in April 2015.
- We returned in July 2015 to perform air sampling on a small number of environmental services employees. We collected full-shift and cleaning task-based personal time-weighted average air samples on 5 employees and analyzed the samples for hydrogen peroxide, peracetic acid, and acetic acid content.
- We also administered a post-shift survey of acute symptoms to the five environmental services staff who wore full-shift samplers in July 2015.
- We returned in August and September 2015 to administer a health and work history questionnaire to a total of 163 hospital employees, 79 of whom were environmental services staff.
- In September 2015, we collected an additional 45 full-shift personal air samples on

We evaluated employee health concerns and exposures to the three main chemicals, hydrogen peroxide, peracetic acid, and acetic acid, found in the sporicidal disinfectant OxyCide. Hydrogen peroxide, peracetic acid, and acetic acid were detected in all full-shift air samples. We observed upper airway, eye, and lower airway symptoms in staff exposed to vapors from OxyCide. We recommend that management tailor the use of sporicidal disinfectants like OxyCide to areas of high risk for healthcare-acquired infections and minimize the use of sporicidal disinfectants on noncritical surfaces and in non-patient areas. We also recommend that management provide workplace accommodations for employees who develop symptoms related to the use of sporicidal disinfectants like OxyCide. Additionally, we provide several means to reduce employee exposure to OxyCide.

environmental services staff and observed staff while they performed their regular cleaning duties. We also administered a post-shift survey of acute symptoms to the 45 environmental services employees who participated in air sampling. We combined results from the September 2015 post-shift surveys of acute symptoms with the five post-shift surveys collected in July 2015 for a total of 50 post-shift surveys.

- We performed an assessment of the heating, ventilation and air-conditioning systems in place in September 2015.
- In April 2016, we provided a report with our interim findings and recommendations.

What NIOSH Found

- We found that OxyCide is used predominantly by environmental services staff and that nursing and ancillary staff predominantly use PDI® or bleach wipes for routine point-of-care cleaning activities.
- We observed environmental services employees using OxyCide on surfaces throughout the hospital, including patient rooms, patient bathrooms, operating rooms, and public bathrooms.
- We observed pH measurements of the diluted OxyCide product that ranged from 2.85-4.86. The product's safety data sheet indicates that OxyCide should be diluted to a pH of 3.
- We noted that some environmental services staff reported that there was no ventilation in some of the bathrooms that they cleaned. Several environmental services staff mentioned that their symptoms were worse when performing cleaning duties in the bathrooms, especially in the shower stalls.
- We observed that the environmental services staff cleaning closets in the 3100 and 5300 units had no supply or return airflow.
- Several employees reported previous OxyCide splashes and spills that resulted in skin or eye irritation.
- We observed that the log of work-related injuries and illnesses (Occupational Safety and Health Administration's Form 300) is maintained and generated by a third-party claims administrator that handles workers' compensation claims for the hospital, which could lead to underestimation of work-related injuries and illnesses.
- We did not observe a comprehensive system for reporting and tracking workplace injuries and illnesses that includes reports of near-misses, minor injuries and illnesses, and employee safety concerns.
- We found that employees using OxyCide reported respiratory symptoms that came on during their shift.
- We detected hydrogen peroxide, peracetic acid, and acetic acid in all full-shift air samples.
- We found that increased exposure to hydrogen peroxide, peracetic acid, and acetic acid

vapors was associated with increases in acute work-related nasal and eye symptoms and with increased shortness of breath on level ground reported by cleaning staff.

What the Employer Can Do

- Minimize the use of sporicidal disinfectants like OxyCide in non-patient care areas.
- Ensure that OxyCide dispensers are calibrated to effectively dilute the product to a pH of 3. If OxyCide is not effectively diluted, a pH of less than 3 may increase skin, eye, and respiratory symptoms in exposed employees.
- Require lids for all OxyCide buckets to minimize generation of hydrogen peroxide, peracetic acid, and acetic acid vapors that can be inhaled.
- Ensure that employees use only rags and wipes to apply OxyCide to surfaces and that OxyCide is not used as a spray.
- Require employees to wear extended cuff nitrile gloves or rubber gloves when using OxyCide and goggles or a face shield while dispensing and pouring OxyCide into or out of the bucket on their cleaning cart.
- Ensure that all heating, ventilation, and air-conditioning systems meet all ASHRAE standards. Specifically, ensure that additional airflow is provided to EVS closets in the 3100 and 5300 units to meet the ASHRAE requirement of a minimum of 10 air changes per hour.
- Ensure that all patient bathrooms meet minimum total air changes per hour as specified by ASHRAE. ASHRAE standard 2013-170 requires inpatient bathrooms to have at least 10 air changes per hour.
- Review the process for Occupational Safety and Health Administration Form 300 reporting and maintenance to assure that all reportable injuries are recorded, regardless of whether a workers' compensation claim is filed.
- Consider implementing a comprehensive system for reporting and tracking workplace injuries and illnesses that includes reports of near-misses, minor injuries and illnesses, and employee safety concerns. This information should be reviewed by the Safety Officer on a regular basis to identify hazards, implement risk-reduction strategies, and prevent significant injuries and illnesses.
- Provide workplace accommodations to employees who develop work-related symptoms after exposure to OxyCide. Consider relocating employees who develop work-related symptoms to areas of the hospital where sporicidal disinfectants like OxyCide are used less frequently.

What Employees Can Do

- Report patient rooms or bathrooms with no ventilation or airflow to your manager.
- Wear extended cuff nitrile gloves or rubber gloves when using OxyCide and goggles or

a face shield when dispensing and pouring OxyCide into or out of the bucket on your cleaning cart.

- Do not use a spray bottle to apply OxyCide to surfaces. Spraying OxyCide can generate mists that can be hazardous for you to breathe.
- Keep a lid on the OxyCide bucket whenever possible to minimize the generation of hydrogen peroxide, peracetic acid, and acetic acid vapors that can be inhaled.
- Report new, persistent, or worsening symptoms to your personal healthcare provider and, as instructed by your employer, to a designated individual at your workplace.

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Abbreviations

AA	Acetic acid
ACGIH®	American Conference of Governmental Industrial Hygienists
AHU	Air-handling unit
cc	Cubic centimeters
CFR	Code of Federal Regulations
CI	Confidence interval
EPA	U. S. Environmental Protection Agency
EVS	Environmental Services
°F	Degrees Fahrenheit
HICPAC	Healthcare Infection Control Practices Advisory Committee
HP	Hydrogen peroxide
HVAC	Heating, ventilation, and air-conditioning
ICU	Intensive care unit
mL/min	Milliliters per minute
NIOSH	National Institute for Occupational Safety and Health
NHANES	National Health and Nutrition Examination Survey
NICU	Neonatal intensive care unit
OM	Oxidant exposure mixture
OR	Odds Ratio
OSHA	Occupational Safety and Health Administration
PAA	Peracetic acid
PEL	Permissible exposure limit
PPE	Personal protective equipment
ppm	Parts per million
ppb	Parts per billion
PR	Prevalence ratio
REL	Recommended exposure limit
SMR	Standardized morbidity ratio
STEL	Short-term exposure limit
TCU	Transitional care unit
TM	Total mixture
TWA	Time-weighted average
TLV®	Threshold limit value
WCBC	Womancare birth center

Summary

The National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request to conduct a health hazard evaluation at a hospital. The request cited concerns about exposure of hospital employees to the sporicidal disinfectant, OxyCide, and described symptoms experienced by employees. Employee symptoms noted in the health hazard evaluation request included burning eyes, nose, and throat; runny nose; cough; headache; dizziness; nausea; nose bleeds; asthma exacerbation; skin burns; and rashes.

We performed a walk-through assessment of cleaning product use at the hospital on April 9, 2015, and informally interviewed employees about their cleaning product use and any related health concerns that they may have had. We learned that OxyCide was used predominantly by environmental services staff and that nursing and ancillary staff predominantly used PDI® or bleach wipes for routine point of care cleaning activities. We observed that OxyCide was the main cleaning product used by environmental services staff for all surface cleaning duties. Environmental services staff were observed occasionally using other asthmagen-containing products including products containing ethanolamines, bleach, or quaternary ammonium compounds when cleaning glass, general surfaces, or bathroom surfaces. Asthmagens are substances capable of causing asthma.

On July 29, 2015, we performed a small-scale air sampling and a post-shift survey of environmental services staff. We collected ten samples, including full-shift, task-based, and 15-minute exposure samples, from employees' breathing zones while they performed regular cleaning tasks. All samples were analyzed for the three chemicals found in OxyCide: hydrogen peroxide, peracetic acid, and acetic acid. All 15-minute air samples for acetic acid were below the NIOSH recommended short-term exposure limit of 15 parts per million (ppm). All 15-minute and task-based exposure air samples for hydrogen peroxide and peracetic acid were below the limit of detection for the instrument used to detect the analyte. The limit of detection 4 µg of hydrogen peroxide per sample and 2 µg of peracetic acid per sample. We combined all full-shift time-weighted average samples and post-shift survey results from the small-scale survey on July 29 with the results from our full environmental survey from September 8-11, 2015.

We returned in August 2015 and administered a voluntary health and work history questionnaire to 79 environmental services staff and 84 non-environmental services staff for a total of 163 hospital employees. Non-environmental services staff were recruited from the same areas and departments of the hospital where environmental services staff were located. Questions addressed respiratory and dermatological symptoms, asthma and other diagnoses, smoking history, work history and practices, and demographic information.

On September 8-11, 2015, we returned to perform full-shift air sampling on environmental services staff performing cleaning activities. We collected 45 full-shift air samples for hydrogen peroxide, peracetic acid, and acetic acid from the daylight, evening,

and night shift environmental services staff. We also administered a voluntary post-shift survey identical to the post-shift survey used in July 2015 to all staff who participated in the air sampling survey. We observed environmental services staff while they performed their regular cleaning duties and noted task duration, cleaning product use and duration, and use of any personal protective equipment. We also assessed the ventilation systems in areas of the hospital where frequent cleaning was observed.

The highest full-shift time-weighted average exposures to hydrogen peroxide, peracetic acid, and acetic acid were observed in the Womancare Birth Center, Birth Center Triage, Birth Center Operating Rooms, and the Medical-Surgical areas. Full-shift time-weighted average exposure levels for hydrogen peroxide, peracetic acid, and acetic acid ranged from 5.5 parts per billion (ppb) – 511.4 ppb for hydrogen peroxide, 1.1 ppb – 48.0 ppb for peracetic acid, and 6.7 ppb – 530.3 ppb for acetic acid. No full-shift samples were below the limit of detection. All full-shift time-weighted average air samples for hydrogen peroxide and acetic acid were below established U.S. occupational exposure limits. The OSHA permissible exposure limit and NIOSH recommended exposure limit is 1 ppm for hydrogen peroxide and 10 ppm for acetic acid. To date, no full-shift time-weighted average occupational exposure limit for peracetic acid has been established in the United States.

The most commonly reported symptoms in the health and work history questionnaire were nasal problems and watery eyes. Forty-two percent of health and work history questionnaire participants reported nasal problems and 40% of all questionnaire participants reported watery eyes. Other commonly reported health outcomes included, asthma-like symptoms (28%), skin problems (19%), and wheeze (16%). Among reported symptoms, some were described to be work-related, as they improved away from the facility. OxyCide users reported higher prevalence of work-related health outcomes including cough, shortness of breath, asthma-like symptoms, asthma attack, use of asthma medicine, asthma symptoms, use of allergy medicine, nasal problems, and skin problems, with wheeze and watery eyes being significantly higher in OxyCide users than non-users.

Nasal and eye irritation were also the most frequently reported symptoms in the post-shift survey of acute symptoms. We observed increases in work-related acute upper and lower airway symptoms in employees exposed to hydrogen peroxide, peracetic acid, and acetic acid vapors. Increased exposure to hydrogen peroxide, peracetic acid, and acetic acid was significantly associated with increases in acute nasal and eye irritation. For employees who participated in our air sampling survey as well as the health and work history questionnaire, shortness of breath on level ground was also significantly associated with increased exposure to hydrogen peroxide, peracetic acid, and acetic acid.

We provide several means to reduce employee exposure to OxyCide. We recommend that management customize the use of sporicidal disinfectants like OxyCide to areas of high risk for healthcare-acquired infections and minimize the use of sporicidal disinfectants on non-critical surfaces and in non-patient areas. We also recommend that management pro-

vide workplace accommodations for employees who develop symptoms related to the use of sporicidal and high-level disinfectants. Management should also ensure that all heating, ventilation, and air-conditioning systems are functioning well and meet all applicable ASHRAE standards. Additional details and recommendations to reduce employee exposure to OxyCide liquids, vapors, and mists are provided in this report.

Introduction

The National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request to conduct a health hazard evaluation at a hospital. The request cited concerns about exposure of hospital employees to the sporicidal disinfectant, OxyCide, and described symptoms experienced by employees. Employee symptoms noted in the health hazard evaluation request included burning eyes, nose, and throat; runny nose; cough; headache; dizziness; nausea; nose bleeds; asthma exacerbation; skin burns; and rashes.

In response to the health hazard evaluation request, we performed a walk-through assessment of cleaning product use at the hospital in April 2015, and informally interviewed employees about their cleaning product use and any related health concerns that they may have had. We learned that OxyCide is a one-step sporicidal disinfectant that consists of hydrogen peroxide (HP), peracetic acid (PAA), and acetic acid (AA). The product is diluted with water prior to use to a pH of 3. We observed that OxyCide was the main cleaning product used for all surface cleaning duties and was used predominantly by Environmental Services (EVS) staff. We also noted that EVS staff occasionally used other asthmagen-containing products, to include products containing ethanolamines, bleach, or quaternary ammonium compounds when cleaning glass, general surfaces, or bathroom surfaces. Asthmagens are substances capable of causing asthma.

In July 2015, we performed a small-scale air sampling and post-shift survey of EVS staff.

In August 2015, we administered a voluntary health and work history questionnaire to hospital employees. In September 2015, we returned to the hospital to perform a full-shift air sampling survey and collect air samples from employees performing cleaning activities.

We also administered a voluntary post-shift survey identical to the post-shift survey used in July 2015, to all staff who participated in the September air sampling survey. We observed EVS staff during both the July and September air sampling surveys, while they performed their regular cleaning duties and noted task duration, cleaning product use and duration, and use of any personal protective equipment. Additionally in September 2015, we performed an assessment of the heating, ventilation and air-conditioning (HVAC) systems in place during the September 2015 survey.

In this report, we summarize the results from our environmental survey and HVAC assessment. We also summarize results from the health and work history questionnaire and post-shift survey of acute symptoms. Additionally, we provide recommendations to help protect the health of employees. We previously mailed letters with interim results and recommendations in May and October of 2015, and April of 2016.

Process Description

The hospital that is the subject of this health hazard evaluation is primarily a women's hospital, and specializes in obstetrics and gynecology services for women. The hospital also offers medical and surgical services for both women and men. Beginning in March and April of 2015, OxyCide was used by EVS staff as the primary sporicidal disinfectant for all surface cleaning duties throughout the hospital. Environmental services staff were the primary housekeeping staff and performed cleaning duties and tasks in areas throughout the hospital. Other healthcare personnel, such as nursing and ancillary staff, performed occasional surface cleaning tasks, such as wiping down medical equipment in occupied patient rooms, as part of routine point-of-care cleaning activities. OxyCide was used predominantly by environmental services staff and nursing and ancillary staff predominantly used PDI® or bleach wipes for routine cleaning activities.

Methods

Measurement of pH of diluted product samples in April 2015
During the walkthrough assessment in April 2015, we collected bulk samples of diluted OxyCide product from multiple hospital units. Bulk samples of the diluted OxyCide product were collected to assess the Oxycide dispenser calibration. Dispenser calibration was assessed by measuring diluted OxyCide product pH less than 12 hours after collection. Samples were kept capped and stored at room temperature (21°C−23°C). Measurements of sample pH were taken using a pH meter (Fisher Scientific International Inc., Hampton, NH).

Air Sampling Survey and HVAC Assessment in July and September 2015
We performed a pilot air sampling survey of EVS staff performing cleaning tasks on July 29, 2015. We collected five full-shift, one task-based, and four 15-minute exposure samples from daylight shift employees' breathing zones while they performed regular cleaning tasks. On September 8-11, 2015, we performed a larger air sampling survey and collected 45 additional full-shift samples on daylight, evening, and night shift employees. Thirty-six of the full-shift samples were collected from employees' breathing zones while they performed their regular cleaning duties. Nine of the samples collected in September were moving area samples. For the moving area samples, we followed employees while they performed their cleaning duties and placed the samplers near EVS staff while they were cleaning. We also performed an assessment of HVAC systems in place as of September 2015. Additionally, we observed staff while they performed their regular cleaning duties and noted task duration, cleaning product use and duration, and use of any personal protective equipment.

All air samples were analyzed for the three chemicals found in OxyCide: HP, PAA, and AA. HP and PAA were collected and analyzed according to the methods specified by Hecht et al. [2004]. AA was collected and analyzed according to the Occupational Safety and Health Administration (OSHA) Method PV2119 [OSHA 2003]. Results from the July and September 2015 air sampling surveys were combined and are summarized in the Results section.

Post-Shift Survey of Acute Symptoms in July and September 2015
We administered a voluntary post-shift survey in July and September 2015 that asked if employees had experienced acute symptoms during their shift as follows: (1) burning, itchy, runny nose; (2) sneeze; (3) burning, itchy, watery eyes; (4) burning, dry, sore throat; (5) cough; (6) wheeze; (7) chest tightness; (8) shortness of breath; (9) difficulty breathing; and (10) dizziness. When employees reported symptoms that occurred during their work shift, we asked (1) if their symptom had worsened during their shift; (2) what they were doing when the symptom first began; and (3) if they had that symptom upon arrival at work that day. Work-related symptoms were defined as symptoms that occurred during the participants' shift that were not present upon arrival at work that day. Results from the July and September 2015 post-shift surveys were combined and are summarized in the Results section.

Health and Work History Questionnaire
We administered a voluntary health and work history questionnaire to hospital employees in August and September 2015. We aimed to offer the health and work history questionnaire to all EVS staff working the week of our visit, and an equal number of non-EVS staff in the same departments. Non-EVS staff were recruited from the same areas and departments of the hospital where EVS staff were located. Questions addressed eye, respiratory, and dermatological symptoms; asthma and other diagnoses; smoking history; work history and practices; and demographic information. Questions regarding respiratory symptoms and asthma were taken from the Third National Health and Nutrition Examination Survey (NHANES III) [CDC 1996] and the European Community Respiratory Health Survey [Burney et al. 1994; ECRHS 2014].

We defined asthma-like symptoms as a response of "yes" to any of the following questions [Grassi et al. 2003]:

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.

Statistical Analyses

<u>Comparison of Pre-hire and Post-hire Onset Asthma</u>
The incidence densities of self-reported adult-onset asthma diagnosed by a physician before and after hire 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 total number of participants' adult 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 total

number of participants' years at risk after hire. An incidence ratio was calculated using Poisson regression.

Comparison to U.S. Population

We compared the observed prevalence of symptoms and diagnoses among participants to expected values for the U.S. adult population obtained from NHANES III. To compare the survey participants to the U.S. adult population, we calculated Standardized Morbidity Ratios (SMRs) using indirect standardization for race (White, Black, or Mexican-American), sex, age (range: 17 to 39 years or ≥ 40 years), and cigarette smoking status (ever vs. never smoker) [CDC 1996].

Health Outcomes and Exposure Metrics Associations: EVS vs. Non-EVS and OxyCide Use vs. Non-OxyCide Use

Statistical significance was assessed using t-test for continuous variables and chi-square test for categorical variables. We used Fisher's exact test when cell sizes were less than 5. We considered two-sided $p \leq 0.05$ to be statistically significant. Prevalence ratios were calculated for symptoms and diagnoses using Poisson regression.

Associations Between Acute and Chronic Health Outcomes and Exposure Metrics: Individual Level Exposure

We explored associations between employee's personal exposure to HP, PAA, and AA and work-related acute symptoms and symptoms occurring in the last 12 months using log-binomial regression. We used the American Conference of Governmental Industrial Hygienists' (ACGIH) Additive Mixture Formula to create mixture exposure groups for the total mixture (TM) of HP, PAA, and AA as well as the oxidant exposure mixture (OM) of HP and PAA [ACGIH 2016]. Measured ppm concentrations of HP and AA were divided by their established OSHA Permissible Exposure Limit (PEL) and NIOSH Recommended Exposure Limit (REL) of 1 ppm for HP and 10 ppm for AA (Equations 1 and 2). Measured ppm concentrations of PAA were divided by 0.2 ppm, the occupational exposure limit proposed by multiple researchers [Gagnaire et al. 2002; Pechacek et al. 2015; Pacenti et al. 2010]. TM and OM exposure was determined using Eq. (1) and (2),

$$TM = \frac{[HP]}{1\ ppm} + \frac{[PAA]}{0.2\ ppm} + \frac{[AA]}{10\ ppm} \quad (1)$$

$$OM = \frac{[HP]}{1\ ppm} + \frac{[PAA]}{0.2\ ppm} \quad (2)$$

where [HP], [PAA], and [AA] represent the measured full-shift TWA concentrations for HP, PAA, and AA. The summed values from the additive formula were divided into tertiles to create TM and OM exposure variables with low, medium, and high exposure categories. TM and OM exposure variables were used for exposure and health outcome analyses.

SAS PROC GENMOD's log-binomial regression was used to calculate prevalence ratios and 95% confidence intervals for acute and chronic symptoms associated with individual level exposure. TM exposure was analyzed as continuous or categorical, with categories defined as (1) low = less than 0.088, (2) medium = 0.088 to 0.236, or (3) high = greater than 0.236. OM exposure was analyzed as continuous or categorical with categories defined as (1) low = less than 0.08, (2) medium = 0.080 to 0.218, and (3) greater than 0.218. When the GENMOD models did not converge, Fischer's exact test was used to compare symptom prevalence among the exposure categories. Age, gender, and smoking status were initially included in the GENMOD log-binomial regression models; however, the models did not converge. The LOGISTIC procedure in SAS was used to examine associations of age, gender, or smoking status with eye, upper and lower airway symptoms.

We also explored associations between work-related acute symptoms and age, gender, tenure, smoking status, and use of cleaning products containing known asthmagens using logistic regression. Asthmagen-containing cleaning products were defined as products containing quaternary ammonium compounds, bleach, or ethanolamines. Use of quaternary ammonium compounds, bleach, or ethanolamines was recorded from our direct observations of EVS staff while they performed their regular cleaning duties. We explored associations between work-related symptoms and use of products containing (1) quaternary ammonium compounds; (2) bleach; or (3) ethanolamines. We also assessed associations between work-related symptoms and use of a combination of these products throughout the work day by using an asthmagen index value. The asthmagen index value (0-3) was determined by adding the number of asthmagen products that an employee was observed using on the day of air sampling.

Associations Between Acute and Chronic Health Outcomes and Exposure Metrics: Departmental Level Exposure

We also calculated the average TM exposure for each of the nine hospital departments where air sampling was performed. Eighty-five survey participants worked on a department where air sampling was performed. We assessed associations between average departmental TM exposure and symptoms reported by staff. SAS PROC GENMOD's Poisson regression was used to calculate unadjusted prevalence ratios and 95% confidence intervals for symptoms associated with department level exposure. TM exposure was analyzed as a categorical variable by dividing each of the nine departments into three categories: high, medium and low TM exposure, with three departments in each category. SMRs for symptoms were calculated among individuals who worked on the department with the highest TM exposure.

Comparison of Post-shift Survey and Health and Work History Questionnaire

We summarized the prevalence of symptoms reported by EVS staff in both the post-shift acute symptom survey and health and work history questionnaire. Symptoms that were asked about in both the post-shift acute symptom survey and work history questionnaire included: nasal irritation, eye irritation, cough, wheeze, shortness of breath, and chest tightness.

Results

Major findings in relation to EVS staff, OxyCide use, and related exposure measurements are presented below. Supplemental analyses and findings from the site visits are presented in Appendix A. In general, we observed that Oxycide was the main cleaning product used for all surface cleaning duties. We noted that some hospital employees had the impression that because the chemicals contained in OxyCide are similar to chemicals found in common household products, there is little health risk from exposure to this product. We also noted that OxyCide was formerly used as a spray cleaner by some staff in some units. Several employees reported previous Oxycide splashes and spills that resulted in skin or eye irritation. Some environmental services staff reported that there was no ventilation in some of the bathrooms that they cleaned. Several staff mentioned that their symptoms were worse when performing cleaning duties in the bathrooms, especially in the shower stalls.

During our visits, we observed that EVS staff used automated dispensers designed to dilute the concentrated OxyCide product to its at-use pH of 3. We made pH measurements of the diluted OxyCide product that ranged from 2.85-4.86. The product's safety data sheet indicates that OxyCide should be diluted to a pH of 3. We observed staff using the automated dispensers to pour OxyCide directly into plastic bottles. The plastic bottles were then used to pour OxyCide into open faced buckets that housed a roll of disposable cloth wipes. We observed that nitrile gloves were used routinely when working with cleaning products. Staff occasionally chose to also wear goggles or a surgical mask when dispensing or working with cleaning products.

Summary of July 2015 and September 2015 Air Sampling Results and Post-Shift Survey of Acute Symptoms

Full shift air sample results ranged from 6 parts per billion (ppb) to 511 ppb for HP, 7 ppb to 530 ppb for AA, and 1 ppb to 48 ppb for PAA (Figure 1). For AA, 15-minute air samples ranged from 442 ppb to 456 ppb. All 15-minute and task-based exposure air samples for HP and PAA were below the limit of detection for the instrument used to detect the analyte. The limit of detection was 4 µg of hydrogen peroxide per sample and 2 µg of PAA per sample. The median exposure levels observed were 72 ppb for HP, 14 ppb for PAA, and 124 ppb for AA. The highest personal exposures were observed for employees in the Womancare Birth Center (WCBC). The average air concentrations measured on employees in each sampled unit are provided in Table 1. The highest summed values for HP, PAA, and AA, and HP and PAA exposures were observed in the Womancare Birth Center, Birth Center Triage, Birth Center Operating Rooms, and the Medical Surgical areas.

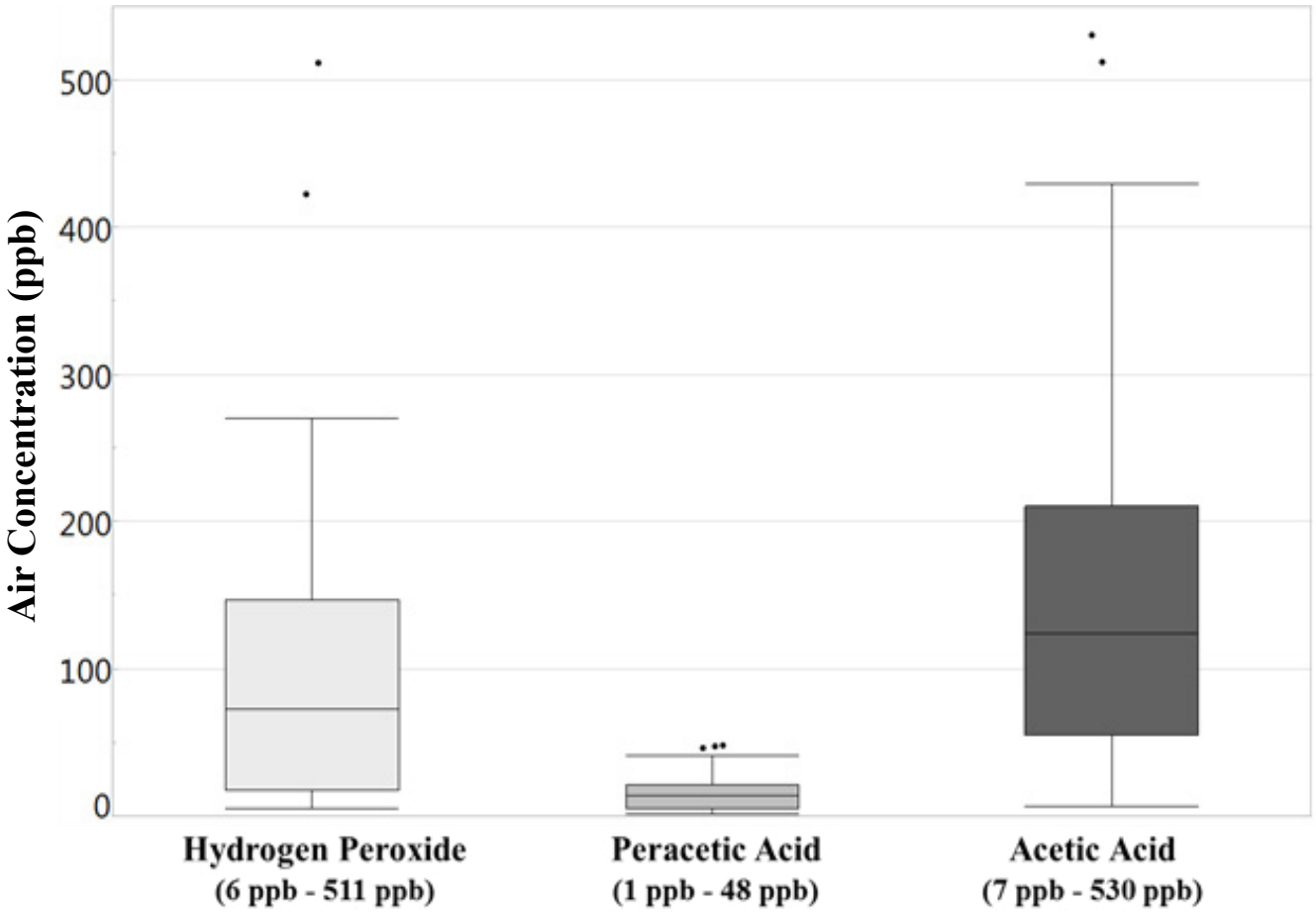

Figure 1. Box-plots of full-shift time-weighted average exposure levels of hydrogen peroxide, peracetic acid, and acetic acid, NIOSH survey, July and September 2015. Note: ppb=parts per billion. The box-plots illustrate each quartile with the lowest quartile shown as the line and hatch mark below the box, the second and third quartiles indicated by the shaded box, and the highest quartile indicated by the line and hatch mark above the boxes. The line within each box indicates the median air sample concentration. Outlier air samples are denoted by dots. The OSHA PEL and NIOSH REL is 1000 ppb (1 ppm) for hydrogen peroxide and 10,000 ppb (10 ppm) for acetic acid.

Table 1. Average and 95th percentile concentrations (in parts per billion) of hydrogen peroxide, peracetic acid, and acetic acid, by hospital area, July and September 2015.

Hospital Area	Hydrogen Peroxide			Peracetic Acid			Acetic Acid			HP+PAA+AA			HP+PAA		
	Mean (± SD)	GM	95%ile	Mean (± SD)	GM	95%ile	Mean (± SD)	GM	95%ile	Mean (± SD)	GM	95%ile	Mean (± SD)	GM	95%ile
Main OR (n=3)	13 (± 11)	11	26	3 (± 12)	2	7	43 (± 59)	20	110	60 (± 73)	13	144	17 (± 14)	13	33
WCBC (n=10)	186 (± 11)	143	511	23 (± 12)	20	46	263 (± 126)	238	512	472 (± 224)	423	828	208 (± 132)	173	522
WCBC, Triage (n=3)	90 (± 42)	85	138	32 (± 14)	30	48	138 (± 69)	128	218	260 (± 78)	253	338	122 (± 42)	117	166
WCBC OR (n=3)	175 (± 59)	167	222	26 (± 20)	21	48	251 (± 80)	241	313	451 (± 150)	432	583	200 (± 72)	191	270
Ante- and Post-partum (n=6)	64 (± 30)	55	94	18 (± 12)	15	41	151 (± 69)	139	273	233 (± 98)	213	377	82 (± 36)	73	117
Medical Surgical (n=2)	113 (± 52)	–	–	21 (± 8)	–	–	261 (± 173)	–	–	395 (± 217)	–	–	134 (± 44)	–	–
Orthopedics (n=3)	32 (± 36)	19	72	5 (± 7)	3	13	78 (± 108)	33	203	115 (± 150)	61	288	37 (± 43)	22	85
ICU (n=2)	62 (± 15)	61	73	15 (± 1)	15	15	138 (± 6)	138	142	215 (± 10)	215	222	77 (± 16)	76	88
Oncology (n=3)	97 (± 107)	46	215	9 (± 10)	5	21	66 (± 32)	61	103	173 (± 112)	140	273	107 (± 108)	53	222
NICU (n=5)	133 (± 168)	62	423	11 (± 9)	6	22	53 (± 45)	40	123	197 (± 215)	120	561	144 (± 172)	69	437
Outpatient Clinic (n=3)	14 (± 7)	13	19	7 (± 5)	5	12	49 (± 22)	45	65	71 (± 34)	64	96	21 (± 12)	18	31
Public BR (n=1)	25*	–	–	5*	–	–	122*	–	–	151*	–	–	30*	–	–
Float (n=4)	69 (± 92)	26	202	13 (± 16)	5	34	211 (± 225)	98	530	292 (± 327)	146	766	81 (± 108)	31	236
Floors (n=1)	8*	–	–	2*	–	–	10*	–	–	19*	–	–	9*	–	–

Note: SD=one standard deviation, ± one standard deviation shown in parentheses; GM=geometric mean; 95%= 95th percentile; HP=hydrogen peroxide; PAA=peracetic acid; AA=acetic acid; OR = operating room; WCBC = Womancare Birth Center; NICU = neonatal intensive care unit; BR = bathroom.
***Not a true average: only one personal sample was obtained in each of these units.**

Currently, there is no OSHA PEL or NIOSH REL for exposure to the mixture of HP, PAA, and AA. Most exposure limit values are created for exposure to a single chemical substance [ACGIH 2016]. There are occupational exposure limits for exposure to HP or AA. The OSHA PEL and NIOSH REL is one ppm (1000 ppb) for exposure to HP and 10 ppm (10,000 ppb) for exposure to AA. All measurements for HP and AA were below their respective OSHA PELs and NIOSH RELs [NIOSH 2010] for exposure to HP or AA alone. There is currently no OSHA PEL or NIOSH REL for occupational exposure to PAA, however, several research groups have suggested 0.2 ppm as an exposure limit [Gagnaire et al. 2002; Pechacek et al. 2015; Pacenti et al. 2010]. ACGIH developed a mixture formula that can be used when multiple chemical exposures occur simultaneously and have similar biological effects [ACGIH 2016]. The ACGIH mixture formula was used to create the TM and OM used for the results presented below. HP and PAA are strong oxidants, and their mixture is listed as an asthmagen and respiratory sensitizer by the Association of Occupational and Environmental Clinics [AOEC 2015]. Asthmagens are substances that can cause asthma. Respiratory sensitizers are materials that can cause an immune response and adverse respiratory effects, even at low levels of exposure.

Mucous membrane irritation (burning eyes and/or burning nose) was reported by 64% (n = 32/50) of post-shift survey participants, and 84% (n = 27/32) of these participants reported symptom onset while cleaning. Lower airway symptoms such as cough, wheeze, chest tightness, shortness of breath or difficulty breathing were reported in 34% (n = 17/50) of post-shift survey participants; of whom 88% (n = 15/17) reported symptom onset during cleaning activities. Symptom prevalence in low, medium, and high TM and OM exposure groups can be seen in Table 2. Prevalence of work-related acute eye and upper airway symptoms were similar in the TM and OM exposure groups (Table 2).

In the highest TM exposure group, 1.4–6.5-fold more participants reported work-related nasal irritation, eye irritation, sneeze, and burning, dry or sore throat compared to the lowest exposure group. In the highest TM exposure group, 87.5% of participants reported work-related nasal irritation; 81.3%, reported eye irritation; 37.5%, reported sneeze, and 25.0% of participants reported burning dry or sore throat.

Age, smoking status, gender, and use of products containing other asthmagens were not significantly associated with acute eye, upper airway, or lower airway symptoms reported in the post-shift survey and were not included in our models. Nasal and eye irritation were significantly associated with increased TM and OM exposure. Both the highest TM and OM exposure groups had 3.5 fold higher prevalence of nasal irritation symptoms when compared to the lowest TM and OM exposure groups (Figure 2). Eye irritation prevalence was similar for both the highest TM and OM exposure groups as well, with 6.4–6.5 fold higher prevalence, when compared to the lowest TM and OM exposure groups (Figure 2). An exposure-response relationship was observed for sneeze and throat symptoms as well, although the increases were not statistically significant. Employees in the highest TM mixture exposure group had 3.0 ($p = 0.14$) and 2.0 ($p = 0.38$) fold higher prevalence of sneeze and burning throat, respectively, when compared to the lowest exposure group (Figure 2). Employees in the highest OM exposure group had 5.3 ($p=0.11$) and 1.4 ($p=0.6$) fold higher prevalence of sneeze and burning throat, respectively, when compared to the lowest exposure

group.

The number of employees that reported lower airway symptoms during their shift was too small to calculate prevalence ratios using the GENMOD log-binomial procedure in SAS. No employees in the lowest TM or OM exposure groups reported acute work-related (1) wheeze; (2) chest tightness; (3) shortness of breath; or (4) difficulty breathing. In comparison, employees exposed to mixture levels in the medium and highest TM and OM exposure groups (n = 33) reported (1) wheeze (n = 3, 9%); (2) chest tightness (n = 2, 6%); (3) shortness of breath (n = 3, 9%); and difficulty breathing (n = 2, 6%) (Table 2). Despite these trends, Fisher's Exact Test did not indicate any significant associations.

We also explored associations between exposure to HP, PAA, or AA and acute symptoms occurring during the work shift using logistic regression (Appendix A, Table A4). Mucous membrane irritation symptoms, specifically burning itchy, runny nose, sneeze, and burning, itchy, watery eyes, were statistically significantly positively associated with HP, AA, and PAA exposure, indicating an increase in symptoms with increasing exposure. We also explored associations between age, gender, tenure, smoking status, and use of cleaning products containing known asthmagens and work-related acute symptoms using logistic regression. No associations were found.

Summary of Chronic Upper and Lower Airway Symptoms in Participants in the Air Sampling, Post-shift Survey, and Health and Work History Questionnaire

Thirty-five employees participated in all three components of our employee evaluation: the personal air sampling, the post-shift survey of acute symptoms, and the health and work history questionnaire.

On the health and work history questionnaire, 57.1% of these 35 participants reported chronic nasal problems and 51.4% reported watery eyes in the last 12 months (Table 2). Regarding chronic lower respiratory symptoms, 5.7% of these participants reported cough; 22.9% reported usual shortness of breath on level ground; 14.3% reported wheeze in the previous 12 months; and 17.1% reported awaken from chest tightness in the previous 12 months.

The highest TM and OM exposure group for these 35 participants had 3.1 and 3.7 fold higher prevalence of shortness of breath on level ground when compared to the lowest TM and OM exposure groups (Table 3). Shortness of breath on level ground was significantly associated with increased TM exposure ($p = 0.026$) and OM exposure ($p = 0.017$). Prevalence of wheeze in the last 12 months was 2.3-2.8 fold higher in the highest TM and OM exposure groups, when compared to the lowest exposure group (Table 3). Age, smoking status, gender, and use of products containing other asthmagens were not significantly associated with chronic eye, upper airway or lower airway symptoms reported in the health and work history questionnaire and were not included in the analyses presented here.

Table 2. Acute and chronic symptom prevalence, by total mixture and oxidant mixture exposure group, July-September 2015

	Overall Prevalence (%)	TM Prevalence (%)			OM Prevalence (%)		
Work-Related Acute Symptom (post-shift survey)	**(n=50)**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Nasal irritation*†	52.0	25.0	47.1	87.5	25.0	50.0	86.7
Eye irritation*†	44.0	12.5	41.2	81.3	12.5	44.4	80.0
Sneeze	22.0	12.5	17.7	37.5	6.3	27.8	33.3
Burning, dry, sore throat	18.0	12.5	17.6	25.0	18.8	11.1	26.7
Cough	20.0	18.8	23.4	18.8	18.8	22.2	20.0
Wheeze	6.0	0	11.8	6.3	0	11.1	6.7
Chest tightness	4.0	0	5.9	6.3	0	5.6	6.7
Shortness of breath	6.0	0	5.9	12.5	0	5.6	13.3
Difficulty breathing	4.0	0	11.8	0	0	11.1	0
Dizziness	6.0	6.3	5.9	6.3	6.3	5.6	6.7
Chronic Symptom (health and work history questionnaire)	**(n=35)**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Nasal problems, previous 12 months	57.1	40.0	50.0	76.9	45.5	50.0	75.0
Watery eyes, previous 12 months	51.4	40.0	41.7	69.2	45.5	41.7	66.7
Usual cough	5.7	10.0	0	7.7	9.1	0	8.3
Shortness of Breath on level ground†	22.9	10.0	25.0	30.8	9.1	25.0	33.3
Wheeze, previous 12 months	14.3	10.0	8.3	23.1	9.1	8.3	25.0
Awaken from chest tightness, previous 12 months	17.1	20.0	8.3	23.1	27.3	8.3	16.7
Asthma medication use	8.6	10.0	0	15.4	9.1	0	16.7
Asthma-like symptoms	28.6	30.0	16.7	38.5	36.4	16.7	33.3

Note: TM=total mixture (hydrogen peroxide, peracetic acid, and acetic acid); OM=oxidant mixture (hydrogen peroxide and peracetic acid).
***Indicates symptoms significantly positively associated with increased exposure to the total mixture ($p \leq 0.05$).**
†Indicates symptoms significantly positively associated with increased exposure to the oxidant mixture ($p \leq 0.05$).

Table 3. Acute and chronic symptom prevalence ratios relative to the low exposure group, by total mixture and oxidant mixture exposure group, July-September 2015

	TM Prevalence Ratio (95% CI)		OM Prevalence Ratio (95% CI)	
Acute Symptom (post-shift survey)	**Medium**	**High**	**Medium**	**High**
Nasal irritation*†	1.88 (0.70-5.05)	3.50 (1.47-8.34)	2.00 (0.76-5.26)	3.47 (1.45-8.29)
Eye irritation*†	3.29 (0.80-13.56)	6.50 (1.74-24.27)	3.56 (0.88-14.35)	6.40 (1.71-23.98)
Sneeze	1.41 (0.27-7.38)	3.00 (0.71-12.69)	4.44 (0.58-34.14)	5.33 (0.70-40.54)
Burning, dry, sore throat	1.41 (0.27-7.38)	2.00 (0.42-9.42)	0.59 (0.11-3.11)	1.42 (0.38-5.33)
Chronic Symptom (health and work history questionnaire)	**Medium**	**High**	**Medium**	**High**
Nasal problems, previous 12 months	1.25 (0.49-3.22)	1.92 (0.85-4.35)	1.10 (0.47-2.60)	1.65 (0.80-3.41)
Watery eyes, previous 12 months	1.04 (0.38-2.87)	1.73 (0.75-4.01)	0.92 (0.36-2.33)	1.47 (0.69-3.14)
Usual cough	–	0.77 (0.05-10.84)	–	0.92 (0.06-12.95)
Shortness of Breath on level ground†	2.50 (0.31-20.45)	3.08 (0.40-23.44)	2.75 (0.33-22.69)	3.67 (0.48-28.00)
Wheeze, previous 12 months	0.83 (0.06-11.70)	2.31 (0.28-18.99)	0.92 (0.06-12.95)	2.75 (0.33-22.69)
Awaken from chest tightness, previous 12 months	0.42 (0.04-3.95)	1.15 (0.24-5.65)	0.31 (0.04-2.52)	0.61 (0.12-3.00)
Asthma medication use	–	1.54 (0.16-14.66)	–	1.83 (0.19-17.51)
Asthma-like symptoms	0.56 (0.11-2.70)	1.28 (0.40-4.13)	0.46 (0.10-2.03)	0.92 (0.30-2.81)

Note: TM=total mixture (hydrogen peroxide, peracetic acid, and acetic acid); OM=oxidant mixture (hydrogen peroxide, and peracetic acid). Prevalence ratios were calculated for the medium and high exposure groups, compared to the low exposure group. Cough, wheeze, chest tightness, shortness of breath, difficulty breathing, and dizziness reported in the post-shift survey were too few to calculate prevalence ratios using PROC-GENMOD in SAS and are not included in this table.
***Indicates symptoms significantly positively associated with increased exposure to the total mixture ($p \leq 0.05$).**
†Indicates symptoms significantly positively associated with increased exposure to the oxidant mixture ($p \leq 0.05$).
–Number of employees that reported symptoms was too small to calculate prevalence ratios using the GENMOD log-binomial procedure in SAS.

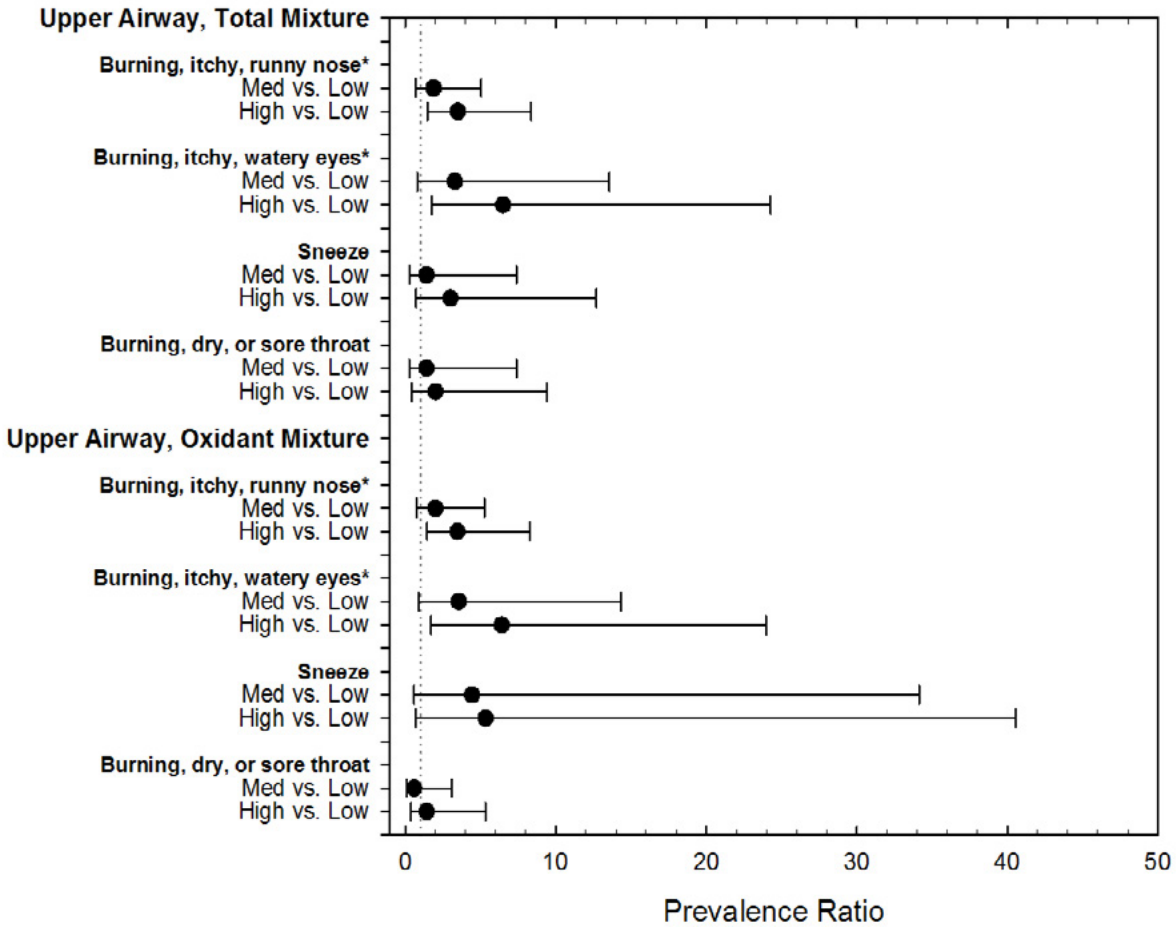

Figure 2. Prevalence ratios and 95% confidence intervals for eye and upper airway symptoms reported during as occurring during employees' shift in the medium and high compared to low total mixture (hydrogen peroxide, peracetic acid, and acetic acid) and oxidant mixture (hydrogen peroxide and peracetic acid) exposure groups, July and September 2015. *signifies symptoms significantly positively associated with the highest exposure group (p-value ≤ 0.05).

Heating, Ventilation, and Air-conditioning System Evaluation

All of the air-handling units and associated ductwork appeared to be in good working order and well maintained. We assessed the ventilation systems present in 29 areas in the hospital, including rooms in the following units: 2700, 2800, 3100, 3200, 3700, 3800, 4100, 4800, 5300, 5800, Neonatal Intensive Care Unit, and Womancare Birth Center. We observed that the EVS cleaning closets in the 3100 and 5300 units had no supply air and no return flow.

Participant Demographics and Responses to Health and Work History Questionnaire

A total of 163 current employees, including 79 EVS staff and 84 non-EVS staff, completed the health and work history questionnaire. The participation rate among EVS staff who were working on the days of the health and work history questionnaire administration was 77%. Table 4 describes the job groups of non-EVS participants.

The median age of EVS participants was 45 years (range: 20 years to 67 years) compared to 40 years among non-EVS participants (range: 19 years to 67 years) (Table 5). A higher proportion of EVS participants (49%) than non-EVS participants (13%) were male. The

majority of non-EVS staff were white (85%); whereas, the majority of EVS participants were black (59%). Tenure and smoking history was similar between the two groups.

Although most EVS staff were OxyCide users, and most non-EVS staff did not use OxyCide, 11 (14%) EVS staff indicated that they did not use OxyCide, while 10 (12%) non-EVS staff members indicated that they used OxyCide.

Table 4. Job groups of 84 non-EVS questionnaire participants, August – September 2015

Job Group	N (% of total non-EVS)
Nursing staff*	27 (32%)
Other patient care staff†	25 (30%)
Administrative staff‡	13 (15%)
Other hospital staff§	19 (23%)

Note: EVS=environmental services staff
*** Nursing Staff includes Staff Nurses, Registered Nurses, Nurse Coordinators, Professional Staff Nurses, Resource Nurses, and Collaborative Practice Nurses.**
† Other Patient Care Staff includes Patient Care Technicians, Certified Nursing Assistants, Clinicians, Respiratory Therapists, Medical Assistants, Nurse Practitioners, Surgical Technicians, Surgical Technologists and Ultrasound Technicians.
‡ Administrative Staff includes Patient Access Staff, Business Managers, Health Unit Coordinators, Administrative Assistants, Unit Directors, and Unit Secretaries.
§ Other Hospital Staff includes Pharmacists, Cooks, Pharmacy Technicians, Laboratory staff, Registered Dieticians, Room Service Attendants, Patient Transporters, Sanitation Aides, and Valet Parking Attendants.

Table 5. Demographic characteristics of survey participants, NIOSH survey, August-September 2015

Characteristic	All Participants (N=163)	EVS (n= 79)	Non-EVS (n= 84)	p*	Oxycide Use (n= 78)	No Oxycide Use (n= 85)	p*
Age, years, median (range)	43 (19-67)	45 (20-67)	40 (19-67)	0.40	43 (20-67)	43 (19-67)	0.43
Tenure, years, median (range)	5 (0.13- 43)	5 (0.21-36)	5 (0.13-43)	0.83	5 (0.21-36)	5 (0.13-43)	0.57
Male, n (%)	50 (31%)	39 (49%)	11 (13%)	<0.05	33 (42%)	17 (20%)	<0.05
Race, n (%)							
White	92 (56%)	21 (27%)	71 (85%)	<0.05	26 (33%)	66 (78%)	<0.05
Black	57 (35%)	47 (59%)	10 (12%)		41 (53%)	16 (19%)	
Asian	4 (2%)	4 (5%)	0 (0%)		4 (5%)	0 (0%)	
Other†	7 (4%)	5 (6%)	2 (2%)		5 (6%)	2 (2%)	
Unknown‡	3 (2%)	2 (3%)	1 (1%)		2 (3%)	1 (1%)	
Smoking status, n (%)							
Current	27 (17%)	16 (20%)	11 (13%)	0.36	16 (21%)	11 (13%)	0.42
Former	32 (20%)	13 (16%)	19 (23%)		14 (18%)	18 (21%)	
Never	104 (64%)	50 (63%)	54 (64%)		48 (62%)	56 (66%)	

Notes: EVS=environmental services staff
*** P values calculated using Chi-Square Test for categorical variables or T-test for continuous variables**
† Includes participants who indicated more than one race
‡ Participants who refused to indicate a race

All participants' responses to questions about symptoms and self-reported diagnoses can be seen in Table 6. The most commonly reported symptoms were nasal problems and watery eyes. Nasal problems were reported by 42%, and watery eyes were reported by 40% of all participants. Other commonly reported health outcomes included asthma-like symptoms (28%), skin problems (19%) and wheeze (16%). Among reported symptoms, some were described to be work-related, as they improved away from the facility. The prevalence of work-related symptoms ranged from 2% to 18%.

Table 6. Symptoms and self-reported diagnoses of all questionnaire participants (N=163), August-September 2015

Health Outcome	All Participants, n (%)	Work Related*, n (%)
Cough	9 (6%)	4 (2%)
Shortness of breath	21 (13%)	7 (4%)
Wheeze†	26 (16%)	6 (4%)
Chest tightness†	18 (11%)	4 (2%)
Asthma attack†	8 (5%)	4 (2%)
Asthma medicine	18 (11%)	6 (4%)
Allergy medicine	48 (29%)	9 (6%)
Asthma-like symptoms§	46 (28%)	16 (10%)
Nasal problems†	68 (42%)	29 (18%)
Watery eyes†	65 (40%)	31 (18%)
Skin problems†	31 (19%)	19 (11%)
Asthma		
Ever	32 (20%)	
Current	23 (14%)	
Nasal allergies	37 (23%)	

***Work-related symptoms were defined as symptoms that improved away from the facility, either on days off or on vacation.**
† In the past 12 months
‡ Asthma-like symptoms were defined as current use of asthma medicine and/or one or more of the following symptoms in the last 12 months: wheezing or whistling in the chest, awakening with a feeling of chest tightness, or attack of asthma.

Comparison of EVS and Non-EVS Staff

Physician Diagnosed Asthma Reported by EVS and Non-EVS Staff

There was no significant difference between EVS and non-EVS staff with regard to ever having a physician's diagnosis of asthma or current asthma (Appendix A, Table A1). The prevalence of ever having a physician diagnosis of asthma among EVS staff participants was 2.1 times (95% CI = 1.2, 3.7) that of the expected prevalence for the U.S. adult population, while the prevalence of current asthma among EVS staff was 2.3 times (95% CI = 1.2, 4.3) the expected prevalence for the U.S. adult population. Similarly, among non-EVS staff, these prevalences were higher than the expected values for the U.S. adult population; 2.6 times (95% CI = 1.6, 4.1) higher for ever-asthma, and 2.4 times (95% CI = 1.3, 4.2) higher for current asthma.

Among the 32 participants who reported ever having a physician diagnosis of asthma, approximately double the percentage of EVS staff (62%) compared to non-EVS staff (32%) indicated that something at work brings on or worsens their asthma; the prevalence of asthma brought on or made worse by work for EVS and non-EVS staff is shown in Figure 4. Among the 14 employees that said something at work brings on or worsens their asthma, 36% indicated that OxyCide brought on or made their asthma worse.

Symptoms and Medication Use Reported by EVS Staff

EVS staff reported higher prevalences of work-related health outcomes including shortness of breath, asthma-like symptoms, use of asthma medicine, use of allergy medicine, nasal problems, and skin problems, with statistically significant higher reports of wheeze and watery eyes (Figure 3; Appendix A, Table A1). In addition, EVS staff had significantly higher prevalence of nasal problems and watery eyes brought on or made worse by something at work (Figure 4). Among the 32 employees who said that something at work brought on or made their nasal problems worse, 56% specified OxyCide. Seventy-one percent of those who reported that something at work brought on or made their watery eye symptoms worse at work, also specified OxyCide. Among EVS staff reporting skin problems, 75% reported that something at work brought on or made this symptom worse, compared to 42% of non-EVS staff. Fifty-three percent of staff who reported that something at work brought on or made their skin problems worse specified that OxyCide brought on or made their skin problems worse.

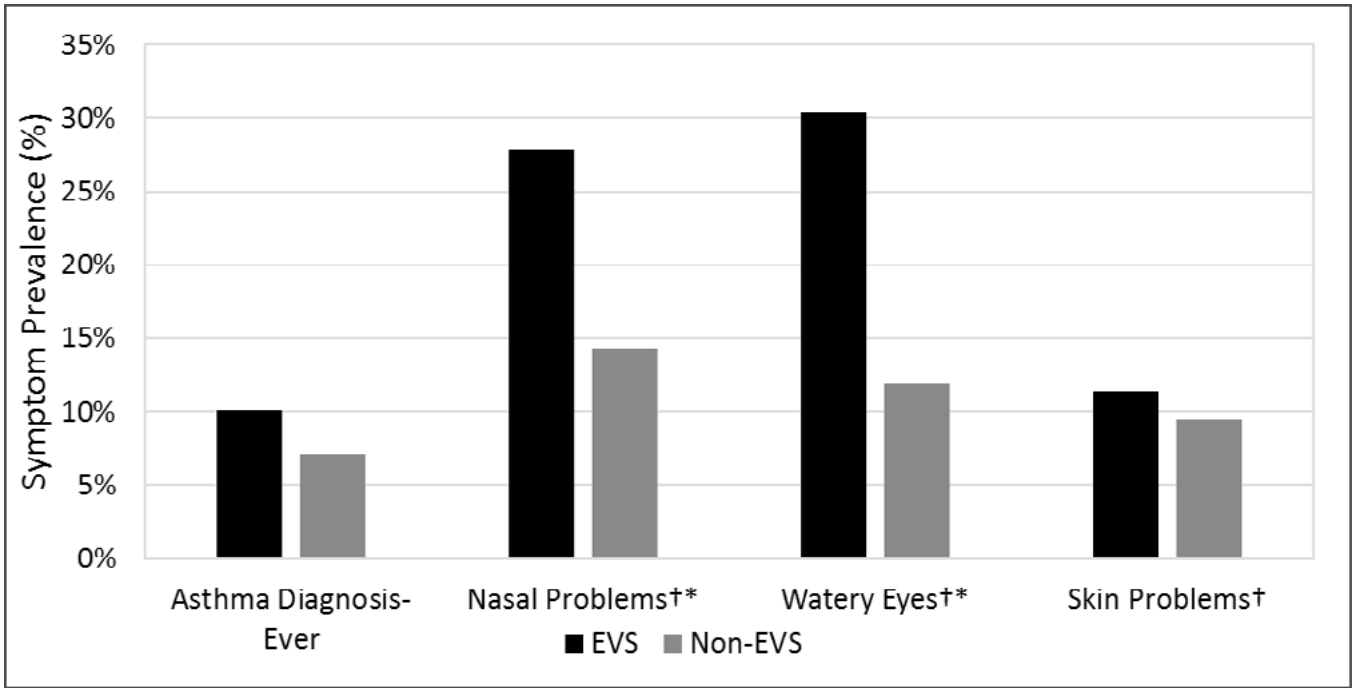

Figure 3. Prevalence of health outcomes brought on or made worse by something at work by EVS vs. non-EVS staff, August-September 2015. Percentages reflect the number of participants who reported a health outcome and indicated if it was brought on or made worse by something at work.

Note: EVS=environmental services staff
*** Statistically significant differences ($p \leq 0.05$) are indicated by an asterisk next to the name of the symptom.**
† Indicates all symptoms specific to the last 12 months

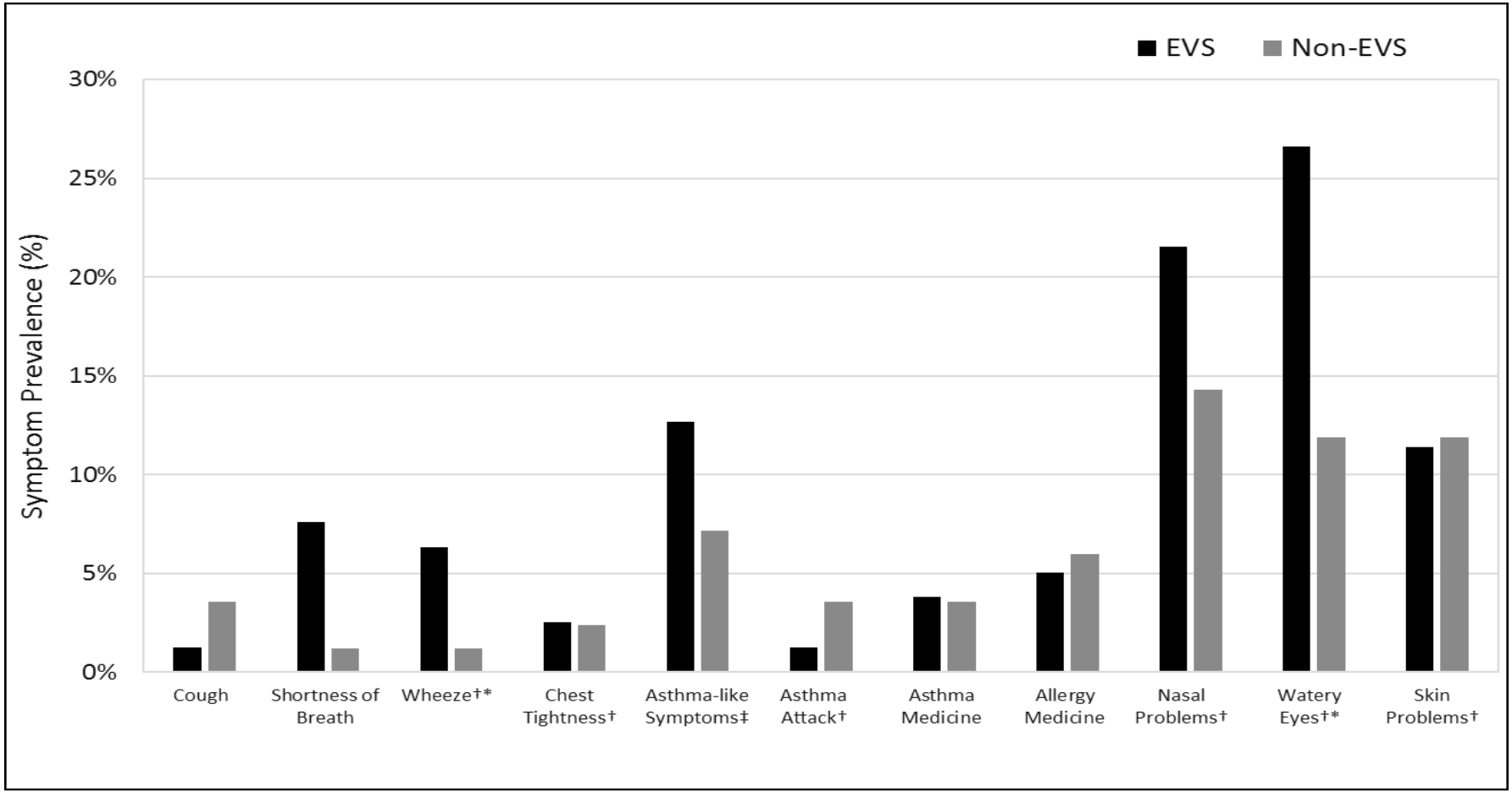

Figure 4. Prevalence of work-related health outcomes by environmental services staff (EVS) vs. non-EVS staff, August-September 2015. Work-related symptoms were defined as symptoms that improved away from the facility, either on days off, or on vacation. Work-related medicine use was defined as increased use of medicine on work-days.

***Statistically significant differences ($p \leq 0.05$) are indicated by an asterisk next to the name of the symptom.**
† Indicates all symptoms specific to the last 12 months
‡ Asthma-like symptoms were defined as current use of asthma medicine and/or one or more of the following symptoms in the last 12 months: wheezing or whistling in the chest, awakening with a feeling of chest tightness, or attack of asthma.

Comparison of OxyCide Users and Non-users

In general, the comparisons between Oxycide users and non-users showed similar patterns to those described above for EVS staff and non-EVS staff.

Physician Diagnosed Asthma Reported by OxyCide Users and Non-Users

There was no significant difference between OxyCide users and non-users with regard to ever having a physician's diagnosis of asthma or current asthma. Both groups had higher than expected asthma prevalence when compared to the U.S. population (Appendix A, Table A2).

Other Health Outcomes Reported by OxyCide Users and Non-Users

OxyCide users reported higher prevalence of work-related health outcomes including cough, shortness of breath, asthma-like symptoms, asthma attack, use of asthma medicine, asthma symptoms, use of allergy medicine, nasal problems, and skin problems, with wheeze and watery eyes being significantly higher (Appendix A, Figure A1).

Associations with department-level exposures

The department with the highest average TM was the WCBC. Prevalence ratios comparing the WCBC to the 3 departments with the lowest average TMs (2700/2800, Outpatient Clinic, and 4100) were calculated for wheeze, chest tightness, nasal problems, watery eyes and asthma-like symptoms and can be seen in Figure 5. Statistically significant results were found for watery eyes in the WCBC (PR= 2.88, 95% CI=1.18-7.05) and for the three highest units (WCBC, 5300, and NICU) with high ACGIH mixture concentrations (PR= 2.58, 95% CI=1.07-6.26) when compared to departments with low concentrations. When compared to all other departments, there were no significant differences among the survey participants in the WCBC with regard to sex, race, smoking status or those working in EVS. However, participants on the WCBC unit were significantly younger, with an average age of 37 and workers on all other units with an average age of 44 (t-test, p=0.0169).

We compared the prevalence of shortness of breath, cough, wheeze, watery eyes and asthma diagnosis among workers in the WCBC compared to the U.S. population. The prevalence of watery eyes (SMR= 1.70, 95% CI= 1.06-2.72), lifetime asthma diagnosis (SMR=2.50, 95% CI=1.07-5.85), and current asthma (SMR= 3.47, 95% CI= 1.48-8.13) was significantly higher than expected when compared to the U.S. population. Watery eyes and current asthma among workers in all other departments was not significantly higher than expected. However, lifetime asthma diagnosis was significantly higher than expected (SMR=2.52, 95% CI=1.41-4.51) in these other departments.

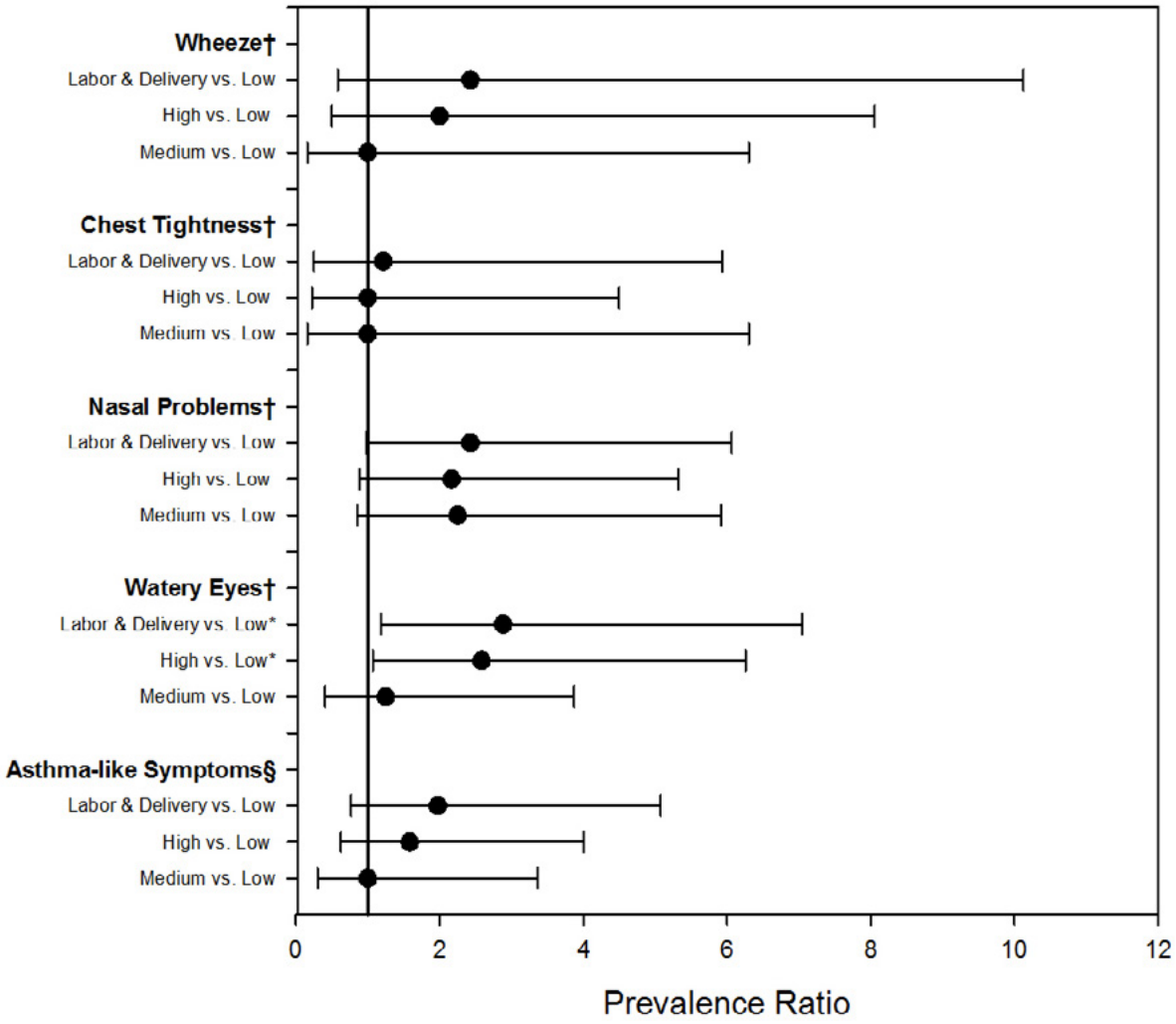

Figure 5. Prevalence ratios for symptoms in the Labor and Delivery Department (WCBC), 3 departments with the highest average TM (WCBC, 5300, NICU) and 3 departments with medium TMs (5800, 3700/3800, 4800) compared to the 3 departments with the lowest average TMs (4100, Outpatient Clinic, 2700/2800). Statistically significant results are noted with an (*). All symptoms specific to the last 12 months are noted with an (†). Asthma-like symptoms (§) were defined as current use of asthma medicine and/or one or more of the following symptoms in the last 12 months: wheezing or whistling in the chest, awakening with a feeling of chest tightness, or attack of asthma.

We compared the prevalence of shortness of breath, cough, wheeze, watery eyes and asthma diagnosis among employees in the WCBC to the U.S. population. The prevalence of watery eyes (SMR= 1.70, CI= 1.06-2.72), lifetime asthma diagnosis (SMR=2.50, CI=1.07-5.85), and current asthma (SMR= 3.47, CI= 1.48-8.13) were significantly higher than expected when compared to the U.S. population. Watery eyes and current asthma among employees in all other departments were not significantly higher than expected. However, lifetime asthma diagnosis was significantly higher than expected (SMR=2.52, CI=1.41-4.51) in these other departments.

Discussion

Overall, we observed a higher prevalence of work-related health outcomes in EVS staff, when compared to non-EVS staff. EVS staff reported a higher prevalence of work-related shortness of breath, asthma-like symptoms, use of asthma medication, use of allergy medicine, nasal problems, and skin problems. In addition, EVS staff had significantly higher prevalence of work-related nasal problems and watery eyes (Figure 4). Among employees who said that something at work brought on or made their nasal problems worse, approximately half (56%) specified OxyCide. Almost three-quarters (71%) of staff who reported that something at work brought on or made their watery eye symptoms worse at work also specified OxyCide. When compared to non-EVS staff, EVS staff had almost twice the prevalence (75% EVS staff, 42% non-EVS staff) of skin problems that were brought on or made worse at work. Of staff who reported that something at work brought on or made their skin problems worse, 53% specified OxyCide. Work-related watery eyes and wheeze were significantly more common among EVS staff when compared to non-EVS staff.

EVS staff using OxyCide reported acute and chronic symptoms. Symptoms were associated with exposure to the mixture of vapors from Oxycide. The highest Oxycide vapor exposure group (TM) had 3.5 and 6.5 fold increases in acute nasal and eye irritation, respectively (Figure 2). Increases in exposure to the vapors from Oxycide were also significantly associated with chronic shortness of breath on level ground. The highest TM exposure group had 3.1 fold higher prevalence of shortness of breath. The highest TM exposure group also had 2.3 fold higher prevalence of wheeze in the last 12 months, when compared to the lowest exposure group, albeit this difference was not significant (Table 3).

Our results suggest that exposure to Oxycide contributed to acute eye and upper airway symptoms, as well as shortness of breath, in hospital cleaning employees using Oxycide. The results of our evaluation are consistent with previous studies that have reported an increased risk for dermatitis, chronic bronchitis and work-related rhinitis and asthma in workers exposed to cleaning and disinfectant chemicals [Maçãira et al. 2007; Rosenman et al. 2003; Vizcaya et al. 2011; Charles, Loomis, and Demissie 2009]. We observed health effects in cleaning staff at exposure levels below established occupational exposure limits. Because both HP and PAA are strong oxidants, the mixture of HP and PAA potentially contributed to the airway symptoms reported by cleaning staff, at the relatively low levels of measured exposures.

We observed that some hospital employees were informed and had the impression that because the chemicals contained in OxyCide are similar to common household products, there is little health risk from exposure. The 2008 HICPAC Guideline recommends that each worker be informed of the possible health effect(s) of his or her exposure to chemicals. Specifically, employees should be educated on the documented health risks from exposure to HP, AA and PAA, as well as chemicals found in other cleaners at the hospital. This information should be consistent with Safety Data Sheets, Environmental Protection Agency regulations, and OSHA requirements and identify areas and tasks where there is the potential for exposure. In 2015, Oxycide was listed as an asthmagen, or a substance that causes asthma, by the Association of Occupational and Environmental Clinics (AOEC) [AOEC 2015].

We recommend that company management pursue the actions listed below to reduce employee exposure to the sporicidal disinfectant, Oxycide. Because employees are most familiar with the areas and tasks involved, we recommend that management involve employees that perform the work duties in each respective area when enacting any actions described below. Labor-management health and safety meetings are an opportune environment to discuss department specific recommendations and develop an action plan. Many of our recommendations come from the CDC's Healthcare Infection Control Practices Advisory Committee (HICPAC), which developed a Guideline for Disinfection and Sterilization in Healthcare Facilities in 2008 [CDC 2008]. This Guideline acknowledges that occupational diseases among cleaning personnel have been associated with disinfectant use at levels below OSHA or NIOSH exposure limits. HICPAC recommends that controls be used to minimize exposure to disinfectants, including elimination or substitution of the chemical, engineering or administrative controls, or the use of personal protective equipment. Additional information is provided in the Recommendations section, below.

Conclusions

In summary, acute eye symptoms and upper and lower respiratory symptoms were common in EVS staff during their shifts. EVS staff using Oxycide, a sporicidal disinfectant consisting of HP, PAA, and AA, reported acute eye and airway symptoms, as well as chronic airway symptoms at low levels of measured exposures. Increased exposure to HP, PAA, and AA was significantly associated with increases in work-shift acute nasal and eye irritation and shortness of breath on level ground. All full-shift TWA air samples for HP and AA were below established occupational exposure limits. Whether analyzed by EVS staff versus non-EVS staff or by OxyCide use versus non-OxyCide use, we found higher prevalences of work-related symptoms in the potentially exposed group versus the comparison group. We also found positive associations between exposure measurements related to OxyCide use and some health effects. Our results indicate a need to (1) monitor respiratory and eye symptoms in hospital cleaning staff using cleaning products containing HP, PAA, and AA, and (2) use a combination of engineering and administrative controls to reduce employee exposures.

Recommendations

Our recommendations are based on an approach known as the hierarchy of controls. This approach groups actions by how effective they are at removing or reducing hazards. In most cases, the primary approach is to eliminate hazardous materials or processes, and to install engineering controls to reduce exposure or shield employees. Administrative measures and personal protective equipment may be needed until such engineering controls are in place, or if engineering controls are not effective or feasible. Hospital management has already taken some steps to minimize employee exposure to OxyCide and address employee concerns. Below, we provide additional recommendations in the continued effort to improve employee health and safety.

Elimination or Substitution

A primary approach to minimizing exposure risk is to eliminate hazardous materials or processes. Sporicidal disinfectants are an important part of reducing healthcare-acquired infections. However, the choice to use sporicidal disinfectants in specific areas of the hospital should be prudent and reflect the level of risk of a healthcare-acquired infection. We observed the sporicidal disinfectant, OxyCide, being used by cleaning staff on surfaces throughout the hospital, including surfaces in non-patient areas. HICPAC provides recommendations for when and where sterilization with sporicides, versus disinfection with high- and low-level disinfectants, should occur in healthcare facilities [CDC 2008]. HICPAC states that HP and PAA can be used as high-level disinfectants for semicritical items that come into contact with mucus membranes or non-intact skin like respiratory therapy and anesthesia equipment, and some endoscopes [CDC 2008]. Surfaces that may come into contact with non-intact skin for short periods of time, like bed side rails, are typically considered noncritical surfaces and may be disinfected with phenolic, iodophors, alcohols, or chlorine compounds [CDC 2008]. Exposure to vapors containing HP, PAA, and AA could be reduced by substituting intermediate or low-level disinfectants for OxyCide when cleaning and disinfecting noncritical surfaces like bed rails, patient furniture, and bedside tables, and when cleaning surfaces in non-patient areas. HICPAC states that detergent and water are adequate for cleaning surfaces in non-patient care areas. We recommend that OxyCide not be used in non-patient care areas such as public bathrooms or administrative offices.

Engineering Controls

Engineering controls can reduce employees' exposures by lowering air concentrations with increased ventilation or by placing a barrier between the hazard and the employee. Engineering controls protect employees effectively without placing primary responsibility of implementation on the employee.

1. We recommend that additional return airflow be provided in the janitorial closets in 3100 and 5300 to ensure that the ASHRAE requirement of a minimum of 10 air changes per hour is met [ASHRAE 2013].
2. Ensure that all patient bathrooms meet minimum total air changes per hour as specified by ASHRAE. ASHRAE standard 2013-170 requires inpatient bathrooms to have at least 10 air changes per hour.
3. Ensure that OxyCide dispensers are calibrated to effectively dilute the product to a pH of 3. If OxyCide is not effectively diluted, a pH of less than 3 may increase skin, eye, and respiratory symptoms in exposed employees.
4. We recommend that management replace the current open-face buckets used to hold the wipes and OxyCide liquid product with bucket wipe dispensers. Exposure to vapors from the Oxycide may be minimized by requiring lids for the containers that EVS staff use to hold the Oxycide liquid product and wipes. Several companies make bucket wipe dispensers that could be used to allow wipes to be pulled from the Oxycide containers while minimizing vapor exposure.

Administrative Controls

Administrative controls refer to employer-dictated work practices and policies to reduce or prevent hazardous exposures. Their effectiveness depends on employer commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that policies and procedures are followed consistently.

1. Minimize the use of sporicidal disinfectants like OxyCide in non-patient care areas.
2. Review the process for Occupational Safety and Health Administration Form 300 reporting and maintenance to assure that all reportable injuries are recorded, regardless of whether a workers' compensation claim is filed. Consider implementing a comprehensive system for reporting and tracking workplace injuries and illnesses that includes reports of near-misses, minor injuries and illnesses, and employee safety concerns. This information should be reviewed by the Safety Officer on a regular basis to identify hazards, implement risk-reduction strategies, and prevent significant injuries and illnesses.
3. We recommend that management implement a reporting system that would allow employees to report work-related symptoms, with the option to remain anonymous for employees who do not wish to be identified. As a performance indicator for disinfection and sterilization, HICPAC recommends that healthcare facilities develop a mechanism for the reporting of all adverse health events potentially resulting from exposure to sporicidal disinfectants and sterilants. These reports should be reviewed regularly, and the facility should implement controls to prevent future exposures.
4. Health and safety concerns related to cleaning and disinfecting products should be regularly evaluated. An annual post-shift survey of acute symptoms may be a useful tool for (1) alerting management to symptoms experienced by cleaning staff and (2) identifying areas of the hospital where symptoms may be more commonly reported and exposures may be higher. Such a system may allow employees with symptoms related to cleaning or disinfecting products to be offered relocation to an area or unit of the hospital with lower risk of exposure to sporicidal disinfectants. This type of evaluation may also help the facility identify additional controls to reduce employee exposure.
5. Employees should report new, persistent, or worsening symptoms to their personal healthcare provider and, as instructed by their employer, to a designated individual at their workplace. An individualized management plan (such as assigning an affected employee to a different work location) is sometimes required, as indicated by medical findings and recommendations of the physician. Employees with symptoms should provide their personal physicians or other healthcare providers with a copy of this report.
6. A team approach should be used when introducing a new cleaning product or system. A committee of EVS staff, infection preventionists, and occupational health and safety representatives should be convened when new cleaners and sporicidal disinfectants are chosen for the facility. Acquiring buy-in from these different groups prior to investment is key to implementing a new cleaning product or system. A trial period

with a new cleaning system or product, with selected trial units or areas of the hospital, could be used to acquire feedback from stakeholders, including EVS staff, to evaluate new cleaning systems or products. Evaluation of a new cleaning system or product should consider effectiveness, cost, and employee health and safety concerns.

7. Ensure employees understand the potential hazards from exposure to cleaning products and how to protect themselves. OSHA's Hazard Communication Standard, also known as the "Right to Know Law" [29 CFR 1910.1200] requires that employees are informed of potential work hazards and trained on associated safe practices, procedures, and protective measures. Ensure employees have access and are informed of potential hazards and trained on the associated safe practices per the information found in the cleaning products' Safety Data Sheets. We found that some hospital employees have the impression that because the chemicals contained in OxyCide are similar to common household products, there is little health risk from exposure. The 2008 HICPAC Guideline recommends that each worker be informed of the possible health effect(s) of his or her exposure to chemicals. Specifically, employees should be educated on the documented health risks from exposure to HP, AA and PAA, as well as chemicals found in other cleaners at the hospital. This information should be consistent with Safety Data Sheets, Environmental Protection Agency regulations, and OSHA requirements and identify areas and tasks where there is the potential for exposure.
8. In an interim letter dated October 19, 2015, we observed that OxyCide was formerly used as a spray cleaner by some staff in some units. Because spraying OxyCide may increase an employee's risk of inhalational exposure, we recommend that employees discontinue the practice of using OxyCide as a spray cleaner. Instead, employees should continue using rags or wipes to apply OxyCide to surfaces.

Personal Protective Equipment

Personal protective equipment is the least effective means for controlling hazardous exposures. Proper use of personal protective equipment requires a comprehensive program and a high level of employee involvement and commitment. The right personal protective equipment must be chosen for each hazard. Supporting programs such as training, change-out schedules, and medical assessment might be needed. Personal protective equipment should not be the sole method for controlling hazardous exposures. Rather, personal protective equipment should be used until effective engineering and administrative controls are in place.

1. Require employees to wear extended cuff nitrile gloves or rubber gloves when using OxyCide and goggles or a face shield while dispensing and pouring OxyCide into or out of the bucket on their cleaning cart.

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Appendix A : Supplemental Analyses

All participants - Asthma

Twenty percent (n=32) of participants reported ever being diagnosed with asthma, which was 2.4 times higher (95% confidence interval (CI) = 1.6-3.4) than expected, compared to the U.S. adult population. Current asthma was reported by 14% (n=23) of participants and was 2.3 times higher (95% CI= 1.5-3.6) than expected. A total of 15 (9%) participants had adult-onset asthma, which was 2.8 times higher (95% CI=1.7-4.7) than expected. The pre-hire adult-onset asthma incidence density was 4.8 cases per 1000 person-years. The post-hire adult-onset asthma incidence density was 5.5 cases per 1000 person-years. This produced an incidence density ratio of 1.15, which shows no difference in adult-onset asthma between the pre-hire and post-hire group.

Health outcomes by EVS and non-EVS staff

Among EVS participants, the most commonly reported health outcomes were watery eyes (42%), nasal problems (41%), asthma-like symptoms (28%), and shortness of breath (16%). The most commonly reported health outcomes for non-EVS staff were use of allergy medicine (43%), nasal problems (43%), watery eyes (38%), and asthma-like symptoms (29%) (Table A2). Only the use of allergy medication and nasal allergies diagnosis ($p \leq 0.05$) were significant between EVS and non-EVS participants (Table A1). When compared to expected values for the U.S. adult population, EVS staff were not significantly different for the prevalence of shortness of breath, cough, wheeze, and watery eyes. Non-EVS staff were not significantly different when compared to the U.S. adult population for the prevalence of cough, wheeze and watery eyes. However, they were 57% less likely to report shortness of breath than the U.S. adult population and this difference was significant (SMR= 0.43, CI= 0.21-0.89).

Table A1. Health outcomes of EVS and non-EVS Staff, NIOSH survey August-September 2015

Health Outcome	EVS (n= 79)	Non-EVS (n= 84)	p*
Cough	3 (4%)	6 (7%)	0.50
Shortness of Breath	13 (16%)	8 (10%)	0.24
Wheeze†	11 (14%)	15 (18%)	0.53
Chest Tightness†	11 (14%)	7 (8%)	0.32
Asthma Attack†	2 (3%)	6 (7%)	0.28
Asthma Medicine	8 (10%)	10 (12%)	0.81
Allergy Medicine	12 (15%)	36 (43%)	≤0.05
Asthma-Like Symptoms§	22 (28%)	24 (29%)	1.00
Nasal Problems†	32 (41%)	36 (43%)	0.87
Watery Eyes†	33 (42%)	32 (38%)	0.75
Skin Problems†	12 (15%)	19 (23%)	0.24
Asthma			
Ever	13 (16%)	19 (23%)	0.33
Current	10 (13%)	13 (15%)	0.66
Nasal Allergies	10 (13%)	27 (32%)	≤0.05

Note: EVS=environmental services staff
*** P-values calculated using Chi-Square or Fisher's Exact Test; p ≤ 0.05 considered significant**
† In the past 12 months.
§ Asthma-like symptoms were defined as current use of asthma medicine and/or one or more of the following symptoms in the last 12 months: wheezing or whistling in the chest, awakening with a feeling of chest tightness, or attack of asthma.

Health outcomes by OxyCide use

A comparison of health outcomes between OxyCide users and non-users are shown in Table A2. The most commonly reported symptom among OxyCide users were watery eyes (45%), nasal problems (40%), and asthma-like symptoms (31%). Commonly reported symptoms among OxyCide non-users were nasal problems (44%), use of allergy medicine (38%), and watery eyes (35%). Only nasal allergy diagnosis and the use of allergy medication was significantly different between users and non-users (p≤0.05). Both OxyCide users and non-users were also not significantly different from the U.S. adult population for upper and lower respiratory symptoms.

The prevalence of ever having a physician diagnosis of asthma among OxyCide users was 2.1 times (95% CI = 1.2-3.7) that of the expected U.S. adult population. Similarly, the prevalence of current asthma among OxyCide users was 2.5 times (95% CI = 1.4-4.6) the expected prevalence for the U.S. adult population. Among OxyCide non-users, the prevalence of ever having a physician diagnosis of asthma or current asthma was also higher than the expected values for the U.S. adult population. Among OxyCide non-users, the prevalence of ever having physician diagnosed asthma was 2.6 times (95% CI = 1.6-4.2) and current asthma was 2.2 times (95% CI = 1.2-4.0), the expected prevalence for the U.S. adult population. The prevalence of work-related symptoms was generally higher in OxyCide users (Figure A1).

Table A2. Symptoms and self-reported diagnoses of the survey participants (N=163), by OxyCide Use, NIOSH survey, August-September 2015

Symptom	Disinfectant Use (n= 78)	No Disinfectant Use (n= 85)	p*
Nasal Problems†	31 (40%)	37 (44%)	0.64
Watery Eyes†	35 (45%)	30 (35%)	0.26
Asthma-Like Symptoms§	24 (31%)	22 (26%)	0.60
Skin Problems†	12 (15%)	19 (22%)	0.32
Wheeze†	12 (15%)	14 (16%)	1.00
Shortness of Breath	11 (14%)	10 (12%)	0.82
Chest Tightness†	10 (13%)	8 (9%)	0.62
Cough	5 (6%)	4 (5%)	0.74
Asthma Attack†	3 (4%)	5 (6%)	0.72
Medication Use			
Allergy Medicine	16 (21%)	32 (38%)	<0.05
Asthma Medicine	10 (13%)	8 (9%)	0.62
Diagnosis			
Asthma			
Ever	14 (18%)	18 (21%)	0.69
Current	12 (15%)	11 (13%)	0.66
Nasal Allergies	11 (14%)	26 (31%)	<0.05

Notes:
***P values calculated using Chi-square or Fisher's Exact Test**
†In the past 12 months.
§Asthma-like symptoms were defined as current use of asthma medicine and/or one or more of the following symptoms in the last 12 months: wheezing or whistling in the chest, awakening with a feeling of chest tightness, or attack of asthma.

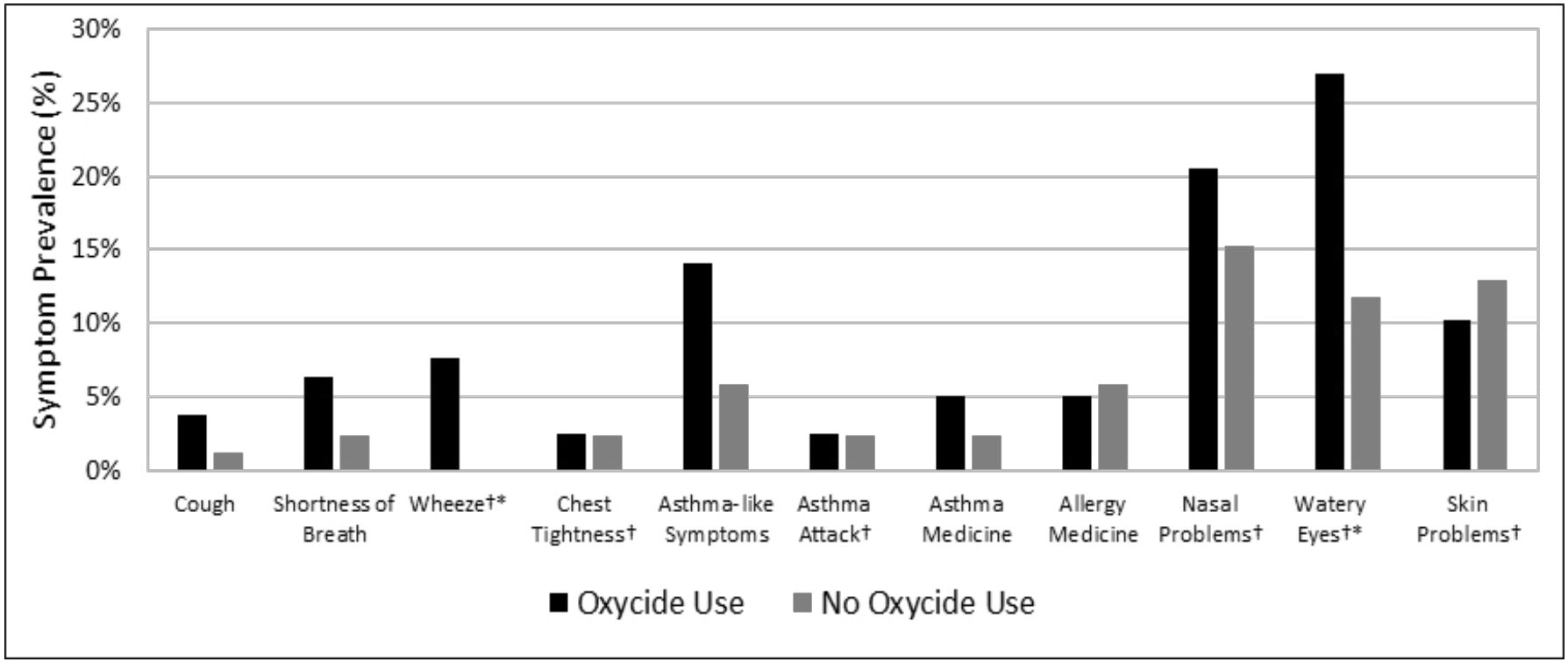

Figure A1. Prevalence of work-related health outcomes by OxyCide use, August-September 2015. Work-related symptoms were defined as symptoms that improved away from the facility, either on days off or on vacation.
*** Statistically significant differences ($p \leq 0.05$) are indicated by an asterisk next to the name of the symptom.**
† Indicates symptoms reported in the last 12 months.

Results for the 68 EVS participants who reported OxyCide use are shown in Table A3.

Table A3. Health outcomes of EVS staff who reported OxyCide use (N=68), NIOSH survey, August-September 2015.

Symptom	Symptom Prevalence, n (%)	Work Related Symptom* Prevalence, n (%)
Cough	3 (4%)	1 (1%)
Shortness of Breath	11 (16%)	5 (7%)
Wheeze†	10 (15%)	5 (7%)
Chest Tightness†	9 (13%)	2 (3%)
Asthma Attack†	2 (3%)	1 (1%)
Asthma-Like Symptoms§	19 (28%)	10 (15%)
Nasal Problems†	28 (41%)	15 (22%)
Watery Eyes†	31 (46%)	20 (29%)
Skin Problems†	10 (15%)	7 (10%)

***Work-related symptoms were defined as symptoms that improved away from the facility, either on days off or on vacation.**
† In the past 12 months.
§ Asthma-like symptoms were defined as current use of asthma medicine and/or one or more of the following symptoms in the last 12 months: wheezing or whistling in the chest, awakening with a feeling of chest tightness, or attack of asthma.

Acute symptoms in EVS staff during a work shift

Table A4 shows the results of logistic regression of acute symptoms during a work-shift in EVS staff in relation to exposure to acetic acid, hydrogen peroxide, and peracetic acid.

Table A4. Odds ratios** for acute symptoms and exposure to hydrogen peroxide, peracetic acid and acetic acid in EVS staff, July and September 2015.

Symptom	Hydrogen Peroxide (95% CI)	Peracetic Acid (95% CI)	Acetic Acid (95% CI)
Burning, itchy, runny nose*	**1.01 (1.00-1.02)**	**1.08 (1.02-1.15)**	**1.01 (1.00-1.02)**
Sneeze	1.01 (1.00-1.01)	1.02 (0.97-1.07)	1.00 (1.00-1.01)
Burning, itchy, watery eyes*	**1.01 (1.00-1.02)**	**1.10 (1.04-1.18)**	**1.02 (1.01-1.03)**
Burning, dry, sore throat	1.00 (1.00-1.01)	1.02 (0.97-1.08)	1.00 (1.00-1.01)
Cough	1.00 (0.99-1.00)	1.03 (0.98-1.09)	1.00 (1.00-1.01)
Wheeze	1.01 (1.00-1.02)	1.00 (0.89-1.08)	1.00 (0.99-1.01)
Chest Tightness	1.00 (0.98-1.01)	1.05 (0.94-1.16)	1.00 (0.98-1.01)
Shortness of Breath	1.00 (0.99-1.01)	1.05 (0.97-1.15)	1.00 (0.98-1.01)
Difficulty Breathing	1.00 (0.97-1.01)	1.04 (0.94-1.15)	1.00 (0.98-1.01)
Dizziness	1.00 (0.98-1.01)	1.03 (0.95-1.12)	1.00 (0.98-1.01)

*** 95% confidence intervals are displayed in parentheses.**
**** The odds ratios represent the change for every parts per billion change in exposure measurements. An odds ratio greater than one indicates an increase in symptoms for an increase in exposure.**
Exposures that were significantly associated with work-related acute symptoms at $p \leq 0.05$ are noted in bold.

Demographics of Air Sampling, Acute Symptom Survey, and Health and Work History Questionnaire Participants

Demographic information for cleaning staff who participated in the air sampling, post-shift survey, and health and work history questionnaire can be seen in Table A5. The median age of participants was 40 years and ranged from 20 to 67 years. Forty-three percent were male. Median tenure was 3.5 years and ranged from 0.21 to 26.2 years. Current, former, and never smokers accounted for 23%, 6%, and 71% of participants, respectively.

Table A5. Demographic characteristics of air sampling, acute symptom survey and health and work history questionnaire participants, August-September 2015

Characteristic	**Hospital Cleaning Staff (N=35)**
Age, years, median (range)	40 (20-67)
Tenure, years, median (range)	3.5 (0.21- 26.2)
Male, n (%)	15 (43%)
Race, n (%)	
White	11 (31%)
Black	17 (49%)
Asian	2 (6%)
Other†	4 (11%)
Unknown‡	1 (3%)
Smoking status, n (%)	
Current	8 (23%)
Former	2 (6%)
Never	25 (71%)

† Includes participants who indicated more than one race.
‡ Participants who refused to indicate a race.

Comparison between Responses Observed in the Post-Shift Acute Symptom Survey and in the Health and Work History Questionnaire

Thirty-five EVS employees participated in the health and work history questionnaire, post-shift survey, and personal air sampling. In Figure A2, we show the prevalence of symptoms reported by 35 employees in both the post-shift survey and health and work history questionnaire. Nasal and eye irritation were the most commonly reported symptoms in both surveys. Cough, nasal, and eye symptoms were more often reported in the post-shift survey as acute symptoms that were experienced during their work shift. Overall, employees reported similarly for acute symptoms that began during their work shift and symptoms reported as usually occurring or as having occurred in the last year.

We also explored associations between exposure to hydrogen peroxide, acetic acid, and peracetic acid and symptoms reported as occurring in the previous 12 months using logistic regression (Table A6). Asthma-like symptoms, nasal irritation, eye irritation, wheeze, and shortness of breath were associated with exposure to acetic acid, hydrogen peroxide, and

peracetic acid. Shortness of breath was significantly associated with hydrogen peroxide exposure. Additionally, exposure to hydrogen peroxide was associated with cough, chest tightness, and allergy medication use. We also explored associations between the use of cleaning products containing known asthmagens and work-related acute symptoms using logistic regression. The use of any single cleaning product containing quaternary ammonium compounds, bleach, ethanolamines or any combination of these products was not significantly associated with work-related acute symptoms. Overall, we observed similar reporting of work-related symptoms in the post-shift acute symptom survey and symptoms that employees had experienced in the last year. We observed associations between exposure to hydrogen peroxide, acetic acid, and peracetic acid and work-related symptoms in EVS employees who participated in both the post-shift acute symptom survey and health and work history questionnaire.

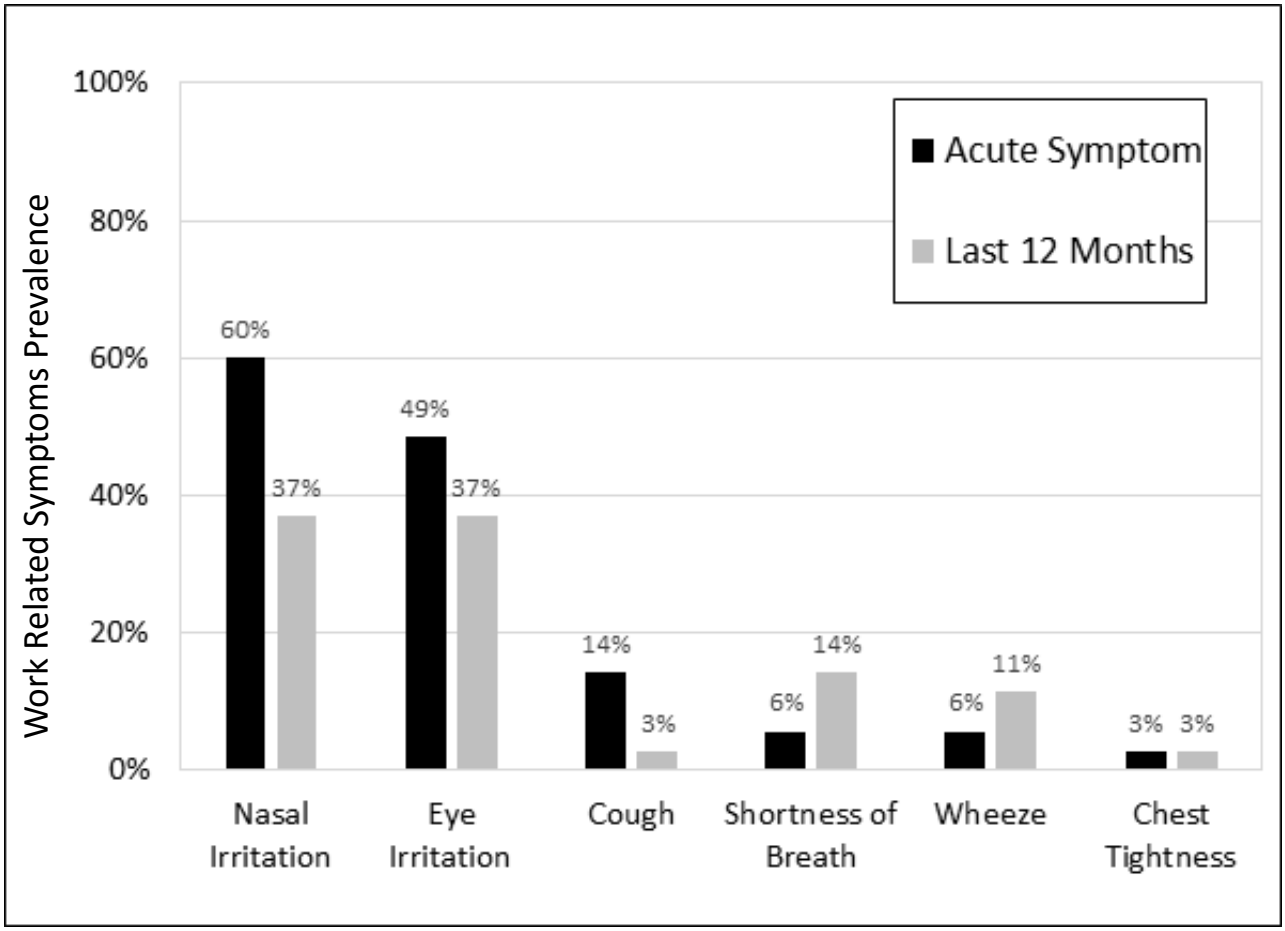

Figure A2. Prevalence of work-related symptoms reported by employees in the post-shift acute symptom survey and health and work history questionnaire (n=35), NIOSH survey, July-September 2015.

Table A6. Odds ratios** for symptoms reported as usually occurring or in the last 12 months with exposure to hydrogen peroxide, peracetic acid, and acetic acid, NIOSH survey, July-September 2015.

Condition	Hydrogen Peroxide (95% CI*)	Peracetic Acid (95% CI)	Acetic Acid (95% CI)
Nasal Problems, previous 12 months	1.01 (1.00-1.02)	1.07 (1.00-1.16)	1.00 (1.00-1.007)
Watery Eyes, previous 12 months	1.01 (1.00-1.02)	1.05 (0.99-1.14)	1.00 (1.00-1.01)
Usual Cough	1.01 (1.00-1.02)	0.88 (0.63-1.04)	1.00 (0.99-1.01)
Shortness of Breath on Level Ground*	**1.01 (1.00-1.02)**	1.04 (0.97-1.11)	1.00 (0.99-1.01)
Wheeze, previous 12 months	1.00 (0.99-1.01)	1.00 (0.91-1.08)	1.00 (0.99-1.01)
Awaken from chest tightness, previous 12 months	1.00 (0.53-2.34)	0.99 (0.90-1.07)	1.00 (0.99-1.00)
Asthma Medication Use	1.01 (1.00-1.02)	1.01 (0.90-1.11)	1.00 (0.99-1.01)
Asthma-like Symptoms	1.00 (1.00-1.01)	0.99 (0.92-1.05)	1.00 (0.99-1.01)

*** 95% confidence intervals are displayed in parentheses.**
**** The odds ratios represent the change for every parts per billion change in exposure measurements. An odds ratio greater than one indicates an increase in symptoms for an increase in exposure.**
Exposures that were significantly associated with work-related acute symptoms at $p \leq 0.05$ are noted in bold.

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Keywords: North American Industry Classification System 622110 (General Medical and Surgical Hospitals), Pennsylvania, peracetic acid, hydrogen peroxide, acetic acid, disinfectant, sporicidal agent, OxyCide

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The recommendations in this report are made on the basis of the findings at the workplace evaluated and may not be applicable to other workplaces.

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Availability of Report

Copies of this report have been sent to the employer, employees, and union at the facility. The state and local health department and the Occupational Safety and Health Administration Regional Office have also received a copy. This report is not copyrighted and may be freely reproduced.

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