Acute Occupational Disinfectant-Related Illness Among Youth, 1993–1998

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Working youths face many safety and health risks. Among these risks are those posed by disinfectant exposures. In this study we describe acute occupational disinfectant-related illness among youth. Data on U.S. children younger than 18 years with acute occupational disinfectant-related illnesses between 1993 and 1998 were collected from the Toxic Exposure Surveillance System and from the California Department of Pesticide Regulation. We analyzed data from persons with exposures who met the case definition for acute occupational disinfectant-related illness. The case definition required onset of new adverse health effects that were both temporally related to a disinfectant exposure and consistent with the known toxicology of the disinfectant. We calculated incidence rates of acute occupational disinfectant-related illness among youths 15–17 years old and incidence rate ratios to compare these rates with those of adults 25–44 years old. We found 307 children with disinfectant-related illnesses. The average annual incidence rate was 16.8/billion hours worked with a relative risk compared with adults of 4.14 (95% confidence interval, 3.66–4.68). Most illnesses were of mild severity (78%). There were no fatalities. Hypochlorites (e.g., bleach) were responsible for 45% of the illnesses. Among the 206 cases where the responsible disinfectant's U.S. Environmental Protection Agency toxicity category was known, 80% were in category I (highest toxicity level). These findings suggest the need for greater efforts to prevent adolescent acute occupational disinfectant-related illness. This may require strengthening regulations and enforcement as well as increased educational efforts directed at employers, youths, parents, school officials, and physicians. Better mechanisms for reporting and tracking chemical illnesses among working adolescents are also needed. ***Key words:*** **adolescence, disinfectants, halogens, hypochlorite, incidence, occupational diseases, phenols, poisoning, risk, youth.** ***Environ Health Perspect*** **111:1654–1659 (2003). doi:10.1289/ehp.6157 available via** ***http://dx.doi.org/*** **[Online 12 June 2003]**

Disinfectants are chemical or physical agents used widely on inanimate objects to kill disease-causing bacteria, viruses, protozoa, and fungi. Disinfectants are among the janitorial supplies used in institutional, commercial, and consumer settings. They are also widely used in the food industry to assist in the production, preservation, preparation, and service of foods and in numerous other industrial applications. In addition, disinfectants are used for water purification and treatment of waste water. Their effectiveness is altered by concentration, time of exposure, pH, temperature, and the amount of organic material present (Block 1993).

In the United States in 1999, 2.95 billion pounds of disinfectants were used, based on the weight of active ingredients. Most consisted of chlorine/hypochlorites used in disinfecting portable, waste, and recreational water (2.609 billion pounds). Excluding chlorine or hypochlorites, 62 million pounds of specialty biocides were used as disinfectants and sanitizers in industrial/institutional applications and household cleaning products, and 230 million pounds were used in swimming pools, spas, and industrial water treatment. The remaining 51 million pounds of biocides were used in other industries (i.e., adhesives and sealants, leather, synthetic latex polymers, metalworking fluids, paints and coatings, petroleum products, plastics, and mineral slurries) (Donaldson et al. 2002).

Unlike work regulations regarding agriculture [U.S. Department of Labor (DOL) 1970], no specific laws regulate working youths' exposure to or use of pesticides or disinfectants in nonagricultural industries.

A previous study (Calvert et al. 2003) showed that the rate of acute occupational pesticide-related illness was higher among working adolescents 15–17 years old than among workers 25–44 years old. Although the U.S. Environmental Protection Agency (U.S. EPA) classifies disinfectants under the general heading of pesticides, they were not included in that earlier report. To address the need for more information about the effects of disinfectant exposure upon working adolescents, in this study we provide information on the magnitude, incidence, and nature of acute occupational disinfectant-related illness among youth; compare those data with the corresponding data for adults; and provide recommendations for prevention of these illnesses.

Materials and Methods

We gathered data on all children 17 years old or younger and adults 25–44 years old who developed acute disinfectant-related illnesses occurring as a direct result of the person being on the job or in the workplace during 1993–1998. This report excludes cases involving nonoccupational exposures, exposures that produced no health effects, attempted suicide, cases of attempted homicide or child abuse, cases where the intent was euphoria or other psychotropic effect, and cases where intent could not be determined. The age range for adults was chosen *a priori* based on methodologies previously used to investigate occupational fatalities [Castillo et al. 1994; U.S. Bureau of Labor Statistics (BLS) 2000] and acute pesticide-related illnesses (Calvert et al. 2003).

We used data from the Toxic Exposure Surveillance System (TESS) and the California Department of Pesticide Regulation (CDPR; Sacramento, CA) for this investigation. TESS is maintained by the American Association of Poison Control Centers (Washington, DC) and collects poisoning reports from approximately 85% of the poison control centers (PCCs) in the United States (Litovitz et al. 1999). Four states did not participate in TESS: Maine, Mississippi, South Carolina, and Vermont. CDPR is a department of the California Environmental Protection Agency. CDPR maintains a database of known and suspected cases of acute pesticide poisoning, including disinfectant-related injuries. California is the only state that conducts surveillance on acute disinfectant-related illness. The greatest number (60–75%) of cases comes from workers' compensation reports reviewed at the California Bureau of Labor Statistics, with physicians' reports (required since 1971) providing most of the remainder (Calvert et al. 2001).

For each case report, staff from CDPR and the PCCs participating in TESS routinely collect information to determine whether the reported health effects were caused by the disinfectant exposure. Cases were included only if health effects developed after exposure and if the health effects were consistent with the known toxicology of the disinfectant product. Acute health effects

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We thank A. Mardis for providing the Current Population Survey data and D.F. Stroup and M. Petersen for their statistical advice.

The authors declare they have no conflict of interest.

Received 13 December 2002; accepted 12 June 2003.

from exposure to disinfectants usually involve inflammation, edema, and burns (Reigart and Roberts 1999). One case involving a girl 8 years old was excluded from analysis because of inconsistencies. Reportedly, after she inhaled phenol, her only medical finding was papilledema, and despite being coded with having an illness of major severity, her papilledema resolved within 8 hr. Our review of the literature found no association between phenol exposure and papilledema in the absence of other clinical findings.

Information collected by both TESS and CDPR included the date of the illness event, a determination of whether the illness occurred as the result of workplace exposure, information on the ill individual (age, sex, signs, and symptoms), and the disinfectant(s) that produced the illness. For each individual exposed, the CDPR database also recorded the industry, workplace activity of the individual when exposed, and whether personal protective equipment (PPE) was used. To avoid double-counting cases in the CDPR and TESS databases, we matched California cases on year of incident, age, sex, organ system affected, and disinfectant active ingredient. Individuals found in both databases were counted only once in the U.S. and California totals.

Information on illness severity was sought for all eligible cases. Cases provided by TESS included illness severity. A description of the severity categories used by PCCs participating in TESS has been previously described (Litovitz et al. 1999). A mild effect consists of minimally bothersome health effects that generally resolve rapidly. A moderate effect consists of non-life-threatening health effects that are more pronounced, prolonged, or of a systemic nature compared with minor effects. Major effects are life-threatening health effects or those that result in "significant residual disability or disfigurement." The TESS criteria [National Institute for Occupational Safety and Health (NIOSH) 2001] were used by the lead author (T.A.B.) to assign severity codes to the CDPR cases.

We obtained U.S. EPA acute toxicity category data for all disinfectants responsible for illness. The U.S. EPA classifies all disinfectant products into one of four acute toxicity categories based on established criteria (U.S. EPA 1975). Disinfectant products with the greatest toxicity are placed in category I, and those with the least toxicity are assigned to category IV. CDPR provided the acute toxicity category for the disinfectant products in each of their reported illnesses. TESS did not provide such information. For these cases, information on acute toxicity category was retrieved from a data set provided by the U.S. EPA.

Industry codes were available only in the California database. We converted these from the Standard Industrial Classification codes to U.S. Bureau of the Census (BOC) industry codes (BOCICs) for use in calculating the illness incidence rates (U.S. BOC 1992).

Five categories of disinfectants were analyzed for this study. Halogens include chlorine, hypochlorites, chlorine dioxide, *N*-chloramines, and iodine. Quaternary ammonium compounds (quats) are surface-active agents with the property of producing bacteriostasis in very high dilution. Phenolic compounds (phenols) include phenol derivatives, bisphenols (e.g., hexachlorophene), and coal-tar disinfectants (e.g., Lysol). Pine oils (mixtures of monoterpenes) have bactericidal activity but are used in disinfectant products primarily for their clean, woodsy odor (Block 1993). For CDPR cases that had an unknown disinfectant listed, and for TESS cases that did not have a disinfectant active ingredient specified, the disinfectant was classified as "unspecified." Unspecified disinfectants accounted for 14 and 19% of the cases in the youths and adults, respectively.

Case definition. Identification of cases in TESS relies on the experience and judgment of the PCCs specialist managing the specific case to determine whether the case has signs and symptoms consistent with the toxicology, dose, and timing of the disinfectant exposure, because there are no standardized criteria used to make this determination. The CDPR case definition has been described (Calvert et al. 2001). Briefly, CDPR requires that the onset of new adverse health effects be temporally related to the disinfectant exposure and that the health effects be consistent with known toxicology of the disinfectant from commonly available toxicology and epidemiology texts and reports.

Data analysis. We used SAS software (Proprietary Software Release 8.2; SAS Institute, Cary, NC) for data management and chi-square statistical analysis of categorical data. The chi-square or Fisher's exact test was used to assess the association between illness severity and disinfectant class, year, age, sex, and toxicity level. In addition, the chi-square or Fisher's exact test was used to compare the proportion of PPE use between youths and adults.

Average annual incidence rates for working adolescents 15–17 years old and working adults 25–44 years old were determined as follows. For each calculation, the numerator was obtained by summing the total number of cases of illness reported between 1993 and 1998. The denominators were obtained from the hours worked estimates derived from the Current Population Survey conducted between 1993 and 1998 as described previously (Ruser 1998; U.S. BLS 2001). The Current Population Survey does not collect data on workers younger than 15 years. Because youth work fewer hours per week and fewer weeks per year, it is preferable to use hours worked rather than employment counts when calculating rates for young workers (Ruser 1998). Using employment counts would underestimate the risk of acute disinfectant-related illness in adolescent workers.

An incidence rate ratio (IRR) of acute occupational disinfectant-related illness among youth 15–17 years of age was calculated by dividing the incidence rate (the number of acute disinfectant-related illnesses per hour worked) of the youths by the incidence rate of adults 25–44 years old. A ratio greater than 1 suggests that youth have a higher risk of acute occupational disinfectant-related illness compared with adults. In addition, we calculated IRRs for the two industries comprising most of the illnesses among California adolescents. We calculated confidence intervals (CIs)

Table 1. Number of youths with acute disinfectant-related illness by disinfectant class and severity, 1993–1998.

Disinfectant class	Illness severity: Mild	Moderate	Total (%)
Halogens	136	44	180 (58.6)
Quaternary ammonium compounds	30	9	39 (12.7)
Phenols	24	0	24 (7.8)
Pine oils	18	4	22 (7.2)
Unspecified	33	9	42 (13.6)
Total	241	66	307

Table 2. Clinical manifestations of disinfectant-related illness among 307 youths, 1993–1998.

Clinical effect	Number[a]	Percent
Eye	158	51
Irritation/pain/conjunctivitis	150	49
Blurred vision	13	4
Corneal abrasions	11	4
Corneal burns	10	3
Tearing	9	3
Skin	59	19
Irritation/pain	26	8
Rash	14	5
Pruritis/itching	12	4
Superficial burns	10	3
Edema/swelling	6	2
2nd–3rd-degree burns	2	1
Hives/welts	2	1
Gastrointestinal	50	16
Throat irritation	29	9
Nausea	17	6
Vomiting	11	4
Oral irritation	10	3
Noncardiac chest pain	4	2
Respiratory	35	11
Cough/choke	28	9
Dyspnea, shortness of breath	14	5
Noncardiac chest pain	7	2
Bronchospasm	3	1
Nervous system	22	7
Dizziness	10	3
Headache	10	3
Syncope, light headedness	3	1

[a]Because more than one clinical effect may have been reported for any one person, the sum of the specific effects may not total the number reported for the organ system as a whole.

according to methods previously described (Rothman 1996).

Results

From 1993 through 1998, we identified 307 youths, ages 6–17 years, with acute occupational disinfectant-related illness; 240 from TESS, ages 6–17, and 67 from CDPR, ages 14–17 (five cases identified by both databases were included only in the CDPR totals). The median age of cases was 17 years. Thirty-two (10.4%) were younger than 15 years, including 22 (7.2%) younger than 14 years. Males comprised 161 (52%) of the cases and females 146 (48%), including three pregnant teens. The average annual number of cases was 51, with a range of 49–52. Halogens were responsible for 59% (180 of 307) of all cases (Table 1). Among the halogens, hypochlorites were responsible for 77% (139 of 180). The organ systems most commonly affected were the eyes (51%), and the skin (19%). A summary of reported clinical manifestations is provided in Table 2.

The illness severity was rated mild in 241 (78%) of the cases, with 66 (22%) rated moderate (Table 3). No cases were rated severe, and there were no fatalities. There was no statistically significant difference in the distribution of illness severity by year (p = 0.195), sex (p = 0.346), age (p = 0.639), disinfectant class (p = 0.103), or toxicity category (p = 0.311).

Table 3. Age distribution of youths with acute disinfectant-related illness according to severity of illness, 1993–1998.

	Illness severity		
Age (years)	Mild	Moderate	Total (%)
6–11	13	0	13 (4.2)
12–14	13	6	19 (6.2)
15	23	10	33 (10.7)
16	64	21	85 (27.7)
17	128	29	157 (51.0)
Total (%)	241 (78.5)	66 (21.5)	307 (100)

Information on the U.S. EPA toxicity category was recorded (CDPR cases) or could be derived (TESS cases) for 206 (67%) of the youths' cases. Of these, 165 (80%) involved exposure to acute toxicity category I disinfectants, 36 (17%) to category II disinfectants, and 5 (2%) to category III.

Table 4 summarizes information on the incidence of acute occupational disinfectant-related illness in the United States and California. Among those 15–17 years old in 1993–1998, the average annual incidence rate for acute occupational disinfectant-related illness in the United States was 16.8/billion hours worked (BHW). The average annual incidence rates for California youths 15–17 years old were 55.9/BHW for all industries, 88.6/BHW in eating and drinking places (BOCIC 641), and 98.2/BHW in miscellaneous entertainment and recreation services (BOCIC 810). The relative risk of acute disinfectant-related illness was higher for adolescents than for adults in all instances. For the United States, the IRR was 4.14 (95% CI, 3.66–4.68] for working youths compared with adults. This ratio was slightly lower for the California cases (IRR = 2.91; 95% CI, 2.28–3.70). The IRR for those employed in eating and drinking places in California was also significantly elevated (IRR = 2.69; 95% CI, 1.86–3.91).

For the years 1993–1998 in California, industries that employed 38% of the 15- to 17-year-old adolescent workforce accounted for 69% of the disinfectant-related illness (U.S. BLS 2001). Although only 32% of California youths ages 15–17 years worked in eating and drinking establishments (BOCIC 641), this industry accounted for 57% of reported disinfectant-related illness in working adolescents. Six percent of Californians 15–17 years old worked in miscellaneous entertainment and recreation services (BOCIC 810), an industry accounting for 11.5% of the reported disinfectant-related illness among working adolescents. For the adults in 1993–1998, eating and drinking establishments employed 4% of 25- to 44-year-olds and accounted for 7.5% of the reported disinfectant illness. The respective proportions among these adults in the miscellaneous entertainment and recreation services were 1 and 3%.

Table 5 summarizes information on the seasonal incidence of acute occupational disinfectant-related illness in the United States and California using estimates of hours worked. The rate of illness is roughly the same for the summer months as for the rest of the year. The disinfectant-related illness incidence rates and IRRs remain elevated for working youths compared with adults in both the summer months and the remainder of the year.

Table 6 provides information on the annual incidence rate of U.S. working youths 15–17 years old and the annual IRR between these youths and working adults 25–44 years old. Between 1993 and 1998, there has been

Table 4. Total number of cases of acute occupational disinfectant-related illness, hours worked estimates, and IRRs, United States and California, and by BOCICs 641 and 810, 1993–1998.

		Working youth, 15–17 years old			Working adults, 25–44 years old			
Geographic location and industrial sector (BOCIC[a])	Source of data	Number (%)	Total hours worked[b]	Incidence rate[c]	Number (%)	Total hours worked[b]	Incidence rate[c]	IRR[d] (95% CI)
United States, all industries	TESS and CDPR	275 (100)	16,328	16.8	3,276 (100)	804,785	4.1	4.14 (3.66–4.68)
California, all industries	TESS and CDPR	68 (100)	1,217	55.9	1,835 (100)	804,785	19.2	2.91 (2.28–3.70)
California	CDPR							
All industries		61 (100)	1,217	50.1	1,728 (100)	95,429	18.1	2.77 (2.14–3.57)
Eating and drinking places (641)		35 (57.4)	395	88.6	130 (7.5)	3,955	32.9	2.69 (1.86–3.91)
Entertainment and recreation services (810)		7 (11.5)	71	98.2	52 (3)	937	55.5	1.77 (0.80–3.89)

[a]Industry codes available only for CDPR cases. [b]Estimate in millions of hours. [c]Per BHW. [d]Compares the risk of acute disinfectant-related illness among working youths with that of working adults.

Table 5. Total number of cases of acute occupational disinfectant-related illness, hours worked estimates, and IRRs, United States and California, by season, 1993–1998.

	Working youths, 15–17 years old			Working adults, 25–44 years old			
Geographic location and season[a]	Number (%)	Total hours worked[b]	Incidence rate[c]	Number (%)	Total hours worked[b]	Incidence rate[c]	IRR[d] (95% CI)
United States							
June–August	102	6,448	15.8	944	196,327	4.8	3.29 (2.68–4.04)
September–May	173	9,881	17.5	2,332	608,458	3.8	4.57 (3.91–4.94)
Total	275	16,328	16.8	3,276	804,785	4.1	4.14 (3.66–4.68)
California							
June–August	24	461	52.0	543	23,671	22.9	2.27 (1.51–3.41)
September–May	44	756	58.2	1,292	71,758	20.3	3.23 (2.29–3.37)
Total	68	1,217	55.9	1,835	95,429	19.2	2.91 (2.28–3.70)

[a]Data from both TESS and CDPR were used. [b]Estimate in millions of hours. [c]Per BHW. [d]Compares the risk of acute disinfectant-related illness among working youths with that of working adults.

little change in the observed incidence rates or IRRs (Figure 1).

The use of PPE was recorded only in the CDPR data. Among the 67 youths identified by CDPR with acute disinfectant related illness, 63 had information on whether PPE was used (Table 7). Among these 63, 22 (35%) youths used PPE. Of the 39 cases with ocular involvement and information on PPE use, only one youth was wearing any eye protection, consisting only of his sunglasses (a lifeguard adding chlorine tablets to the pool skimmer). Of the 12 youths with dermatologic illness, three wore protective equipment. These included one youth who wore short chemical gloves but had an eyelid irritation, and two youths who wore protective eye gear but developed lesions on their hands. Among the 14 California youths who had a respiratory illness and information on PPE use, none used any respiratory PPE. Three youths with respiratory illness also had gastrointestinal effects. Overall, a statistically significantly higher proportion of adults with acute occupational disinfectant-related illness wore PPE compared with youths ($p = 0.006$). However, within the industries that employed most of the ill youths, there was no significant difference in PPE use between youths and adults.

Case reports. A few representative cases that were detected through these surveillance efforts are briefly described below.

Case 1. A 17-year-old female food establishment worker was cleaning a sink with a cyanurate (halogen) disinfectant solution (toxicity category II) when she splashed some of it into her left eye. She experienced redness and pain and was diagnosed with scleral and corneal burns of her left eye. She missed 3 days of work. Although wearing long chemical-resistant gloves, she did not use eye protection and was not adequately trained.

Cases 2 and 3. Two males, 14 and 16 years old, while working in a job-training situation, mixed together bleach (toxicity category I), a lime descaler (hydroxyacetic/phosphoric acid mixture), and a detergent to clean the walls of a gym shower. From the released chlorine gas, they experienced coughing, burning of the eyes and throat, and chest irritation. They missed no days of work.

Case 4. A 14-year-old male restaurant worker cleaned the kitchen walls with sodium hypochlorite bleach (toxicity category not recorded). He sought medical attention the next day for burning, red, swollen, and sore hands. He wore safety glasses but no hand protection. He missed 7 days of work.

Discussion

Most U.S. youths work at some point during their school years (Institute of Medicine 1998). Attention has been paid to injuries that occur in the workplace (Brooks and Davis 1996; Castillo et al. 1994; Dunn et al. 1998; Hendricks and Layne 1999; Runyan and Zakocs 2000), but less information is available on chemical exposures (Pollack 2001; Woolf and Flynn 2000; Woolf et al. 2001). In this study, we addressed the need for more information on chemical exposures in the workplace and found that working youths are at a higher risk of acute occupational disinfectant-related illness than are adults. We found an average annual incidence rate of 16.8 acute disinfectant-related illness per billion hours worked for working youths 15–17 years old, with a relative risk compared with adults of 4.14 (95% CI, 3.66–4.68). These findings suggest a need for greater efforts to monitor and prevent these illnesses.

Recognizing the job hazards faced by youth, several organizations have previously made recommendations to better educate employers, workers, physicians, parents, and schools about safety and health issues in adolescent employment. These organizations include the American Academy of Pediatrics (AAP 1995), the American Academy of Family Physicians (Rubenstein et al. 1999), and the Centers for Disease Control and Prevention (NIOSH 1995). In addition, recommendations have been made for strengthening enforcement of the Fair Labor Standards Act (FLSA 1938) and child labor laws, revising the work permit system, increasing surveillance of workplace illness and injury, and providing better (uniform) data collection (AAP 1995; American Public Health Association 2001; NIOSH 1997).

The National Longitudinal Survey of Youth 1997 found that at age 12 half of American youths engage in some work activity (U.S. BLS 2000). This occurs despite a minimum age requirement of 14 years for most work (U.S. DOL 1976a). Thirty-two of our 307 (10.4%) cases were younger than 15 years, with 22 (7.2%) younger than 14 years. Nonagricultural jobs that involve handling or applying disinfectants are not explicitly prohibited from youth. The only proviso in the FLSA that may be construed to apply to disinfectant exposures in nonagricultural jobs is one stating that the employment of those between the ages of 14 and 16 be confined to "conditions that will not interfere with their health and well-being" (U.S. DOL 1976a, 1976b).

Working youths have a legal right to a safe workplace as well as compensation for medical and rehabilitation expenses and lost wages for injuries and illnesses occurring on their jobs. However, youths are generally less experienced and assertive than adults and may not question assignments that place them at risk in the workplace (Castillo et al. 1999; Zakocs et al. 1998). In addition, those who become ill or injured on the job may be less likely to enter the workers' compensation system because many are part-time workers and may fail to meet the criteria for missed work days or lost work time (Castillo et al. 1999).

Use of PPE among youths was low. Although at least 34 California youths were exposed to toxicity category I disinfectants, which require the use of goggles and protective gloves (U.S. EPA 1992), only 12 (35%) of these youths used PPE. Because the overall prevalence of PPE use among working youths is not available, it is not known whether the low proportion of youths wearing PPE is widespread or confined only to poisoned youths.

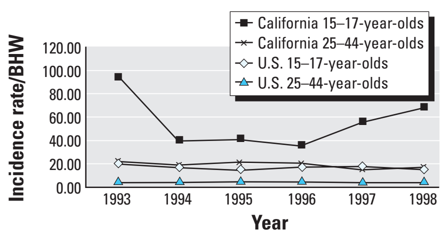

Figure 1. Acute occupational disinfectant-related illness incidence rates, per BHW, United States and California, 1993–1998. Data from both TESS and CDPR were used.

Table 6. Annual number of cases of acute occupational disinfectant-related illnesses, hours worked estimates, incidence rate, and IRRs, United States, 1993–1998.

	Working youths, 15–17 years old			Working adults, 25–44 years old			
Year	Number	Total hours worked[a]	Incidence rate[b]	Number	Total hours worked[a]	Incidence rate[b]	IRR[c] (95% CI)
1993	47	2,366	19.9	519	133,066	3.9	5.09 (3.78–6.87)
1994	44	2,636	16.7	516	131,773	3.9	4.26 (3.13–5.80)
1995	39	2,752	14.2	589	132,993	4.4	3.20 (2.31–4.42)
1996	48	2,794	17.2	592	134,419	4.4	3.90 (2.91–5.23)
1997	49	2,801	17.5	511	136,483	3.7	4.67 (3.49–6.26)
1998	48	2,980	16.1	549	136,050	4.0	3.99 (2.97–5.36)
Total	275	16,328	16.8	3,276	804,785	4.1	4.14 (3.66–4.68)

[a]Estimate in millions of hours. [b]per BHW. [c]Compares the risk of acute disinfectant-related illness among working youths with that of working adults.

Table 7. Use of PPE among youths and adults with acute occupational disinfectant-related illness, California, 1993–1998.

Clinical effects and industrial sector	Working youth, 14–17 years old: No. with clinical effect	No. with PPE data (%)	PPE used (%)	Working adults, 25–44 years old: No. with clinical effect	No. with PPE data (%)	PPE used (%)	*p*-Value
All Cases	67	63 (94)	22 (35)[a]	1,728	1,519 (88)	797 (52)[a]	0.006
BOCIC 641	36	35 (97)	9 (26)[a]	130	119 (92)	27 (22)[a]	0.710
BOCIC 810	8	7 (88)	1 (14)[a]	52	45 (87)	22 (49)[a]	0.117
Eye							
All BOCIC	40	39 (98)	1 (3)[b]	989	875 (88)	153 (17)[b]	0.015
BOCIC 641	19	18 (95)	0 (0)[b]	82	72 (89)	3 (4)[b]	0.999*
BOCIC 810	6	6 (100)	1 (17)[b]	18	16 (89)	2 (12)[b]	0.999*
Respiratory							
All BOCIC	17	14 (82)	0 (0)[c]	598	399 (67)	17 (4)[c]	0.999*
BOCIC 641	7	6 (86)	0 (0)[c]	22	19 (86)	0 (0)[c]	—
BOCIC 810	2	1 (50)	0 (0)[c]	27	21 (78)	2 (10)[c]	0.999*
Skin							
All BOCIC	12	12 (100)	3 (25)[a]	330	308 (93)	178 (58)[a]	0.025
BOCIC 641	9	9 (100)	1 (11)[a]	42	41 (98)	10 (24)[a]	0.662*
BOCIC 810	1	1 (100)	0 (0)[a]	8	7 (88)	6 (86)[a]	0.250*
Gastrointestinal							
All BOCIC	4	3 (75)	0 (0)[a]	210	160 (76)	72 (45)[a]	0.256*
BOCIC 641	3	3 (100)	0 (0)[a]	9	8 (89)	7 (88)[a]	0.024*
BOCIC 810	0	—	—	11	8 (73)	2 (18)[a]	—
Nervous system							
All BOCIC	10	8 (80)	4 (50)[a]	317	238 (75)	106 (45)[a]	0.999*
BOCIC 641	4	4 (100)	1 (25)[a]	11	10 (91)	2 (20)[a]	0.999*
BOCIC 810	1	0	0 (0)	10	10 (100)	2 (20)[a]	—

BOCIC 641, employed in eating and drinking places; BOCIC 810, employed in entertainment and recreation services.
[a]Any PPE. [b]Eye protection. [c]Respiratory protection. *Fisher's exact test.

The findings in this study suggest the need to educate youths on appropriate PPE use. Also, because some youths who wore PPE still became ill, efforts are needed to ensure appropriate use of PPE, and to ensure that gloves and goggles are available to youths who may require sizes smaller than those available for adults.

No state besides California has a surveillance system to identify acute disinfectant-related illness. As observed in California, state-based surveillance systems can identify many more cases compared with PCCs. California's PCCs found only 118 of 1,835 California adults and 14 of 76 youths with acute occupational disinfectant-related illness. However, state-based surveillance systems also miss many cases. There are many reasons for this including the presence of barriers that can prevent workers from filing for workers' compensation insurance benefits, and the lack of physician reporting (Azaroff et al. 2002). If these barriers disproportionately affect youth, differential workers' compensation reporting between youths and adults may bias the IRRs toward the null.

There are limitations with the data used in this analysis. TESS forms a nationwide system that collects information on toxic chemical exposures, but does not collect information on industry and occupation or information about the circumstances that led to the disinfectant work-related exposure. Without this additional coding, the true status of the youths who were coded as occupational exposures is not clear. Although PCCs may be the best national data collection currently available for toxic exposures in the workplace for youths (Woolf and Flynn 2000; Woolf et al. 2001), they miss many adults and working adolescents that worker compensation systems collect. Because TESS may more effectively capture youth cases compared with adults (Litovitz et al. 1999), this may explain the higher IRRs that were observed when the TESS data were used compared with when only CDPR data were used (Table 3).

An additional limitation was that California accounted for more than half of the U.S. adult cases (1,836 of 3,276) and almost one-fourth of the U.S. youth cases (76 of 307) of acute occupational disinfectant-related illness, with most of these cases identified by CDPR. As such, our industry-specific findings may not be representative of the entire United States. Although we would expect that other states would have similar risks in eating and drinking establishments (BOCIC 641) and in miscellaneous entertainment and recreation services (BOCIC 810), additional industries in other states may be found that have high risks.

To address the need for better data collection and disease prevention, we suggest the following: *a*) Information on child labor laws, recognition and prevention of adolescent occupational hazards, and disease and injury reporting requirements should be disseminated more effectively to employers, youths, parents, school officials and physicians. *b*) PCCs should collect data on the industry/occupation involved, the type of work activity at the time of illness, and information on the use of PPE. *c*) All states should collect information on occupational disinfectant-related illnesses. Improved access to worker compensation data can help accomplish this. These data may identify additional industries and work activities with a high risk for disinfectant-related illness. *d*) The U.S. BLS should collect statistics on working youths younger than 15 years. This would provide additional denominator data for calculating injury and illness rates. *e*) The FLSA should be reviewed and appropriately revised to ensure that workers younger than 18 years are protected against disinfectant exposures. *f*) Better enforcement of existing workplace health and safety regulations may also be needed, especially to ensure that PPE are used in accordance with the disinfectant label.

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