This search summary contains the results of a literature search undertaken by the Lincolnshire Knowledge and Resource Service librarians in February 2012.

All of the literature searches we complete are tailored to the specific needs of the individual requestor. If you would like this search re-run with a different focus, or updated to accommodate papers published since the search was completed, please let us know.

We hope that you find the information useful. If you would like the full text of any of the abstracts listed, please let us know.

Alison Price  alison.price@lpct.nhs.uk
Janet Badcock  janet.badcock@lpct.nhs.uk

Librarians, Lincolnshire Knowledge and Resource Service
NHS Lincolnshire

Beech House,
Waterside South
Lincoln LN5 7JH
Chlorine in swimming pools: health effects on lifeguard / pool attendants. Evidence re: the above especially eye problems - I have one article by Lenntech.

Search requested: 23rd February 2012  
Completed by: Alison Price, 24th February 2012

The article cited by LennTech was published by Abvakado Nederland, the Dutch public sector trade union. I have not been able to locate any further reference to this research, and it is not listed on the available databases or on Google Scholar.

Eyes

Title: Acute illness and injury from swimming pool disinfectants and other chemicals --- United States, 2002–2008
Abstract: Swimming pools require disinfectants and other chemicals to maintain water quality and prevent swimmers from acquiring infections. When these chemicals are stored or used improperly or when they are handled or applied by persons not using appropriate personal protective equipment (PPE), illness or injury can result. To assess the frequency of illness and injury related to pool chemicals, CDC analyzed data for the period 2002–2008 from six states participating in the Sentinel Event Notification System for Occupational Risk (SENSOR)--Pesticides surveillance program and from the National Electronic Injury Surveillance System (NEISS). This report describes the results of that analysis, which identified 584 cases of illness or injury associated with pool chemicals in the six SENSOR-Pesticides states and indicated an estimated national total of 28,071 cases (based on 688 NEISS cases) during that period. For the 77% of state cases and 49% of NEISS cases that had sufficient information to determine factors contributing to illness or injury, the most common contributing factors included mixing incompatible products, spills and splashes of chemicals, lack of appropriate PPE use, and dust clouds or fumes generated by opening a chemical container. Adhering to existing CDC recommendations can prevent some of the reported illnesses and injuries, but additional measures (e.g., improving package design to limit the release of dust clouds and fumes when a container is opened, making containers child-proof, and making product labels easier to understand) might reduce them further.

Contact LKRS for full text.

Symptoms most frequently reported were respiratory symptoms, such as cough, upper respiratory irritation, and dyspnea (65% of state cases and 24% of NEISS cases), eye injuries (33% of state cases and 42% of NEISS cases), and skin injuries (18% of state cases and 19% of NEISS cases). In the six SENSOR-Pesticides states, the active ingredients most frequently associated with acute illness or injury were sodium hypochlorite (31%), triazine compounds (22%), and calcium hypochlorite (16%). Most of the disinfectants were toxicity category I (87%). The majority of state cases (85%) involved low-severity illnesses or injuries. Forty percent of state cases were work-related, 9% of which involved loss of 1 or more days from work. A small proportion of cases involved hospitalization (2% of state cases and 4% of NEISS cases).
Editorial Note
Chlorine-based disinfectants are the most commonly used disinfectants for treating swimming pool water. A total of 36 pool chemical-associated events were reported in New York during 1983–2007, of which 31 events were attributed to chlorine gas exposure, which most often resulted from mixing sodium hypochlorite solutions (e.g., household chlorine bleach) with acid (4). In England and Wales, 13 events involving pool chemicals were reported during June–October 2007, of which 10 events involved sodium hypochlorite and nine events resulted from equipment failure or mixing incompatible chemicals (5). Several individual cases of illness or injury attributed to pool disinfectants have been reported and include respiratory illness and eye and skin injury (6,7).

Title: Prevalence of ocular, respiratory and cutaneous symptoms in indoor swimming pool workers and exposure to disinfection by-products (DBPs)
Citation: International Journal of Environmental Research and Public Health, April 2010, vol./is. 7/4(1379-1391), 1660-4601 (April 2010)
Author(s): Guglielmina F., Righi E., Predieri G., Giacobazzi P., Mastroianni K., Abstract: The objective of this cross-sectional study was to investigate the prevalence of self-reported respiratory, ocular and cutaneous symptoms in subjects working at indoor swimming pools and to assess the relationship between frequency of declared symptoms and occupational exposure to disinfection by-products (DBPs). Twenty indoor swimming pools in the Emilia Romagna region of Italy were included in the study. Information about the health status of 133 employees was collected using a self-administered questionnaire. Subjects working at swimming pools claimed to frequently experience the following symptoms: cold (65.4%), sneezing (52.6%), red eyes (48.9%) and itchy eyes (44.4%). Only 7.5% claimed to suffer from asthma. Red eyes, runny nose, voice loss and cold symptoms were declared more frequently by pool attendants (lifeguards and trainers) when compared with employees working in other areas of the facility (office, cafe, etc.). Pool attendants experienced generally more verrucas, mycosis, eczema and rash than other workers; however, only the difference in the frequency of self-declared mycosis was statistically significant (p = 0.010). Exposure to DBPs was evaluated using both environmental and biological monitoring. Trihalomethanes (THMs), the main DBPs, were evaluated in alveolar air samples collected from subjects. Swimming pool workers experienced different THM exposure levels: lifeguards and trainers showed the highest mean values of THMs in alveolar air samples (28.5 +/- 20.2 mug/m^3), while subjects working in cafe areas (17.6 +/- 12.1 mug/m^3), offices (14.4 +/- 12.0 mug/m^3) and engine rooms (13.6 +/- 4.4 mug/m^3) showed lower exposure levels. Employees with THM alveolar air values higher than 21 mug/m^3 experienced higher risks for red eyes (OR 6.2; 95% CI 2.6-14.9), itchy eyes (OR 3.5; 95% CI 1.5-8.0), dyspnea/asthma (OR 5.1; 95% CI 1.0-27.2) and blocked nose (OR 2.2; 95% CI 1.0-4.7) than subjects with less exposure. This study confirms that lifeguards and trainers are more at risk for respiratory and ocular irritative symptoms and cutaneous diseases than subjects with other occupations at swimming pool facilities. Contact LKRS for full text.
Title: **Ocular and respiratory symptoms among lifeguards at a hotel indoor waterpark resort.**

Citation: Journal of Occupational & Environmental Medicine, February 2010, vol./is. 52/2(207-13), 1076-2752;1536-5948 (2010 Feb)

Author(s): Dang B, Chen L, Mueller C, Dunn KH, Almaguer D, Roberts JL, Otto CS

Abstract: OBJECTIVES: To determine the cause of eye and respiratory irritation symptoms among lifeguards at an indoor waterpark. METHODS: Investigators 1) performed environmental sampling for chloramine, endotoxin, and microbials; 2) administered symptom questionnaires; 3) reviewed ventilation system designs; and 4) reviewed water chemistry. RESULTS: Airborne trichloramine concentrations were found at levels reported to cause irritation symptoms in other studies. Some endotoxin concentrations were found at levels associated with cough and fever in previous studies. Exposed lifeguards were significantly more likely to report work-related irritation symptoms than unexposed individuals. The ventilation system may not have provided sufficient air movement and distribution to adequately capture and remove air contaminants at deck level. No water microbes were detected, and water chemistry met state standards. CONCLUSIONS: Indoor waterparks need to control water chemistry and ensure adequate air movement and distribution to control air contaminants and reduce health symptoms.

Title: **Respiratory and ocular symptoms among employees of a hotel indoor waterpark resort--Ohio, 2007**

Citation: MMWR. Morbidity and mortality weekly report, February 2009, vol./is. 58/4(81-85), 1545-861X (6 Feb 2009)

Abstract: During January--March 2007, the Warren County Combined Health District (WCCHD) received 665 reports of respiratory and eye irritation from patrons and lifeguards at a hotel indoor waterpark resort in Ohio. Tests revealed normal water chemistry and air chlorine concentrations, and exposure to airborne trichloramine in the waterpark was suspected as the cause of the symptoms. Because of the number of symptom reports and WCCHD's limited ability to measure trichloramine, the district requested an investigation by CDC's National Institute for Occupational Safety and Health (NIOSH). This report describes the results of that investigation, which revealed that trichloramine concentrations in the waterpark ranged from below the limit of detection to 1.06 mg/m3, and some concentrations were at levels that have been reported to cause irritation symptoms (≥0.5 mg/m3). Lifeguards reported significantly more work-related symptoms (e.g., cough, wheezing, shortness of breath, chest tightness, and eye irritation) than unexposed hotel employees. Lifeguards also reported significantly more eye irritation and cough on days when hotel occupancy was high versus low. Insufficient air movement and distribution likely led to accumulation of trichloramine and exacerbation of symptoms. Based on recommendations to increase air movement and distribution at pool deck level, hotel management modified the ventilation system extensively, and subsequently no new cases were reported to WCCHD. The results of this investigation emphasize the importance of appropriate design and monitoring of ventilation and water systems in preventing illness in indoor waterparks.

http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5804a3.htm
Respiratory symptoms and bronchial responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming pools.

Citation: Occupational & Environmental Medicine, April 1998, vol./is. 55/4(258-63), 1351-
Author(s): Massin N, Bohadana AB, Wild P, Hery M, Toamain JP, Hubert G

Abstract: OBJECTIVES: To measure the levels of exposure to nitrogen trichloride (NCl3) in the atmosphere of indoor swimming pools and to examine how they relate to irritant and chronic respiratory symptoms, indices of pulmonary function, and bronchial hyperresponsiveness to methacholine in lifeguards working in the pools.

METHOD: 334 lifeguards (256 men; 78 women) recruited from 46 public swimming pools (n = 228) and 17 leisure centre swimming pools (n = 106) were examined. Concentrations of NCl3 were measured with area samplers. Symptoms were assessed by questionnaire and methacholine bronchial challenge (MBC) test by an abbreviated method. Subjects were labelled MBC+ if forced expiratory volume in one second (FEV1) fell by ≥ 20%. The linear dose-response slope was calculated as the percentage fall in FEV1 at the last dose divided by the total dose given.

RESULTS: 1262 samples were taken in the 63 pools. Mean NCl3 concentrations were greater in leisure than in public pools. A significant concentration-response relation was found between irritant eye, nasal, and throat symptoms—but not chronic respiratory symptoms—and exposure concentrations. Among women, the prevalence of MBC+ was twice as great as in men. Overall, no relation was found between bronchial hyperresponsiveness and exposure.

CONCLUSIONS: The data show that lifeguards exposed to NCl3 in indoor swimming pools are at risk of developing irritant eye, nasal, and throat symptoms. Exposure to NCl3 does not seem to carry the risk of developing permanent bronchial hyperresponsiveness, but this association might have been influenced by self selection. The possibility that subjects exposed to NCl3 are at risk of developing transient bronchial hyperresponsiveness cannot be confidently ruled out.
Title: Trihalomethane exposures in indoor swimming pools: A level III fugacity model
Citation: Water Research, October 2011, vol./is. 45/16(5084-5098), 0043-1354;1879-
Author(s): Dyck R., Sadiq R., Rodríguez M.J., Simard S., Tardif R.
Abstract: The potential for generation of disinfection byproducts (DBPs) in swimming pools is high due to the concentrations of chlorine required to maintain adequate disinfection, and the presence of organics introduced by the swimmers. Health Canada set guidelines for trihalomethanes (THMs) in drinking water; however, no such guideline exists for swimming pool waters. Exposure occurs through ingestion, inhalation and dermal contact in swimming pools. In this research, a multimedia model is developed to evaluate exposure concentrations of THMs in the air and water of an indoor swimming pool. THM water concentration data were obtained from 15 indoor swimming pool facilities in Quebec (Canada). A level III fugacity model is used to estimate inhalation, dermal contact and ingestion exposure doses. The results of the proposed model will be useful to perform a human health risk assessment and develop risk management strategies including developing health-based guidelines for disinfection practices and the design of ventilation system for indoor swimming pools. 2011 Elsevier Ltd.

Title: Haloacetic acids in swimming pools: swimmer and worker exposure.
Citation: Environmental Science & Technology, July 2011, vol./is. 45/13(5783-90), 0013-
Author(s): Cardador MJ, Gallego M
Abstract: For the first time, the exposure of swimmers and workers to haloacetic acids (HAAs) in indoor and outdoor pools was evaluated through the analysis of urine samples. The subjects of this study, 49 volunteers, were male and female workers as well as swimmers (adults and children) who regularly attended an indoor pool (January-June) and an outdoor one (July and August). The results showed that HAAs appeared 20-30 min after exposure and were eliminated within 3 h. After 2 h exposure, urine samples taken from workers contained dichloroacetic (DCAA) and trichloroacetic (TCAA) acids at ~300 and ~120 ng/L levels since HAAs were aerosolized in the indoor ambient, whereas only DCAA was found in some workers' urine samples from the outdoor pool but at ~50 ng/L levels, despite the fact that the outdoor pools generally had somewhat higher levels of HAAs than the indoor pools. After 1 h swimming TCAA, DCAA and MCAA were present at concentrations of ~4400, ~2300, and ~560 ng/L, respectively, in the swimmers' urine in the indoor pool; similar results were obtained from the swimmers in the outdoor pool due to accidental ingestion. Finally, exposure estimates indicate that ingestion is the major route of exposure (~94%), followed by inhalation (~5%) and dermal contribution (~1%).
Title: Occupational exposure to trihalomethanes in indoor swimming pools.  
Citation: Science of the Total Environment, January 2001, vol./is. 264/3(257-65), 0048- 
Author(s): Fantuzzi G, Righi E, Predieri G, Ceppelli G, Gobba F, Aggazzotti G  
Abstract: The study evaluated occupational exposure to trihalomethanes (THMs) in indoor swimming pools. Thirty-two subjects, representing the whole workforce employed in the five public indoor swimming pools in the city of Modena (Northern Italy) were enrolled. Both environmental and biological monitoring of THMs exposure were performed. Environmental concentrations of THMs in different areas inside the swimming pools (at the poolside, in the reception area and in the engine-room) were measured as external exposure index, while individual exposure of swimming pool employees was estimated by THMs concentration in alveolar air. The levels of THMs observed in swimming pool water ranged from 17.8 to 70.8 microg/l; the mean levels of THMs in ambient air were 25.6+/-24.5 microg/m3 in the engine room, 26.1+/-24.3 microg/m3 in the reception area and 58.0+/-22.1 microg/m3 at the poolside. Among THMs, only chloroform and bromodichloromethane were always measured in ambient air, while dibromochloromethane was detected in ambient air rarely and bromoform only once. Biological monitoring results showed a THMs mean value of 20.9+/-15.6 microg/m3. Statistically significant differences were observed according to the main job activity: in pool attendants, THMs alveolar air were approximately double those observed in employees working in other areas of the swimming pools (25.1+/-16.5 microg/m3 vs. 14.8+/-12.3 microg/m3, P < 0.01). THMs in alveolar air samples were significantly correlated with THMs concentrations in ambient air (r = 0.57; P < 0.001). Indoor swimming pool employees are exposed to THMs at ambient air levels higher than the general population. The different environmental exposure inside the swimming pool can induce a different internal dose in exposed workers. The correlation found between ambient and alveolar air samples confirms that breath analysis is a good biological index of occupational exposure to these substances at low environmental levels.
**Title:** Assessment of exposure of workers and swimmers to trihalomethanes in an indoor swimming pool.

Citation: Environmental Science & Technology, July 2007, vol./is. 41/13(4793-8), 0013-936X;0013-936X (2007 Jul 1)

Author(s): Caro J, Gallego M

Abstract: A simultaneous study on workers' and swimmers' exposure to trihalomethanes (THMs) in an indoor swimming pool has been carried out by analyzing urine samples using the headspace and gas chromatography-mass spectrometry technique. The subjects of this study were male and female workers of an indoor swimming pool as well as swimmers regularly attending the pool. The results reported show that only chloroform and bromodichloromethane were detected in the urine of those people exposed, which can be used as a specific index of exposure to these compounds. THM uptake of swimmers after 1 h of swimming was higher than that of workers after a 4 h work shift since THM levels in the workers' urine were associated only with inhalation, while levels in swimmers' urine were mainly associated with dermal absorption, apart from inhalation and occasional ingestion, as well as increased uptake due to the physical stress (swimming). The kinetics of THM excretion in the urine of the participants exposed has been calculated after termination of the exposure to select the sampling time and determine the elimination process. An interval of 15 min after exposure was selected as the sampling time, and the absorbed dosage was eliminated by 2 h after exposure. A good correlation between THM concentrations found in the swimming pool water and the urinary THM concentrations of the people affected after exposure has also been obtained.

**Respiratory**

**Title:** Exhaled nitric oxide and airway hyperresponsiveness in workers: A preliminary study in lifeguards

Citation: BMC Pulmonary Medicine, December 2009, vol./is. 9/, 1471-2466 (31 Dec

Author(s): Demange V., Bohadana A., Massin N., Wild P.

Abstract: Background: Airway inflammation and airway hyperresponsiveness (AHR) are two characteristic features of asthma. Fractional exhaled nitric oxide (FENO) has shown good correlation with AHR in asthmatics. Less information is available about FENO as a marker of inflammation from work exposures. We thus examined the relation between FENO and AHR in lifeguards undergoing exposure to chloramines in indoor pools.

Methods: 39 lifeguards at six indoor pools were given a respiratory health questionnaire, FENO measurements, spirometry, and a methacholine bronchial challenge (MBC) test. Subjects were labeled MBC+ if the forced expiratory volume (FEV1) fell by 20% or more. The normalized linear dose-response slope (NDRS) was calculated as the percentage fall in FEV1 at the last dose divided by the total dose given. The relation between MBC and FENO was assessed using logistic regression adjusting on confounding factors. The association between NDRS and log-transformed values of FENO was tested in a multiple linear regression model.

Results: The prevalence of lifeguards MBC+ was 37.5%. In reactors, the median FENO was 18.9 ppb (90% of the predicted value) vs. 12.5 ppb (73% predicted) in non-reactors. FENO values >= 60% of predicted values were 80% sensitive and 42% specific to identify subjects MBC+. In the logistic regression model no other factor had an effect on MBC after adjusting for FENO. In the linear regression model, NDRS was significantly predicted by log FENO.

Conclusions: In lifeguards working in indoor swimming pools, elevated FENO levels are associated with increased airway responsiveness. 2009 Demange et al;
Title: Exposure to trichloramine and respiratory symptoms in indoor swimming pool workers.

Citation: European Respiratory Journal, April 2007, vol./is. 29/4(690-8), 0903-1936;0903-1936 (2007 Apr)

Author(s): Jacobs JH, Spaan S, van Rooy GB, Mielke C, Zaat VA, Rooyackers JM,

Abstract: The association between swimming pool characteristics and activities of employees and respiratory symptoms in employees was studied. Trichloramine levels were measured to evaluate relationships with pool characteristics and to estimate long-term exposure levels. Questionnaires were available from 624 pool workers and 38 swimming facilities. Chloramine levels were measured by area sampling over 2-h periods and analysed using ion chromatography. Work-related and general respiratory symptoms, and symptoms indicative of atopy and bronchial hyperresponsiveness were considered. Respiratory symptom prevalence among pool workers was compared with symptoms in a Dutch population sample. Chloramine levels were modelled with regression analysis. This model was used to estimate long-term average chloramine levels for each pool studied. Employees with higher exposure reported upper respiratory symptoms with greater frequency. Upper respiratory symptoms were statistically significantly associated with cumulative chloramine levels (odds ratio (OR) >1.4 for hoarseness, lost voice, sinusitis). General respiratory symptoms were significantly elevated compared with a Dutch population sample (OR ranged 1.4-7.2). An excess risk for respiratory symptoms indicative of asthma was observed in swimming pool employees. Aggravation of existing respiratory disease or interactions between irritants and allergen exposures are the most likely explanations for the observed associations.

Title: Chlorine, chlorination by-products and their allergic and respiratory health effects

Citation: Current Respiratory Medicine Reviews, February 2007, vol./is. 3/1(39-47),

Author(s): Kohlhammer Y., Heinrich J.

Abstract: Although chlorine and most of its derivates are known toxic agents, it has been pronounced as a safe disinfectant for water treatments. More detailed analyses and extended studies concerning chlorine safety have only started recently. The objective of this article was to review data on the use of chlorine in pool environments, the resulting chlorination by-products in these environments and their potential effects on allergic and respiratory health in humans. The MEDLINE database search comprised articles from 1966 to August 2006. Additional studies were identified by searching references of already published articles. A total of twenty-one studies evaluating effects of chlorine and its by-products on allergic or respiratory health were included in the analysis. Exposure to chlorination by-products through swimming pool attendance showed adverse health effects on children, subjects occupationally exposed, athletic swimmers and asthmatic subjects. These adverse effects were seen despite the presence of official directives in most countries to control and regulate the use of chlorine for water disinfection. Contact to chlorination by-products might not be the leading reason for poor respiratory health, but might not be as harmless as earlier thought. In particular, baby swimming in chlorinated pools is highly questionable. 2007 Bentham Science Publishers
Title: Occupational asthma caused by chloramines in indoor swimming-pool air.
Citation: European Respiratory Journal, May 2002, vol./is. 19/5(827-32), 0903-
Author(s): Thickett KM, McCoach JS, Gerber JM, Sadhra S, Burge PS
Abstract: The first series of three workers who developed occupational asthma following exposure to airborne chloramines in indoor chlorinated swimming pools is reported. Health problems of swimmers in indoor pools have traditionally been attributed to the chlorine in the water. Chlorine reacts with bodily proteins to form chloramines; the most volatile and prevalent in the air above swimming pools is nitrogen trichloride. Two lifeguards and one swimming teacher with symptoms suggestive of occupational asthma kept 2-hourly measurements of peak expiratory flow at home and at work, analysed using the occupational asthma system (OASYS) plotter, and/or had specific bronchial challenge testing to nitrogen trichloride, or a workplace challenge. Air measurement in one of the pools showed the nitrogen trichloride levels to be 0.1-0.57 mg x m(-3), which was similar to other studies. Two workers had peak expiratory flow measurements showing occupational asthma (OASYS-2 scores 2.88 and 3.8), both had a positive specific challenge to nitrogen trichloride at 0.5 mg x m(-3) with negative challenges to chlorine released from sodium hypochlorite. The third worker had a positive workplace challenge. Swimming-pool asthma due to airborne nitrogen trichloride can occur in workers who do not enter the water because of this chloramine. The air above indoor swimming pools therefore needs to be assessed and managed as carefully as the water.
Chlorine in swimming pools: health effects on lifeguard / pool attendants. Evidence re: the above especially eye problems - I have one article by Lenntech.

**Search requested:** Ann Ellis, 23rd February 2012  
**Completed by:** Alison Price, 24th February 2012

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**Eyes**

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**Abstract:** Swimming pools require disinfectants and other chemicals to maintain water quality and prevent swimmers from acquiring infections. When these chemicals are stored or used improperly or when they are handled or applied by persons not using appropriate personal protective equipment (PPE), illness or injury can result. To assess the frequency of illness and injury related to pool chemicals, CDC analyzed data for the period 2002--2008 from six states participating in the Sentinel Event Notification System for Occupational Risk (SENSOR)--Pesticides surveillance program and from the National Electronic Injury Surveillance System (NEISS). This report describes the results of that analysis, which identified 584 cases of illness or injury associated with pool chemicals in the six SENSOR-Pesticides states and indicated an estimated national total of 28,071 cases (based on 688 NEISS cases) during that period. For the 77% of state cases and 49% of NEISS cases that had sufficient information to determine factors contributing to illness or injury, the most common contributing factors included mixing incompatible products, spills and splashes of chemicals, lack of appropriate PPE use, and dust clouds or fumes generated by opening a chemical container. Adhering to existing CDC recommendations can prevent some of the reported illnesses and injuries, but additional measures (e.g., improving package design to limit the release of dust clouds and fumes when a container is opened, making containers child-proof, and making product labels easier to understand) might reduce them further.

**Full text attached – extract relating to eyes**

Symptoms most frequently reported were respiratory symptoms, such as cough, upper respiratory irritation, and dyspnea (65% of state cases and 24% of NEISS cases), **eye injuries (33% of state cases and 42% of NEISS cases)**, and skin injuries (18% of state cases and 19% of NEISS cases). In the six SENSOR-Pesticides states, the active ingredients most frequently associated with acute illness or injury were sodium hypochlorite (31%), triazine compounds (22%), and calcium hypochlorite (16%). Most of the disinfectants were toxicity category I (87%). The majority of state cases (85%) involved low-severity illnesses or injuries. Forty percent of state cases were work-related, 9% of which involved loss of 1 or more days from work. A small proportion of cases involved hospitalization (2% of state cases and 4% of NEISS cases).

**Citation:** Morbidity and Mortality Weekly Report, October 2011, vol./is. 60/39(1343-1347), 0149-2195;1545-861X (07 Oct 2011)
Chlorine-based disinfectants are the most commonly used disinfectants for treating swimming pool water. A total of 36 pool chemical–associated events were reported in New York during 1983–2007, of which 31 events were attributed to chlorine gas exposure, which most often resulted from mixing sodium hypochlorite solutions (e.g., household chlorine bleach) with acid (4). In England and Wales, 13 events involving pool chemicals were reported during June–October 2007, of which 10 events involved sodium hypochlorite and nine events resulted from equipment failure or mixing incompatible chemicals (5). Several individual cases of illness or injury attributed to pool disinfectants have been reported and include respiratory illness and eye and skin injury (6,7).

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Abstract: OBJECTIVES: To determine the cause of eye and respiratory irritation symptoms among lifeguards at an indoor waterpark.METHODS: Investigators 1) performed environmental sampling for chloramine, endotoxin, and microbials; 2) administered symptom questionnaires; 3) reviewed ventilation system designs; and 4) reviewed water chemistry.RESULTS: Airborne trichloramine concentrations were found at levels reported to cause irritation symptoms in other studies. Some endotoxin concentrations were found at levels associated with cough and fever in previous studies. Exposed lifeguards were significantly more likely to report work-related irritation symptoms than unexposed individuals. The ventilation system may not have provided sufficient air movement and distribution to adequately capture and remove air contaminants at deck level. No water microbes were detected, and water chemistry met state standards.CONCLUSIONS: Indoor waterparks need to control water chemistry and ensure adequate air movement and distribution to control air contaminants and reduce health symptoms.

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Author(s): Massin N, Bohadana AB, Wild P, Hery M, Toamain JP, Hubert G

Abstract: OBJECTIVES: To measure the levels of exposure to nitrogen trichloride (NCI3) in the atmosphere of indoor swimming pools and to examine how they relate to irritant and chronic respiratory symptoms, indices of pulmonary function, and bronchial hyperresponsiveness to methacholine in lifeguards working in the pools.

METHOD: 334 lifeguards (256 men; 78 women) recruited from 46 public swimming pools (n = 228) and 17 leisure centre swimming pools (n = 106) were examined. Concentrations of NCI3 were measured with area samplers. Symptoms were assessed by questionnaire and methacholine bronchial challenge (MBC) test by an abbreviated method. Subjects were labelled MBC+ if forced expiratory volume in one second (FEV1) fell by > or = 20%. The linear dose-response slope was calculated as the percentage fall in FEV1 at the last dose divided by the total dose given.

RESULTS: 1262 samples were taken in the 63 pools. Mean NCI3 concentrations were greater in leisure than in public pools. A significant concentration-response relation was found between irritant eye, nasal, and throat symptoms—but not chronic respiratory symptoms—and exposure concentrations. Among women, the prevalence of MBC+ was twice as great as in men. Overall, no relation was found between bronchial hyperresponsiveness and exposure.

CONCLUSIONS: The data show that lifeguards exposed to NCI3 in indoor swimming pools are at risk of developing irritant eye, nasal, and throat symptoms. Exposure to NCI3 does not seem to carry the risk of developing permanent bronchial hyperresponsiveness, but this association might have been influenced by self selection. The possibility that subjects exposed to NCI3 are at risk of developing transient bronchial hyperresponsiveness cannot be confidently ruled out.
Title: Trihalomethane exposures in indoor swimming pools: A level III fugacity model
Citation: Water Research, October 2011, vol./is. 45/16(5084-5098), 0043-1354;1879-
Author(s): Dyck R., Sadiq R., Rodriguez M.J., Simard S., Tardif R.
Abstract: The potential for generation of disinfection byproducts (DBPs) in swimming pools is high due to the concentrations of chlorine required to maintain adequate disinfection, and the presence of organics introduced by the swimmers. Health Canada set guidelines for trihalomethanes (THMs) in drinking water; however, no such guideline exists for swimming pool waters. Exposure occurs through ingestion, inhalation and dermal contact in swimming pools. In this research, a multimedia model is developed to evaluate exposure concentrations of THMs in the air and water of an indoor swimming pool. THM water concentration data were obtained from 15 indoor swimming pool facilities in Quebec (Canada). A level III fugacity model is used to estimate inhalation, dermal contact and ingestion exposure doses. The results of the proposed model will be useful to perform a human health risk assessment and develop risk management strategies including developing health-based guidelines for disinfection practices and the design of ventilation system for indoor swimming pools. 2011 Elsevier Ltd.

Title: Haloacetic acids in swimming pools: swimmer and worker exposure.
Citation: Environmental Science & Technology, July 2011, vol./is. 45/13(5783-90), 0013-
Author(s): Cardador MJ, Gallego M
Abstract: For the first time, the exposure of swimmers and workers to haloacetic acids (HAAs) in indoor and outdoor pools was evaluated through the analysis of urine samples. The subjects of this study, 49 volunteers, were male and female workers as well as swimmers (adults and children) who regularly attended an indoor pool (January-June) and an outdoor one (July and August). The results showed that HAAs appeared 20-30 min after exposure and were eliminated within 3 h. After 2 h exposure, urine samples taken from workers contained dichloroacetic (DCAA) and trichloroacetic (TCAA) acids at ~300 and ~120 ng/L levels since HAAs were aerosolized in the indoor ambient, whereas only DCAA was found in some workers' urine samples from the outdoor pool but at ~50 ng/L levels, despite the fact that the outdoor pools generally had somewhat higher levels of HAAs than the indoor pools. After 1 h swimming TCAA, DCAA and MCAA were present at concentrations of ~4400, ~2300, and ~560 ng/L, respectively, in the swimmers' urine in the indoor pool; similar results were obtained from the swimmers in the outdoor pool due to accidental ingestion. Finally, exposure estimates indicate that ingestion is the major route of exposure (~94%), followed by inhalation (~5%) and dermal contribution (~1%).
Title: Occupational exposure to trihalomethanes in indoor swimming pools.
Citation: Science of the Total Environment, January 2001, vol./is. 264/3(257-65), 0048-
Author(s): Fantuzzi G, Righi E, Fredieri G, Ceppelli G, Gobba F, Aggazzotti G
Abstract: The study evaluated occupational exposure to trihalomethanes (THMs) in
indoor swimming pools. Thirty-two subjects, representing the whole workforce employed
in the five public indoor swimming pools in the city of Modena (Northern Italy) were
enrolled. Both environmental and biological monitoring of THMs exposure were
performed. Environmental concentrations of THMs in different areas inside the
swimming pools (at the poolside, in the reception area and in the engine-room) were
measured as external exposure index, while individual exposure of swimming pool
employees was estimated by THMs concentration in alveolar air. The levels of THMs
observed in swimming pool water ranged from 17.8 to 70.8 microg/l; the mean levels of
THMs in ambient air were 25.6+/-24.5 microg/m3 in the engine room, 26.1+/-24.3
microg/m3 in the reception area and 58.0+/-22.1 microg/m3 at the poolside. Among
THMs, only chloroform and bromodichloromethane were always measured in ambient
air, while dibromochloromethane was detected in ambient air rarely and bromoform only
once. Biological monitoring results showed a THMs mean value of 20.9+/-15.6
microg/m3. Statistically significant differences were observed according to the main job
activity: in pool attendants, THMs alveolar air were approximately double those observed
in employees working in other areas of the swimming pools (25.1+/-16.5 microg/m3 vs.
14.8+/-12.3 microg/m3, P < 0.01). THMs in alveolar air samples were significantly
correlated with THMs concentrations in ambient air (r = 0.57; P < 0.001). Indoor
swimming pool employees are exposed to THMs at ambient air levels higher than the
general population. The different environmental exposure inside the swimming pool can
induce a different internal dose in exposed workers. The correlation found between
ambient and alveolar air samples confirms that breath analysis is a good biological index
of occupational exposure to these substances at low environmental levels.

Title: Assessment of exposure of workers and swimmers to trihalomethanes in an
indoor swimming pool.
Citation: Environmental Science & Technology, July 2007, vol./is. 41/13(4793-8), 0013-
Author(s): Caro J, Gallego M
Abstract: A simultaneous study on workers' and swimmers' exposure to trihalomethanes
(THMs) in an indoor swimming pool has been carried out by analyzing urine samples
using the headspace and gas chromatography-mass spectrometry technique. The
subjects of this study were male and female workers of an indoor swimming pool as well
as swimmers regularly attending the pool. The results reported show that only
chloroform and bromodichloromethane were detected in the urine of those people
exposed, which can be used as a specific index of exposure to these compounds. THM
uptake of swimmers after 1 h of swimming was higher than that of workers after a 4 h
work shift since THM levels in the workers' urine were associated only with inhalation,
while levels in swimmers' urine were mainly associated with dermal absorption, apart
from inhalation and occasional ingestion, as well as increased uptake due to the physical
stress (swimming). The kinetics of THM excretion in the urine of the participants
exposed has been calculated after termination of the exposure to select the sampling
time and determine the elimination process. An interval of 15 min after exposure was
selected as the sampling time, and the absorbed dosage was eliminated by 2 h after
exposure. A good correlation between THM concentrations found in the swimming pool
water and the urinary THM concentrations of the people affected after exposure has also
been obtained.
Title: Exhaled nitric oxide and airway hyperresponsiveness in workers: A preliminary study in lifeguards
Citation: BMC Pulmonary Medicine, December 2009, vol./is. 9/, 1471-2466 (31 Dec
Author(s): Demange V., Bohadana A., Massin N., Wild P.
Abstract: Background: Airway inflammation and airway hyperresponsiveness (AHR) are two characteristic features of asthma. Fractional exhaled nitric oxide (FENO) has shown good correlation with AHR in asthmatics. Less information is available about FENO as a marker of inflammation from work exposures. We thus examined the relation between FENO and AHR in lifeguards undergoing exposure to chloramines in indoor pools.Methods: 39 lifeguards at six indoor pools were given a respiratory health questionnaire, FENO measurements, spirometry, and a methacholine bronchial challenge (MBC) test. Subjects were labeled MBC+ if the forced expiratory volume (FEV1) fell by 20% or more. The normalized linear dose-response slope (NDRS) was calculated as the percentage fall in FEV1 at the last dose divided by the total dose given. The relation between MBC and FENO was assessed using logistic regression adjusting on confounding factors. The association between NDRS and log-transformed values of FENO was tested in a multiple linear regression model.Results: The prevalence of lifeguards MBC+ was 37.5%. In reactors, the median FENO was 18.9 ppb (90% of the predicted value) vs. 12.5 ppb (73% predicted) in non-reactors. FENO values >= 60% of predicted values were 80% sensitive and 42% specific to identify subjects MBC+. In the logistic regression model no other factor had an effect on MBC after adjusting for FENO. In the linear regression model, NDRS was significantly predicted by log FENO.Conclusions: In lifeguards working in indoor swimming pools, elevated FENO levels are associated with increased airway responsiveness. 2009 Demange et al;

Title: Exposure to trichloramine and respiratory symptoms in indoor swimming pool workers.
Citation: European Respiratory Journal, April 2007, vol./is. 29/4(690-8), 0903-1936;0903-1936 (2007 Apr)
Author(s): Jacobs JH, Spaan S, van Rooy GB, Meliefste C, Zaat VA, Rooyackers JM,
Abstract: The association between swimming pool characteristics and activities of employees and respiratory symptoms in employees was studied. Trichloramine levels were measured to evaluate relationships with pool characteristics and to estimate long-term exposure levels. Questionnaires were available from 624 pool workers and 38 swimming facilities. Chloramine levels were measured by area sampling over 2-h periods and analysed using ion chromatography. Work-related and general respiratory symptoms, and symptoms indicative of atopy and bronchial hyperresponsiveness were considered. Respiratory symptom prevalence among pool workers was compared with symptoms in a Dutch population sample. Chloramine levels were modelled with regression analysis. This model was used to estimate long-term average chloramine levels for each pool studied. Employees with higher exposure reported upper respiratory symptoms with greater frequency. Upper respiratory symptoms were statistically significantly associated with cumulative chloramine levels (odds ratio (OR) >1.4 for hoarseness, lost voice, sinusitis). General respiratory symptoms were significantly elevated compared with a Dutch population sample (OR ranged 1.4-7.2). An excess risk for respiratory symptoms indicative of asthma was observed in swimming pool employees. Aggravation of existing respiratory disease or interactions between irritants and allergen exposures are the most likely explanations for the observed associations.
Title: Chlorine, chlorination by-products and their allergic and respiratory health effects
Citation: Current Respiratory Medicine Reviews, February 2007, vol./is. 3/1(39-47),
Author(s): Kohlhammer Y., Heinrich J.
Abstract: Although chlorine and most of its derivates are known toxic agents, it has been pronounced as a safe disinfectant for water treatments. More detailed analyses and extended studies concerning chlorine safety have only started recently. The objective of this article was to review data on the use of chlorine in pool environments, the resulting chlorination by-products in these environments and their potential effects on allergic and respiratory health in humans. The MEDLINE database search comprised articles from 1966 to August 2006. Additional studies were identified by searching references of already published articles. A total of twenty-one studies evaluating effects of chlorine and its by-products on allergic or respiratory health were included in the analysis. Exposure to chlorination by-products through swimming pool attendance showed adverse health effects on children, subjects occupationally exposed, athletic swimmers and asthmatic subjects. These adverse effects were seen despite the presence of official directives in most countries to control and regulate the use of chlorine for water disinfection. Contact to chlorination by-products might not be the leading reason for poor respiratory health, but might not be as harmless as earlier thought. In particular, baby swimming in chlorinated pools is highly questionable. 2007 Bentham Science Publishers

Title: Occupational asthma caused by chloramines in indoor swimming-pool air.
Citation: European Respiratory Journal, May 2002, vol./is. 19/5(827-32), 0903-
Author(s): Thickett KM, McCoach JS, Gerber JM, Sadhra S, Burge PS
Abstract: The first series of three workers who developed occupational asthma following exposure to airborne chloramines in indoor chlorinated swimming pools is reported. Health problems of swimmers in indoor pools have traditionally been attributed to the chlorine in the water. Chlorine reacts with bodily proteins to form chloramines; the most volatile and prevalent in the air above swimming pools is nitrogen trichloride. Two lifeguards and one swimming teacher with symptoms suggestive of occupational asthma kept 2-hourly measurements of peak expiratory flow at home and at work, analysed using the occupational asthma system (OASYS) plotter, and/or had specific bronchial challenge testing to nitrogen trichloride, or a workplace challenge. Air measurement in one of the pools showed the nitrogen trichloride levels to be 0.1-0.57 mg x m(-3), which was similar to other studies. Two workers had peak expiratory flow measurements showing occupational asthma (OASYS-2 scores 2.88 and 3.8), both had a positive specific challenge to nitrogen trichloride at 0.5 mg x m(-3) with negative challenges to chlorine released from sodium hypochlorite. The third worker had a positive workplace challenge. Swimming-pool asthma due to airborne nitrogen trichloride can occur in workers who do not enter the water because of this chloramine. The air above indoor swimming pools therefore needs to be assessed and managed as carefully as the water.
Swimming pools require disinfectants and other chemicals to maintain water quality and prevent swimmers from acquiring infections (1). When these chemicals are stored or used improperly or when they are handled or applied by persons not using appropriate personal protective equipment (PPE), illness or injury can result (2). To assess the frequency of illness and injury related to pool chemicals, CDC analyzed data for the period 2002–2008 from six states participating in the Sentinel Event Notification System for Occupational Risk (SENSOR)–Pesticides surveillance program and from the National Electronic Injury Surveillance System (NEISS). This report describes the results of that analysis, which identified 584 cases of illness or injury associated with pool chemicals in the six SENSOR-Pesticides states and indicated an estimated national total of 28,071 cases (based on 688 NEISS cases) during that period. For the 77% of state cases and 49% of NEISS cases that had sufficient information to determine factors contributing to illness or injury, the most common contributing factors included mixing incompatible products, spills and splashes of chemicals, lack of appropriate PPE use, and dust clouds or fumes generated by opening a chemical container. Adhering to existing CDC recommendations can prevent some of the reported illnesses and injuries, but additional measures (e.g., improving package design to limit the release of dust clouds and fumes when a container is opened, making containers child-proof, and making product labels easier to understand) might reduce them further.

In the six SENSOR-Pesticides states (California, Iowa, Louisiana, Michigan, North Carolina, and Texas)*, a case of poisoning associated with pool disinfectants was defined as two or more acute adverse health effects resulting from exposure to any pool disinfectant. Cases were categorized by certainty of exposure, reported health effects, and consistency of health effects with known toxicology of the chemical (3) (Table 1). State cases categorized as definite, probable, possible, and suspicious and California Department of Pesticide Regulation cases categorized as definite, probable, and possible were included in the analysis. NEISS cases† were those involving exposure to swimming pool chemicals (product code 938). State cases were excluded if the event occurred during crop farming activities. Neither state nor NEISS cases were included if the illness or injury was not directly caused by pool chemicals.§ Data were analyzed for demographic characteristics, event location, health effects, outcomes (e.g., hospitalization), and factors contributing to illness or injury. Data from the SENSOR-Pesticides states also were analyzed for reporting source, illness or injury severity,†† chemical toxicity,‡‡ active ingredients, work-relatedness, and time lost from work.

For the period 2002–2008, a total of 584 cases were identified in the six SENSOR-Pesticides states (Table 2); most cases occurred in California (306 [52%]). Most cases reported by the states (65%) were identified through poison control centers, followed by cases indentified from workers’ compensation claims (28%). The number of cases from NEISS for the period 2002–2008 was 688, which yields a weighted national estimate of 28,071 cases (Table 2). A substantial

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* Currently, 12 states conduct surveillance of pesticide-related illness and injury, and these states comprise the SENSOR-Pesticides program. Of these states, only California, Louisiana, Michigan, and Texas collected data on illnesses and injuries related to disinfectants for the period 2002–2008. The North Carolina Department of Health and Human Services Division of Public Health began collecting data on illnesses and injuries related to disinfectants in 2008. The Iowa Department of Public Health has a collaborative relationship with the poison control centers in Iowa and was able to identify pesticide poisoning cases associated with swimming pool disinfectants for the period 2005–2008. The California Department of Public Health provided data for the period 2006–2008 (14 cases), and the California Department of Pesticide Regulation provided data for the period 2002–2008 (222 cases). The numbers of cases contributed by each state were as follows: California, 306; Louisiana, 138; Texas, 57; Michigan, 43; North Carolina, 25; and Iowa, 15.

† NEISS is a probability sample of emergency departments based on a sampling frame of 100 emergency departments in the United States and its territories. Each case is assigned a weight based on the sample design. The national estimate is the sum of weights.

§ NEISS cases that did not meet the case definition for inclusion in this analysis did not directly involve the pool chemical, did not have acute symptoms related to pool chemicals, or involved intentional exposure (e.g., drug use). Examples of cases that were excluded include a case in a person who injured his back while lifting a bucket of pool chlorine, a case in a person who sprained their ankle when they fell into the pool while adding pool chemicals to the pool water, cases in persons who had symptoms because they were drowning, cases in persons who lived in a home where chlorine, fertilizer, or muriatic acid was stored but did not have any symptoms, and cases in other persons whose illnesses or injuries did not directly involve pool chemicals or for whom no symptoms after exposure were reported. A total of 55 NEISS cases with product code 938 occurred during 2002–2008 that did not meet the case definition for this analysis. If these cases were included, the national estimate for illnesses and injuries associated with pool chemicals during that period would be 30,235 cases.

¶ Severity of illness or injury of cases was categorized into four groups using standardized criteria for state-based surveillance programs. In low-severity cases, illness or injury usually resolves without treatment and <3 days are lost from work. In moderate-severity cases, illness or injury is non–life-threatening but requires medical treatment and ≤6 days are lost from work. In high-severity cases, illness or injury is life-threatening and requires hospitalization and >5 days are lost from work. The category for fatal poisonings is death.

†† The toxicity category of a pesticide is determined by the Environmental Protection Agency under guidance from Code of Federal Regulations Title 40 Part 156. Pesticides in category I have the greatest toxicity, and pesticides in category IV have the least toxicity.

<table>
<thead>
<tr>
<th>Classification criteria</th>
<th>Classification category*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Definite</td>
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<tr>
<td>Exposure</td>
<td>1</td>
</tr>
<tr>
<td>Health effects</td>
<td>1</td>
</tr>
<tr>
<td>Causal relationship</td>
<td>1</td>
</tr>
</tbody>
</table>


* Case classifications are slightly different between the SENSOR—Pesticides program and the California Department of Pesticide Regulation (CDPR) Pesticide Illness Surveillance system. CDPR classifies cases as definite, probable, and possible based on the relationship between exposure and health effects: definite = both physical (e.g., disinfectant residue on clothing) and medical evidence document exposure and consequent health effects; probable = limited or circumstantial evidence supports a relationship to pesticide exposure; and possible = evidence neither supports nor contradicts a relationship. Additional information available at http://www.cdpdr.ca.gov/docs/whs/pisp/brochure.pdf.

Fifteen percent of cases occurred at private residences (48% of state cases and 56% of NEISS cases) followed by nonmanufacturing facilities, which included hotels, health clubs, and other facilities (28% of state cases and 14% of NEISS cases). Symptoms most frequently reported were respiratory symptoms, such as cough, upper respiratory irritation, and dyspnea (65% of state cases and 24% of NEISS cases), eye injuries (33% of state cases and 42% of NEISS cases), and skin injuries (18% of state cases and 19% of NEISS cases). In the six SENSOR—Pesticides states, the active ingredients most frequently associated with acute illness or injury were sodium hypochlorite (31%), triazine compounds (22%), and calcium hypochlorite (16%). Most of the disinfectants were toxicity category I (87%). The majority of state cases (85%) involved low-severity illnesses or injuries. Forty percent of state cases were work-related, 9% of which involved loss of 1 or more days from work. A small proportion of cases involved hospitalization (2% of state cases and 4% of NEISS cases).

Factors most frequently associated with illness or injury included mixing incompatible products (21% of state cases and 6% of NEISS cases), spills and splashes of pool chemicals (18% of state cases and 33% of NEISS cases), and dust clouds or fumes generated by opening a chemical container (15% of state and NEISS cases) (Table 3). Factors that contributed to worker illness or injury included spills and splashes of liquid or dust (33%), lack of appropriate PPE use (24%), and equipment failure (19%). Among state and NEISS cases, 9% occurred when a child gained access to chemicals not securely stored, and 6% of state cases and 2% of NEISS cases involved other improper storage. Of cases that involved storage within reach of a child, 14% of state cases involved children aged 4–11 years who opened containers.

Five high-severity cases were identified by the six SENSOR—Pesticides states. One case occurred in a man aged 39 years in Louisiana with no pertinent medical history. He was in a public recreational swimming pool when chlorine was added to shock chlorinate it. He inhaled fumes and developed nausea, headache, cough, upper respiratory irritation, dyspnea, wheezing, hypoxia, and tachycardia. He was diagnosed with chlorine inhalation and ingestion, and was hospitalized for 4 days. The second case occurred in a boy aged 5 years in Louisiana who stuck his face in a bucket of pool shock treatment (65% calcium hypochlorite). Cyanosis and dyspnea were documented, and the boy was admitted to the critical-care unit, where he was hospitalized for 4 days. The third case involved a previously healthy woman aged 61

What is already known on this topic?
Swimming pools require frequent application of disinfectants and other pool chemicals, and exposure to these chemicals can cause illness and injury.

What is added by this report?
During 2002–2008, an estimated 28,071 cases of illness or injury associated with pool disinfectants and other pool chemicals occurred nationally (an average of 4,010 cases per year). Most cases occurred at private residences. In the six states participating in the Sentinel Event Notification System for Occupational Risk (SENSOR)—Pesticides surveillance program, 40% of cases were work-related, 9% of which involved loss of 1 or more days from work. The most frequently identified causes of illness or injury were mixing incompatible chemicals, spills and splashes of pool chemicals, lack of appropriate personal protective equipment (PPE) use, lack of proper training and supervision, and dust clouds or fumes generated by opening a pool chemical container.

What are the implications for public health practice?
Some of the identified illnesses and injuries resulted from failure to follow CDC recommendations to prevent illnesses and injuries associated with pool chemicals. Additional measures to reduce exposures to pool chemicals that are suggested by these findings include altering pool chemical container design and modifying labels to make them easier to understand, including using pictograms to depict appropriate PPE use.
### TABLE 2. Number and percentage of acute illnesses and injuries associated with pool chemicals, by selected characteristics — six Sentinel Event Notification System for Occupational Risk (SENSOR)–Pesticides states and the National Electronic Injury Surveillance System (NEISS), 2002–2008*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SENSOR states</th>
<th>NEISS</th>
<th>U.S. estimate§ (%)†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total cases</strong></td>
<td>584 (100)</td>
<td>688</td>
<td>28,071</td>
</tr>
<tr>
<td><strong>Year of exposure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>103 (18)</td>
<td>95</td>
<td>3,753 (13)</td>
</tr>
<tr>
<td>2003</td>
<td>49 (8)</td>
<td>116</td>
<td>4,813 (17)</td>
</tr>
<tr>
<td>2004</td>
<td>42 (7)</td>
<td>64</td>
<td>3,111 (11)</td>
</tr>
<tr>
<td>2005</td>
<td>45 (8)</td>
<td>121</td>
<td>4,015 (14)</td>
</tr>
<tr>
<td>2006</td>
<td>97 (17)</td>
<td>79</td>
<td>3,507 (12)</td>
</tr>
<tr>
<td>2007</td>
<td>99 (17)</td>
<td>109</td>
<td>4,508 (16)</td>
</tr>
<tr>
<td>2008</td>
<td>149 (26)</td>
<td>104</td>
<td>4,364 (16)</td>
</tr>
<tr>
<td><strong>Age group (yrs)</strong></td>
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<tr>
<td>0–5</td>
<td>43 (7)</td>
<td>109</td>
<td>3,619 (13)</td>
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<td>6–14</td>
<td>106 (18)</td>
<td>186</td>
<td>5,960 (21)</td>
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<td>15–24</td>
<td>121 (21)</td>
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<td>3,580 (13)</td>
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<td>25–44</td>
<td>175 (30)</td>
<td>171</td>
<td>8,389 (30)</td>
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<td>≥45</td>
<td>125 (21)</td>
<td>133</td>
<td>6,523 (23)</td>
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<tr>
<td><strong>Sex</strong></td>
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<tr>
<td>Male</td>
<td>360 (62)</td>
<td>388</td>
<td>15,986 (57)</td>
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<tr>
<td>Female</td>
<td>218 (37)</td>
<td>300</td>
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<tr>
<td><strong>Status</strong></td>
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<td>Definite</td>
<td>89 (15)</td>
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<tr>
<td>Probable</td>
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<td><strong>Work-related</strong></td>
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<tr>
<td>Yes</td>
<td>233 (40)</td>
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<tr>
<td><strong>Lost time from work</strong></td>
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<td>Yes</td>
<td>51 (9)</td>
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<td><strong>Reporting source</strong></td>
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<tr>
<td>Physician report</td>
<td>32 (5)</td>
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<tr>
<td>Poison control center</td>
<td>377 (65)</td>
<td>—</td>
<td>—</td>
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<tr>
<td>Workers’ compensation</td>
<td>165 (28)</td>
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<tr>
<td>State health department</td>
<td>4 (1)</td>
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<tr>
<td>Other</td>
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<tr>
<td><strong>Event location</strong></td>
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<tr>
<td>Agriculture¶</td>
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<td>—</td>
<td>—</td>
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<tr>
<td>Private residence</td>
<td>281 (48)</td>
<td>339</td>
<td>15,699 (56)</td>
</tr>
<tr>
<td>Institutions</td>
<td>29 (5)</td>
<td>3</td>
<td>115 (&lt;1)</td>
</tr>
<tr>
<td>Manufacturing facility</td>
<td>2 (&lt;1)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Nonmanufacturing facility</td>
<td>161 (28)</td>
<td>145</td>
<td>4,021 (14)</td>
</tr>
<tr>
<td>Other</td>
<td>68 (12)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Unknown/Missing</td>
<td>42 (7)</td>
<td>201</td>
<td>8,236 (29)</td>
</tr>
<tr>
<td><strong>Toxicity</strong>**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-Danger</td>
<td>510 (87)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>II-Warning</td>
<td>5 (1)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>III-Caution</td>
<td>6 (1)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Missing/Unknown</td>
<td>63 (11)</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

* Case classifications are slightly different between the SENSOR-Pesticides program and the California Department of Pesticide Regulation (CDPR) Pesticide Illness Surveillance system. CDPR classifies cases as definite, probable, and possible based on the relationship between exposure and health effects: definite = both physical (e.g., disinfectant residue on clothing) and medical evidence document exposure and consequent health effects; probable = limited or circumstantial evidence supports a relationship to pesticide exposure; and possible = evidence neither supports nor contradicts a relationship. Additional information available at [http://www.cdpr.ca.gov/docs/whs/pisp/brochure.pdf](http://www.cdpr.ca.gov/docs/whs/pisp/brochure.pdf).

† Percentages might not sum to 100 because of rounding.

§ Weighted national estimate.

¶ The injury occurred when a horse ranch maintenance worker applied chlorine to a pool for horses.

** Toxicity categories are classified by the Environmental Protection Agency based on established criteria, with I being the most toxic and IV the least.

†† The total might exceed the number of cases because multiple active ingredients or body parts/systems might have been involved in a single case.

**§§ Information was not available to identify active ingredients in 19 cases in the six SENSOR-Pesticides states.

††† Symptoms were derived from narratives of the illness or injury included in the NEISS dataset and were coded using SENSOR criteria. Narratives that lacked specific symptoms were coded as “Unknown.”

### TABLE 2. (Continued) Number and percentage of acute illnesses and injuries associated with pool chemicals, by selected characteristics — six Sentinel Event Notification System for Occupational Risk (SENSOR)–Pesticides states and the National Electronic Injury Surveillance System (NEISS), 2002–2008*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SENSOR states</th>
<th>NEISS</th>
<th>U.S. estimate§ (%)†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Active ingredient†† §§</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>189 (31)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Triazines</td>
<td>133 (22)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Calcium hypochlorite</td>
<td>99 (16)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Chlorine</td>
<td>72 (12)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Other</td>
<td>111 (18)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>Illness severity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatal</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>High</td>
<td>5 (1)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Moderate</td>
<td>78 (13)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Low</td>
<td>499 (85)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Missing/Unknown</td>
<td>2 (&lt;1)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>Body part/System affected††¶¶</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>379 (65)</td>
<td>193</td>
<td>6,846 (24)</td>
</tr>
<tr>
<td>Eye</td>
<td>194 (33)</td>
<td>271</td>
<td>11,813 (42)</td>
</tr>
<tr>
<td>Skin</td>
<td>103 (18)</td>
<td>125</td>
<td>5,216 (19)</td>
</tr>
<tr>
<td>Neurologic</td>
<td>94 (16)</td>
<td>24</td>
<td>732 (3)</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>95 (16)</td>
<td>59</td>
<td>1,686 (6)</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>28 (5)</td>
<td>6</td>
<td>256 (1)</td>
</tr>
<tr>
<td>Other</td>
<td>18 (3)</td>
<td>6</td>
<td>333 (1)</td>
</tr>
<tr>
<td>Unknown</td>
<td>—</td>
<td>57</td>
<td>2,592 (9)</td>
</tr>
<tr>
<td><strong>Hospitalization</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>14 (2)</td>
<td>32</td>
<td>1,062 (4)</td>
</tr>
</tbody>
</table>

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††† Symptoms were derived from narratives of the illness or injury included in the NEISS dataset and were coded using SENSOR criteria. Narratives that lacked specific symptoms were coded as "Unknown."
years in California who mixed two pool chemicals, calcium hypochlorite and cyanuric acid, in her kitchen sink. The chemicals reacted and created fumes in the poorly ventilated kitchen. She reported cough, upper respiratory irritation, and dyspnea, and was treated with oxygen. The next day, she was wheezing and was diagnosed with pulmonary edema and hospitalized for 6 days. The fourth case occurred in a woman aged 42 years in Iowa who had asthma. She inhaled dust while applying chlorinating granules, resulting in cough, dyspnea, and lower respiratory pain and irritation. She received a diagnosis of asthma exacerbation caused by chemical exposure and was admitted to an intensive-care unit, where she was hospitalized for 4 days. The fifth case occurred in a woman aged 54 years in Michigan who had allergies. She was exposed to chlorine fumes when an excessive amount of chlorine was added to a pool in which she was swimming. She had cough, dyspnea, wheezing, and vomiting. She received a diagnosis of chemical pneumonitis and was hospitalized for 7 days.

Reported by

Editorial Note
Chlorine-based disinfectants are the most commonly used disinfectants for treating swimming pool water. A total of 36 pool chemical–associated events were reported in New York during 1983–2007, of which 31 events were attributed to
chlorine gas exposure, which most often resulted from mixing sodium hypochlorite solutions (e.g., household chlorine bleach) with acid (4). In England and Wales, 13 events involving pool chemicals were reported during June–October 2007, of which 10 events involved sodium hypochlorite and nine events resulted from equipment failure or mixing incompatible chemicals (5). Several individual cases of illness or injury attributed to pool disinfectants have been reported and include respiratory illness and eye and skin injury (6,7).

The findings in this report are subject to at least five limitations. First, illnesses and injuries related to pool chemicals likely are underreported. Case identification by states relies on a passive surveillance system, so cases in persons experiencing minor symptoms who do not seek medical treatment or advice from poison control centers are not reported. Also, cases reported in NEISS only involve persons who sought treatment in a hospital emergency department. Second, cases might have been missed in Iowa, Louisiana, Michigan, North Carolina, and Texas because CDC’s National Institute for Occupational Safety and Health advises these states to prioritize work-related cases when staffing limitations preclude follow-up of all cases. Finally, the NEISS dataset had limited information, which for some cases precluded the identification of symptoms and contributing factors. Furthermore, no product-identifying information was available in NEISS. Thus, whether illnesses and injuries were caused by nondisinfectant pool chemicals or whether noncompliance with product labels contributed to the reported illnesses and injuries could not be determined. However, most NEISS cases are thought to be disinfectant-related, based on the pool chemical–associated events reported in New York and England and Wales (4,5). Pool disinfectant byproducts, such as chloramines, are responsible for many illnesses and injuries reported (8–10). No cases from the six SENSOR-Pesticides states were attributed to chloramines; however, chloramines might have contributed to some NEISS injuries, but their involvement could not be discerned given the limited product and event information.

Current CDC recommendations to reduce illness and injury from pool chemicals, including disinfectants, are available at http://www.cdc.gov/healthywater/swimming/pools/preventing-pool-chemical-injuries.html. These recommendations address contributing factors related to application equipment failure, storage within reach of a child and other improper storage, illegal dumping, and inadequate PPE used by workers. In addition to the existing CDC recommendations, the findings described in this report suggest that pool chemical manufacturers should design containers so that dust clouds or fumes are minimized when containers are opened and should make the containers child-proof. Label information on appropriate PPE usage should be easy to find and understand; the addition of pictograms depicting appropriate PPE might increase the likelihood of correct use. Instructions for consumers to point the container away from their face while opening might also reduce illness and injury from pool chemicals.

References

The Patient Protection and Affordable Care Act (PPACA) is aimed at expanding access to health care and lowering cost barriers to seeking and receiving care, particularly high-value preventive care. The legislation requires Medicare and all qualified commercial health plans (except grandfathered individual and employer-sponsored plans) to cover routine preventive services graded A and B by the U.S. Preventive Services Task Force (USPSTF) at no cost to the consumer, along with recommended immunizations and additional preventive care and screenings for women (1). In 2009, Colorado passed a law with similar USPSTF A and B service coverage requirements (2). To determine how Colorado health plans had interpreted the state and federal law, the Colorado Department of Public Health and Environment (CDPHE) interviewed representatives of commercial health plans serving Colorado residents. The results of those interviews indicated that different health plans interpreted certain USPSTF recommendations differently, including tobacco screening and pharmacotherapy, colorectal cancer screening, and obesity screening and counseling. One health plan communicated the scope, eligibility criteria, and content of the new preventive services coverage to its members or providers. The differences in interpretation of the USPSTF recommendations and limited communication to consumers or health-care providers in Colorado might be repeated in other states. To ensure optimal consumer and health-care provider utilization of preventive service benefits, the preventive services supported by USPSTF A and B recommendations should be clearly defined in health plan benefit language, with processes put in place for consistent implementation and eligibility criteria communicated to both consumers and providers. The experience in Colorado shows that public health organizations can play a key role in successfully implementing PPACA prevention services provisions.

During June–July 2010, CDPHE staff members used a standardized survey protocol to interview seven of the eight local medical directors or quality improvement directors of each of the major commercial health plans in Colorado about their coverage of USPSTF recommended services. USPSTF reviews the most current evidence of effectiveness of clinical preventive health-care services and grades the strength of the evidence. USPSTF recommends that primary-care practitioners and health systems offer or provide their clients preventive services when there is high certainty that the net benefit is substantial (grade A recommendation) or when there is high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial (grade B recommendation) (3). The survey questions focused only on those USPSTF recommendations pertaining to chronic disease prevention, screening, and management. The survey inquired about cardiovascular disease and cancer screening, obesity screening and intervention, and tobacco screening and cessation. Medical directors were questioned about benefit availability across each coverage type provided by the health plan (i.e., individual versus group market) and limits on coverage (i.e., age, frequency, annual or lifetime limits). In addition, directors were questioned regarding how they had communicated these benefit changes to their consumers and providers.

The vast majority of A and B recommendations addressed in the survey were interpreted consistently across all health plans. However, health plans interpreted and designed their coverage around some A and B recommendations differently. One USPSTF A recommendation encourages clinicians to ask all adult patients about tobacco use and provide tobacco cessation interventions for adults who use tobacco products (4). Colorado health plans reported some restrictions and variability in the provided coverage for tobacco screening and pharmacotherapy. Three of the eight plans restricted reimbursement for tobacco use screening to primary-care providers. One plan restricted the frequency that providers could be reimbursed for screening to the annual visit plus one other visit per year. Only one health plan offered all Food and Drug Administration–approved tobacco cessation medications with no restrictions. The most consistent areas of pharmacotherapy benefit limitation were with varenicline and buproprion SR. Two plans did not cover these medications, and five plans offered the medications with restrictions, such as frequency (annual or lifetime limits), step therapy requirements, copays, deductibles, or coinsurance.

In addition to the different interpretations regarding tobacco cessation and counseling, the benefit design for colorectal cancer screening reflected different interpretations of how coverage for such benefits should be structured. USPSTF advises, as an A recommendation, screening for colorectal cancer using fecal occult blood testing, sigmoidoscopy, or colonoscopy in adults beginning at age 50 years and continuing until age 75 years (4). Not all health plans consistently interpreted colonoscopies as a preventive benefit rather than a diagnostic service when performed either as a primary screening or secondary screening after an abnormal fecal occult blood test. Four health plans...