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DIMOND ICE CHALET
ANCHORAGE, ALASKA

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SUMMARY

In May 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the Anchorage, Alaska Health Department to evaluate health effects among emergency responders exposed to a Freon (CFC-22) release at the ice skating rink in the Dimond Center shopping mall. The 24-year-old assistant manager of the rink died of asphyxiation while attempting to stop a refrigerant leak inside a compressor room. Two maintenance workers who were also inside the compressor room and two members of an adjoining health club who were swimming in the pool were overcome and successfully rescuscitated by emergency responders. One hundred and six individuals (including emergency responders and others who were in the building during the incident) were interviewed using standardized questionnaires to evaluate possible adverse health effects. Medical records were also reviewed.

Acute symptoms that were most frequently reported by emergency responders and others who were present in the mall during the CFC release included lightheadedness, dizziness, eye/nose/throat irritation, headache, giddiness, and weakness. Many of these symptoms were significantly associated with exposure to CFC-22 using various proxy definitions of exposure. Transient central nervous system effects, such as mental confusion, may lead to impaired judgement and inappropriate responses that could be life-threatening in an emergency situation. The symptoms reported in this incident following exposure to CFC-22 are similar to those previously reported following exposure to other chlorofluorocarbons, but have not previously been reported for CFC-22.

This incident underlines the lack of awareness of the severity of the hazard associated with overexposure to CFC-22, a common chemical. In an enclosed area without ventilation, such as the compressor room in this incident, high concentrations of CFCs can occur quickly because of their high vapor pressures.

On the basis of this investigation, NIOSH investigators concluded that a fatal hazard existed at the Dimond Ice Chalet in Anchorage, Alaska. Recommendations are provided in this report to prevent similar incidents in the future.

KEYWORDS: SIC 7999 (Ice Skating Ring Operation), air conditioning and refrigeration mechanics, firefighters, emergency responders, Freon, refrigerants, chlorofluorocarbons, CFC-22, confined spaces, asphyxiation, acute effects.

INTRODUCTION

In May 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the Anchorage, Alaska Health Department to evaluate health effects among emergency responders exposed to a Freon release at the ice skating rink in the Dimond Center shopping mall. The 24- year-old assistant manager of the rink died of asphyxiation while attempting to stop the refrigerant leak inside a compressor room. Two maintenance workers who were also inside the compressor room lost consciousness and were successfully rescuscitated by emergency responders. Two members of an adjoining health club were overcome while swimming in the pool. A questionnaire survey was conducted to evaluate possible adverse health effects among those who were in the building during the freon release. A NIOSH FACE Report, evaluating the circumstances surrounding the fatality in this incident was completed and released in 1992.

BACKGROUND

Data from the NIOSH National Occupational Exposure Survey indicate that approximately 900,000 people have potential exposure to chlorofluorocarbons (CFCs) at work.[1] CFCs (also commonly referred to by the trade name Freon) are derived from hydrocarbons by the substitution of chlorine and fluorine for hydrogen atoms. CFCs are commonly referred to by number, which reflects the chemical formula.[a] CFCs are used as propellants, refrigerants, degreasers, deicers, cleaning agents, fire extinguishers, and biological tissue preservatives. CFC-22 (chlorodifluoromethane) is the most commonly used refrigerant gas. Other commonly used refrigerant gases include dichlorodifluoromethane (CFC-12), chloropentafluoroethane (CFC-115), and trichlorotrifluoroethane (CFC-113).

All CFCs share properties that can result in a lethal hazard. Because of their high vapor pressure, hazardous vapor concentrations can be encountered, particularly in confined spaces. They have poor warning properties, since they are odorless or have only a slight odor at high concentrations, and they are not severe irritants at low concentrations. CFCs are heavier (denser) than air, and therefore collect near the floor. Aviado devised a classification scheme for aerosol propellants, including CFCs, based on acute cardiopulmonary effects in animals. According to this classification system, the toxicity of chlorodifluoromethane (CFC-22) is intermediate (Class 3).[2]

Death from cardiac arrhythmia and asphyxiation following exposure to high concentrations of CFCs is well-documented.[3] In 1989, following several deaths caused by exposure to CFC-113 in confined spaces or in areas with insufficient ventilation, NIOSH published a Hazard Alert requesting assistance in preventing death from excessive exposure to CFC-113 and other CFCs.[4]

CFC-22 has been implicated in the deaths of several workers (from dysrhythmias and asphyxiation) following an accidental release into a confined space, but CFC-113 (Class 1, high toxicity) was also present.[2] CFC-22 was also reported to result in palpitations among hospital pathology department employees who used CFCs (CFC-22 and CFC-12) as a tissue preservative. An epidemiologic investigation at this hospital laboratory was prompted by the sudden cardiac

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[a] The number on the right indicates the number of fluorine atoms in the molecule. The number to the left of this is one greater than the number of hydrogen atoms, and the number to the left of this is one less than the number of carbon atoms; it is omitted if it is zero. All other atoms are chlorine.

death of an employee. Average two-minute exposures to CFC-22 while preparing biological specimens were estimated at 300 ppm.[5] An earlier mortality study of workers exposed to CFC-22 and other CFCs did not show any increased mortality from heart, circulatory, or malignant disorders.[6] A case of peripheral neuropathy (distal axonopathy) was reported in a refrigeration repairman[7], who was probably exposed to high levels of fluorocarbons (probably CFC-22, CFC-115, or CFC-12) when a pipe he was repairing broke. No additional cases were identified among 27 other refrigeration repair workers studied.

While the lethal effects of overexposure to CFCs have been well described in humans, less is known about non-fatal acute effects, particularly for CFC-22. Effects of some chlorofluorocarbons on the nervous system, heart, and respiratory system have been documented in animal studies. (Table 1) Cases of occupational asthma[8], neurotoxic effects[9] [10], and edematous pharyngolaryngitis[11] have been reported in workers with chronic exposure to CFCs. In 1967, an experiment was conducted with human subjects exposed to CFC-113. No effect from exposure was observed at 1500 ppm for 3 hours. Two weeks of exposure to CFC-113 at 500-1000 ppm (6 hours/day x 5 days/week) also resulted in no apparent effect, except for mild throat irritation. At 2500-4500 ppm exposure for 30-100 minutes, the human subjects exhibited decreased dexterity, vigilance, and concentration, and increased somnolence.[12] Humans exposed to CFC-12 exhibited dizziness at 50,000 ppm and unconsciousness at 150,000 ppm. Although there are NIOSH Recommended Exposure Limits (RELs) and OSHA Permissable Exposure Limits (PELs) for eight CFCs, there is no REL or PEL for CFC-22.

The Incident

The ice skating rink refrigeration system had a history of leaks for at least 30 months before the incident that prompted this investigation. About one week before the incident, a refrigeration mechanic noticed several slow leaks of CFC-22. A day or two before the incident, an attempt was made to stop a leak, but a pipe broke, resulting in a 3/8" hole leaking CFC-22. This hole was temporarily plugged. At approximately 8:00 a.m., refrigerant oil was observed oozing from the compressor, and a Freon mist was observed on the floor of the compressor room. The power supply to the compressor was shut off by 8:30 a.m., but attempts to stop the leak were unsuccessful until 10:20 a.m. (A maintenance supervisor wearing an organic vapor cartridge respirator entered the compressor room to stop the leak but became disoriented and left the room, complaining of chest pain, palpitations, and dizziness.) By 8:50 a.m. the CFC mist had travelled to adjoining areas, including the swimming pool, where two health club members had difficulty breathing. They were pulled from the pool and brought outside where they recovered. By this time three workers had entered the compressor room to try again to stop the leak. The workers were seen lying unconscious on the floor of the compressor room and calls were made to the emergency response number by 9:00 am.

METHODS

Individuals present in the mall on the day of the CFC release were identified from lists of municipal employees (firefighters, emergency medical care personnel, and police), employees and patrons of the health club and other businesses at the mall, and patient logs at hospital emergency departments and ambulatory clinics. There were no shoppers present, since the mall had not yet opened for business. Between May 22 and June 4, 1991, NIOSH and municipal health department staff administered questionnaires during face-to-face interviews to all adults (>=18 years).

Twenty-two initial interviews were conducted by the Anchorage Health Department. A standardized, multiple-choice questionnaire was then developed based on these interviews and articles in the scientific literature addressing health effects of CFCs. Initial interviewees were

reinterviewed using the standardized, multiple-choice questionnaire, when possible. In cases where individuals could not be reinterviewed, if they did not specifically report a symptom in the initial open-ended interview, and if they were not specifically asked about a particular symptom, then their response to that question was counted as missing. (The percent of individuals who reported various symptoms therefore does not exactly reflect the total number (106) of survey participants.) Questionnaires addressed demographics, job information, time and location in the mall (marked on a map), tasks, personal protective equipment, medical history of preexisting conditions/symptoms, smoking/alcohol history, symptoms during and after the CFC release, and medical follow up, if any.

Individual symptoms were grouped into the following categories: central nervous system (CNS), peripheral nervous system (PNS), and respiratory system (RESP). These grouped symptoms and responses to questions on eye/nose/throat (ENT) irritation, and palpitations were used as outcome variables in the data analysis. Four exposure variables were considered: proximity to point of CFC release, length of time in the building, position (e.g. kneeling vs. standing), and respirator use.

Areas in the building were classified into "exposed" or "unexposed" based on: (1) proximity to the site of CFC release (the compressor room), and (2) reports of visible fog in each area.

Rate ratios or chi-square tests for trend were calculated for each outcome variable by each exposure variable and age, gender, smoking status, alcohol consumption, and prior symptoms/medical conditions. Stratified analyses included all covariates that were significantly related to any outcome at a $p<=0.05$ significance level.

RESULTS

One hundred fourteen adults were present in the mall on the day of the CFC release, based on lists of municipal firefighters, emergency medical care personnel, and police; employees and patrons of the health club and other businesses at the mall; and patient logs at hospital emergency departments and ambulatory clinics. Investigators were unable to locate 8 of these individuals. Of the 106 survey participants, forty-nine (46%) were female, 57 (54%) were male; ages ranged from 18 years to 62 years (mean=34). They entered the building between 5:30 am and 4:00 pm, and remained inside the building for one minute to four hours (mean=61 minutes, standard deviation=74). Up to one-third of survey participants reported at least one acute symptom (Table 3). Lightheadedness, dizziness, eye/nose/throat irritation, headache, giddiness, and weakness were the most frequently reported symptoms (reported by at least 15%). Other symptoms, reported by 5-14% of participants included coughing, confusion, shortness of breath, chest tightness, palpitations, numbness or tingling of hands/feet/lips/tongue, and difficulty driving after the incident.

Central nervous system (CNS) symptoms (lightheadedness, dizziness, giddiness, or confusion) were reported by 40 participants (39%). Eye, nose, or throat (ENT) irritation were reported by 27 (27%). Peripheral nervous system (PNS) symptoms (weakness or numbness) were reported by 20 (20%). Respiratory symptoms (shortness of breath or chest tightness) were reported by 17 (17%). Palpitations were reported by 8 (8%).

Forty participants (38%) sought medical care at local health care facilities following the incident. Twelve (11%) had scheduled follow-up visits with medical care providers at the time of the interview for residual symptoms or problems.

CNS, PNS, and ENT symptoms, and palpitations were significantly associated with exposure to CFCs using various proxy definitions of exposure (Table 4). There was no significant difference in frequency of symptoms by age group, gender, or current smoking status. Preexisting CNS symptoms, respiratory symptoms, and palpitations were not associated with corresponding symptoms during the incident.

CNS symptoms were significantly more common among those who were close to the site of the leak, those who were in a foggy area, and those who were kneeling (for example, emergency responders caring for victims) and therefore closer to the low-lying CFC mist.

PNS symptoms were associated with kneeling position, proximity to the CFC leak, and being in a foggy area, as well as having a prior medical history of PNS symptoms, and a history of alcohol consumption greater than 2 drinks per day. When those with previous PNS symptoms were excluded from the analysis, proximity to the CFC leak was still significantly associated with PNS symptoms during the incident, controlling for drinking history (Summary RR=3.90, 95% CI 1.33-11.42). The risk, however, was greater among those who drank more than two alcoholic drinks per week (RR=4.38, 1.09-17.58) than among those who had two or fewer alcoholic drinks per week (RR=3.33, 0.61-18.26). No trend was observed for increasing length of time in the building (any area) for CNS or PNS symptoms.

Palpitations were associated with kneeling position and proximity to the CFC leak. ENT irritation was associated with being in a foggy area, proximity to the CFC leak, and increasing length of time in the building (chisquare for trend=7.19, p=0.007). Respiratory symptoms were associated with increasing length of time in the building (chisquare for trend=12.36, p=0.0004), regardless of location. No trend was observed for increasing length of time in the building for palpitations.

DISCUSSION

This incident underlines the lack of awareness of the severity of the hazard associated with overexposure to CFC-22, a common chemical. Despite previous reports of similar deaths occurring following exposure to CFCs in confined spaces, the death of a 24-year old worker occurred as a result of a freon (CFC-22) leak from an ice skating rink compressor. Emergency responders, firefighters, police and others present during this incident reported central nervous system and other symptoms that could affect the ability to appropriately react in such a life-threatening situation.

The symptoms reported in this incident following exposure to CFC-22 are similar to those previously reported following exposure to other chlorofluorocarbons, but have not previously been reported for CFC-22. A review of scientific literature reveals that clinically important CNS effects may appear at levels of exposure to CFCs lower than those associated with cardiac arrhythmias (Table I). Although transient CNS effects such as mental confusion may be considered less serious than cardiac arrhythmias, in emergency situations, as noted above, impaired judgement and inappropriate response can be life-threatening.

Proximity to the source of the CFC release and proximity to the floor (working in a kneeling position) were used as proxies for level of exposure to CFC-22. Both were related to the occurrence of CNS and PNS symptoms, and palpitations. Presence in an area where there was a visible mist was associated with CNS, PNS, and ENT symptoms.

It was estimated that 685 lbs. of CFC-22 escaped from the compressor during this incident,[13] but no estimate of concentration is available. As previously noted, studies indicate that 300,000 to 400,000 ppm CFC-22 cause death in animals. Air-purifying respirators, such as that worn by the deceased employee, are designed for known, low-level concentrations of specific chemicals (e.g., organic vapors). Only supplied-air respirators can be relied on to provide adequate protection when the substance has poor warning properties, concentrations are unknown and therefore may be sufficiently high to pose an immediate danger to life and health, or when the environment is oxygen-deficient. In an enclosed area without ventilation, such as the compressor room in this incident, high concentrations of CFCs can occur quickly because of their high vapor pressures. The other deaths that have been reported following CFC exposure all occurred in confined spaces such as tanks or small rooms.[4] In at least one other reported incident, the worker who died was wearing an air-purifying respirator.[14]

RECOMMENDATIONS

Employers who operate CFC-type refrigeration systems should implement:

1) a periodic maintenance program to inspect, identify and repair leaks;

2) a hazard communication program to help workers recognize, understand, and control hazards[15];

3) appropriate posting at all entrances to confined spaces where a CFC leak can result in very high concentrations in a very short period of time;

4) appropriate engineering controls (such as an emergency shut-off valve, and an emergency exhaust ventilation system), and personal protective equipment;

5) a comprehensive respirator program, including training in selection and use of respirators, and fit-testing[16]; and

6) a comprehensive emergency action plan.[17]

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Copies of this report have been sent to:

1. Dimond Ice Chalet and Dimond Athletic Club
2. Anchorage Fire and Police Departments
3. Anchorage Department of Health and Human Services
4. OSHA Region X

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

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HETA 91-246 - Table 2
Exposure-Related Characteristics of Persons Present Following a CFC Release: Anchorage, Alaska, May 1991

	Number	Percent
Employer		
Fire Department	37	35%
Food Court Restaurants	16	15%
Athletic Center	12	11%
Retail Businesses	11	10%
Police Department	10	9%
Mall Patrons	8	8%
Mall Management	7	7%
Day Care Center	5	5%
Location in the Mall		
Compressor Room	9	8%
Skating Rink Changing Room	12	11%
Athletic Center Locker Room	7	7%
Pool Area	4	4%
Food Court	9	8%
Other Locations in the Mall	33	46%
Exposure to Fog or Mist[a]	32	30%
Type of Respirator Worn		
None	86	81%
Supplied Air Respirator	18	17%
Air Purifying Respirator	2	2%

[a] **based on questionnaire responses**

HETA 91-246 - Table 3
Symptoms Reported by 106 Survey Participants
Following CFC Release
Anchorage, Alaska, May 1991

	Number	Percent
Lightheaded	34	34%
Dizziness	30	29%
ENT[a] Irritation	27	27%
Headache	23	23%
Euphoria	18	18%
Weakness	17	17%
Coughing	14	14%
Confusion	13	13%
Shortness of breath	12	12%
Chest tightness	11	11%
Palpitations	8	8%
Difficulty driving	5	6%
Extremity Numbness	5	5%

[a] eye, nose, throat

HETA 91-246 - Table 4
Relative Risk of Symptoms by Personal and Exposure Characteristics Following Freon Release in a Mall, Anchorage, Alaska

	Central Nervous System	Peripheral Nervous System	Respiratory System	Palpitations	Eye, Nose, Throat Irritation
Female Gender	1.06[a] 0.65-1.72[b]	1.17 0.53-2.57	1.64 0.68-3.97	1.91 0.48-7.59	1.64 0.85-3.17
Age group (compared to <30 yrs.)					
30-39	0.97 0.55-1.73	1.11 0.45-2.74	0.94 0.37-2.41	0.94 0.20-4.36	0.83 0.41-1.71
>=40	0.97 0.53-1.76	0.81 0.28-2.28	0.47 0.13-1.66	0.73 0.13-4.09	0.58 0.24-1.38
Current smoker	0.64 0.31-1.33	0.91 0.34-2.44	0.77 0.24-2.44	0.51 0.07-3.95	1.24 0.60-2.55
Alcohol consumption (>=2 drinks/week)	1.08 0.62-1.88	2.17 1.00-4.67	--	--	--
Positive prior medical history	1.45 0.82-2.57	2.18 1.00-4.75	1.59 0.53-4.73	1.64 0.23-11.74	--
Exposed location in building	2.76 1.74-4.39	2.63 1.19-5.81	2.18 0.93-5.09	4.08 1.04-15.97	1.93 1.04-3.60
Kneeling position	2.35 1.55-3.57	2.91 1.39-6.12	1.80 0.72-4.50	7.19 1.88-27.51	1.22 0.57-2.60
In foggy area	2.75 1.80-4.19	2.63 1.24-5.61	2.16 0.90-5.16	2.56 0.67-9.78	2.11 1.13-3.93

[a] rate ratio

[b] 95% confidence interval

HETA 91-246 - Table 1
Toxicity of Some Common Chlorofluorocarbons
Animal Studies

Compound	Species	Concentration	Respiratory	Cardiac	Nervous System	Other
trichlorotrifluoroethane (CFC-113)	guinea pigs	25,000	nasal irritation			
		50,000			incoordination	death in 1 hr.
	dogs	5,000-10,000		arrhythmias		
dichloromonofluoromethane (CFC-21)	guinea pigs	52,000	dyspnea, irregular breathing		tremors, incoordination, convulsions	
		102,000	congested lungs			some deaths
		400,000				death
dichlorotetrafluoroethane (CFC-114)	guinea pigs	47,000	respiratory irritation			
	dogs	140,000-160,000 (8hrs.)			incoordination, tremors, convulsions	frostbite
		200,000 (16 hrs.)				death
monochlorodifluoromethane (CFC-22)	rats and guinea pigs	75,000-100,000			excitation, dysequilibrium	
		200,000			narcosis	
		300,000-400,000				death
	dogs	50,000		arrhythmias		
	pregnant rats	50,000 (6 hrs./day)				decreased weight gain, anopthalmia in offspring
	male rats	50,000 chronic exposure				salivary gland fibrosarcomas
	rodent	10,000 lifetime exposure				no effect