U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
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NIOSH

Health Hazard Evaluation Report

HETA 86-375-1735
PRIMARY CHILDRENS HOSPITAL
SALT LAKE CITY, UTAH

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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PRIMARY CHILDRENS HOSPITAL
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I. SUMMARY

In June 1986 the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate exposures to nitrous oxide, ethrane, halothane and isoflurane in the Department of Surgery at Primary Childrens Hospital, Salt Lake City, Utah. Breathing zone air samples were collected on nurses in all operating rooms and in the recovery room for nitrous oxide, ethrane, halothane and isoflurane. Direct reading measurements were taken during surgical procedures in order to locate leaks in the anesthesiologists' equipment, leaks in the pop-off valve scavenging equipment and other sources of anesthetic waste gas contamination.

Seventeen of 24 or 71 percent of the ethrane air samples exceeded the NIOSH evaluation criteria of 0.5 ppm for halogenated anesthetic agents used in combination with nitrous oxide; ethrane concentrations ranged from below detection limits of 0.01 mg/sample to 3.7 parts per million (PPM). Thirteen of 24 or 54 percent of the halothane samples exceeded the NIOSH evaluation criteria of 0.5 ppm; halothane concentrations ranged from below detection limits of 0.01 mg/sample to 5.6 ppm. Two of 24 or 8 percent of the isoflurane air samples exceeded the NIOSH evaluation criteria of 0.5 ppm; isoflurane concentrations ranged from below the detection limits of 0.01 mg/sample to 1.2 ppm. Nineteen breathing zone air samples were collected and analyzed for nitrous oxide on July 15, 1986. Eighteen of the 19 samples exceeded the NIOSH evaluation criteria of 25 ppm. The other sample was 25 ppm. On July 16, 1986 13 breathing zone air samples were analyzed for nitrous oxide and twelve of the 13 samples exceeded the NIOSH recommended level of 25 ppm. The levels of nitrous oxide ranged from a high of 1000 ppm to a low of 15 ppm during the two day sampling period. Employees were informally interviewed at random and no medical problems that could be attributed to work were identified.

On the basis of the environmental data it was concluded that a health hazard existed in the operating rooms at Primary Childrens Hospital from overexposures to ethrane, halothane, isoflurane, and nitrous oxide. Recommendations on work practices and ventilation that will assist in controlling these hazards are included in this report.

KEYWORDS: SIC: 8070 (Hospitals) surgery, ethrane, halothane, isoflurane, nitrous oxide

II. INTRODUCTION

NIOSH received a request from management in June 1986 to evaluate the operating rooms for waste anesthetic gases at Primary Childrens Hospital, Salt Lake City, Utah. An environmental evaluation was conducted on July 15, and 16,1986. Results of the environmental investigation were discussed with management during the survey and by telephone when the air sampling results were received from the laboratory on August 26, 1986.

III. BACKGROUND

Primary Childrens Hospital in Salt Lake City Utah has five surgery rooms and a recovery room. All the operating rooms and the recovery room were evaluated during the two day evaluation. Scrub and circulating nurses as well as recovery room nurses were monitored for ethrane, halothane, isoflurane, and nitrous oxide. The anesthesiologist and surgeons declined to wear the air sampling equipment. The scrub and circulating room nurses are in close proximity to the patients and the anesthetic administering equipment therefore, exposure data collected from these individuals should present accurate exposure levels for all those working in the surgical operating rooms. During this evaluation most of the anesthesiologists were using either ethrane, halothane or isoflurane with nitrous oxide.

IV. EVALUATION DESIGN AND METHODS

Environmental

Nitrous oxide breathing zone samples were collected by using vacuum pumps and 20 to 40 liter metallic bags attached to the workers. These samples were analyzed immediately on the surgical floor using infrared spectrometry. Ethrane, halothane, and isoflurane samples were collected on workers using charcoal tubes and vacuum pumps. These samples were analyzed according to NIOSH method 1003.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects

because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8 to 10 hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

	Recommended Exposure Limits 8-Hour Time-weighted Exposure Basis (ppm)	
Nitrous Oxide	25.0 (NIOSH)	
Ethrane	0.5 (NIOSH)	75* (ACGIH)
Halothane	0.5 (NIOSH)	50* (ACGIH)
Isoflurane	0.5 (NIOSH)	

ppm = parts of vapor or air per million parts of contaminated air.
* = 1985 ACGIH TLV

Toxicological

In the NIOSH criteria document for a recommended standard for occupational exposure to anesthetic gases, NIOSH states: "Current scientific evidence obtained from human and animal studies suggests that chronic exposure to anesthetic gases increases the risk of both spontaneous abortion among female workers and congenital abnormalities in the offspring of female workers and the wives of male workers. Risks of hepatic and renal diseases are also increased among exposed personnel. In addition, physiological function may be impaired. A few studies have suggested increased risk of cancer. Effects on the central nervous system due to acure exposures of anesthetic gases have been associated with headaches, nausa, fatigue, irritability, etc." Control procedures and work practices presented in that document, however, should prevent the effects caused by acute exposure and significantly reduce the risk associated with long-term, low level exposure. A dose response relationship for halogenated anesthetic toxicity has not been defined. (Reference 2)

That same NIOSH publication recommends maximum exposures to 25 ppm nitrous oxide (eight-hour time-weighted average) and 2 ppm halogenated anesthetic when used alone, or 0.5 ppm when used with nitrous oxide. These recommendations are based upon available technology in reducing waste anesthetic gas levels.

Reports by Vaisman (Reference 3) and Askrong and Harvald (Reference 4) were among the first to identify increased incidence of spontaneous abortion in women exposed to anesthetic gases and in wives of men exposed to anesthetic gases. Results of a more recent and comprehensive nationwide survey of occupational disease among operating personnel were published in 1974 by the American Society of Anesthesiologists (ASA). (Reference 1) The results of this study indicate "that female members of the operating room-exposed group were subject to increase risks of spontaneous abortion, congenital abnormalities in their children, cancer, and hepatic and renal disease. This increased risk of congenital abnormalities was also present among the unexposed wives of male operating room personnel. No increase in cancer was found among the exposed males, but an increased incidence of hepatic disease similar to that in the female was found."

While several investigators have reported increased rates of resorption in animals, particularly rats, most of these studies involved concentrations of anesthetic gases well above the levels found in occupational exposure. One investigator (Reference 5) showed increased fetal death rates in two groups of rats following exposure of 1,000 and 100 ppm of nitrous oxide. Doenicke, et. al., (Reference 6) concluded from their study of anesthetized pregnant rats that halothane

demonstrates an abortive effect directly proportional to the concentration inhaled, again referring to anesthetic concentrations; but nitrous oxide does not produce an abortive effect. Bruce (Reference 7) reports no significant difference, including implantations and resorptions per pregnancy, in his exposure of rats to 16 ppm halothane.

Several epidemiological studies that indicate increased spontaneous abortions also indicate an increased rate of congenital abnormalities. The ASA study (Reference 1) (as well as surveys by Knilljones, et al., (Reference 8) and Corbett, et al. (Reference 9) indicated an increased rate of congenital abnormalities in children of women with occupational exposures to anesthetic levels, one study (Reference 10, 11, 12) indicated liver, kidney, and brain tissue changes in pups born to rats exposed to sub-anesthetic concentrations of halothane during pregnancy.

The same epidemiological and toxicological studies that have indicated an increase in spontaneous abortion and congenital abnormalities. This increase, however, was less pronounced in both rate and severity.

In a study published by NIOSH (Reference 13), "nitrous oxide and halothane in respective concentrations as low as 50 ppm and 1.0 ppm caused measurable decrements in performance on some psychological tests taken by healthy male graduate students. Nitrous oxide alone caused similar effects. The functions apparently most sensitive to these low concentrations on anesthetics were visual perception, immediate memory, and a combination of perception, cognition, and motor responses required in a task of divided attention to simultaneous visual and auditory stimuli." Headache, fatigue, irritability, and disturbance, of sleep have also been reported (References 2, 14); and damage to cerebral cortical neurons has been seen in rats after sub-anesthetic exposure to halothane. (Reference 15) Quimby, et al., (Reference 16) reported permanent learning deficits in rats exposed to anesthetic concentrations of halothane during early development (from conception).

Mortality and epidemiological studies have raised the questions of possible carcinogenicity of anesthetic gases, but sufficient data are lacking to list nitrous oxide, halothane, or ethrane as suspected carcinogens.

Literature reviews regarding halothane (References 17, 18, 10, 20) indicate the most widely accepted mechanism of bio-transformation is the production of trifluoroacetic acid and bromide. The literature regarding enflurane (References 21, 22) does not indicate any one accepted mechanism, but increased serum and urinary fluoride levels were found in patients receiving enflurane anesthesia. While epidemiological and toxicological studies have indicated several symptoms apparently related to sub-anesthetic exposure to anesthetic gases, no cause and effect relationship has yet been shown.

A mail survey of 30,650 dentists and 30,547 chairside assistants grouped according to occupational exposure to inhalation anesthetic/sedatives in the dental operatory indicated increased general health problems and reproductive difficulties among anesthetic-exposed respondents. For heavily anesthetic-exposed male dentists, the increase in liver disease was 1.9-fold, kidney disease 1.2-fold, and neurological disease 1.9-fold. For wives of heavily anesthetic-exposed male dentists the increase in spontaneous abortion rate was 1.5-fold. Among heavily anesthetic-exposed female chairside assistants, the increase in liver disease was 1.6-fold, kidney disease 1.7-fold and neurological disease 2.8-fold. The increase in spontaneous abortion rate among heavily exposed assistants was 2.3-fold. Cancer rates in women heavily exposed to inhalation anesthetics were increased 1.5-fold but this finding was only borderline significant (P = 0.06). Separate analysis of the data for disease rates and birth difficulties by type of inhalation anesthetic indicates that in both dentists and chairside assistants chronic exposure to nitrous oxide alone is associated with an increase rate of adverse response. (Reference 23) It would not be correct to directly extrapolate nitrous oxide epidemiological data taken on dentists and dental assistants to surgical operations. Dentists and their assistants are much closer to their work and are breathing higher concentrations than surgeons, scrub nurses, and anesthesiologists.

VI. RESULTS

Seventeen of 24 air samples (71 percent) taken for ethrane exceeded the NIOSH criteria of 0.5 ppm. Thirteen of 24 air samples (54 percent) taken for halothane exceeded the NIOSH criteria of 0.5 ppm. Two of 24 air samples (8 percent) taken for isoflurane exceeded the NIOSH criteria of 0.5 ppm. Thirty-two air samples were collected on workers and analyzed for nitrous oxide; thirty-one of these exceeded the NIOSH criteria of 25 ppm. The other sample result was 15 ppm. Results maybe reviewed in Tables 1, 2, and 3. Operating room personnel were informally interviewed. Complaints were very few and none of the workers had medical problem that they thought were associated with their work. All workers were interested in what they were exposed to and the chronic and acute effects of these exposures.

VII. CONCLUSIONS

Excessive exposures to ethrane, halothane, isoflurane and nitrous oxide were found in all the operating rooms. These exposures were due to numerous things that can be partially or completely eliminated. Most of the operating rooms do not have enough air changes per hour. Room number 4 is the only room with adequate (20 - 25) air changes per hour. If adequate ventilation was installed in the other four rooms it would lower the exposure levels. Since this is a childrens' hospital the

method of anesthetic gas administration is different from that used in adult procedures; for example, small babies and infants are unique in that they are not intubated for all surgical procedures and generally are not intubated with a cuffed indotracheal tube. As a result gas leaks around the non-cuffed indotracheal tube resulting in contamination of the room. It is also difficult to administer oxygen to flush the anesthetic gases from the lungs and bronchi after surgery is complete. It would be difficult to lower exposure levels to 25 ppm for nitrous oxide and 0.5 ppm for the halogenated hydrocarbons under the present conditions in these operating rooms.

VIII. RECOMMENDATIONS

1. Anesthesiologists should check slip connections and high pressure nitrous oxide connections since these are areas where high concentrations were observed.

2. Air monitoring should be continued in order to eliminate exposures and ensure proper maintenance of the ventilation system and scavenging systems.

3. More ventilation is needed in operating rooms 1, 2, 3 and 5, in order to help lower the levels of the anesthetic gas exposure. 20 air changes per hour would lower levels of anesthetic gases.

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. Primary Childrens Hospital
2. U.S. Department of Labor/OSHA - Region VIII.
3. NIOSH - Region VIII.
4. Utah State Health Department
5. State Designated Agency.

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

Table I
Breathing Zone Air Concentrations of
Ethrane, Halothane, and Isoflurane
at Primary Childrens Hospital
Salt Lake City, Utah
July 15 - 16, 1986

Sample #	O.R	Nurse	Sampling Time	PPM ETHR	HALO	ISOF	Combined
1	1	Circ.*	12:59p - 2:40p	1.8	0.74	N/D	5.1
2	1	Scrub	8:48a - 1:42p	1.8	0.3	N/D	4.2
3	3	Scrub	8:19a - 10:38a	3.3	0.9	N/D	8.4
4	5	Scrub	8:29a - 11:56a	1.2	0.4	0.1	3.4
5	4	Scrub	8:16a - 1:24a	3.2	5.6	N/D	17.6
7	5	Circ.	8:12a - 11:57a	2.0	0.7	0.2	5.8
8	3	Circ.	8:06a - 11:50a	2.2	3.1	N/D	10.6
9	1	Scrub	8:09a - 11:37a	1.2	0.3	N/D	3
10	4	Circ.	8:13a - 10:40a	1.2	0.3	N/D	3
12	2	Circ.	8:08a - 11:54a	N/D	N/D	N/D	N/D
13	1	Circ.	8:22a - 12:56p	1.2	0.4	N/D	3.2
14	2	Scrub	8:35a - 11:50a	2.1	0.6	N/D	7
15	5	Circ.	12:00p - 1:25p	N/D	N/D	N/D	N/D
16	5	Scrub	12:01p - 1:38p	N/D	N/D	N/D	N/D
17	2	Scrub	12:23p - 3:20p	1.4	1.2	N/D	5.2
18	3	Circ.	7:15a - 11:20a	3.1	0.6	0.9	9.2
19	3	Scrub	7:17a - 11:30a	3.7	0.5	1.2	10.8
20	1	Circ.	7:28a - 11:26a	2.3	0.4	N/D	5.4
21	4	Circ.	7:36a - 10:10a	1.8	0.5	N/D	4.6
22	RECOV	Nurse	7:42a - 11:34a	0.1	0.5	N/D	1.2
23	RECOV	Nurse	7:48a - 11:29a	0.1	0.3	N/D	0.8
24	RECOV	Nurse	7:46a - 11:35a	0.1	0.1	N/D	0.4
25	5	Scrub	8:36a - 12:41a	0.2	0.1	N/D	1.8
26	5	Circ.	8:20a - 11:36a	1.0	0.9	N/D	3.8
Evaluation Criteria				.5	.5	.5	1.0
Limits of Detection (mg/sample)				0.01	0.01	0.01	
Percent exceeding Ev. Criteria				71	54	8	79

* = Circ. = Circulating

Table II
Breathing Zone Air Concentrations of
Nitrous Oxide at
Primary Childrens Hospital
Salt Lake City, Utah
July 15 - 16, 1986

OR	NURSE	Sampling Time	PPM Nitrous Oxide
1	Scrub	8:10a - 9:46a	50
	Scrub	10:10a - 10:50a	25
2	Circ.	8:08a - 9:37a	175
	Circ.	9:43a - 11:54a	175
	Scrub	8:36a - 9:45a	75
	Scrub	11:04a - 11:50a	150
3	Circ.	8:06a - 9:30a	250
	Circ.	9:30a - 10:57a	1000
	Circ.	11:30a - 1:09p	1000
	Scrub	9:50a - 11:25a	1000
	Scrub	8:19a - 9:35a	300
	Scrub	9:55a - 10:34a	125
	Scrub	1:21p - 2:38p	1000
4	Scrub	8:17a - 9:40a	125
	Circ.	8:14a - 10:40a	150
5	Scrub	8:30a - 10:04a	150
	Scrub	12:06p - 1:18p	300
	Circ.	8:12a - 10:50a	250
	Circ.	11:32a - 1:25p	450
Evaluation Criteria			25
Limit of Detection			1

Table III
Breathing Zone Air Concentrations of
Nitrous Oxide at
Primary Childrens Hospital
Salt Lake City, Utah
July 15 - 16, 1986

OR	NURSE	Sampling Time	PPM Nitrous Oxide
1	Circ.	7:29a - 8:41a	60
	Circ.	9:50a - 11:26a	50
3	Scrub	7:18a - 8:28a	50
	Scrub	8:28a - 9:50a	250
	Circ.	7:16a - 8:59a	125
	Circ.	9:01a - 11:20a	200
4	Circ.	7:35a - 10:10a	150
5	Circ.	8:20a - 9:55a	450
RECOV	Nurse	7:46a - 9:11a	15
		7:11a - 9:53a	75
		7:41a - 9:05a	15
		9:06a - 11:02a	50
		7:48a - 11:01a	60
Evaluation Criteria			25
Limit of Detection			1