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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH

Health Hazard Evaluation Report

HETA 86-403-1747
ST. JAMES COMMUNITY HOSPITAL
BUTTE, MONTANA

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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ST. JAMES COMMUNITY HOSPITAL
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I. SUMMARY

In June 1986 the National Institute for Occupational Safety and Health (NIOSH) received a request from management to evaluate exposures to nitrous oxide, ethrane, and isoflurane in the department of surgery at St. James Community Hospital, Butte, Montana. Breathing zone air samples were collected on operating room personnel in all operating rooms and in the recovery room for nitrous oxide, ethrane, 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.

Five of 13 or 38 percent of the ethrane air samples exceeded the NIOSH evaluation criteria of 0.5 ppm. Ethrane concentrations ranged from below detection limits of 0.01 mg/sample to 2.5 parts per million (ppm). Three of 13 or 23 percent of the isoflurane samples exceeded the NIOSH evaluation criteria of 0.5 ppm. Isoflurane concentrations ranged from below the laboratory detection limits of 0.01 mg/sample to 4.1 ppm. Combined exposures did not significantly alter the extent of these exposures. Twenty breathing zone air samples were collected and analyzed for nitrous oxide on August 19 and 20th. Only two of these samples showed concentrations that exceeded the NIOSH evaluation criteria of 25 ppm. Concentrations of nitrous oxide ranged from eight ppm to 315 ppm. Leak checks and ventilation checks were made with a direct reading infrared analyzer in several of the operating rooms. Leaks were observed in the pop-off valve scavenging system, high and low pressure hoses to and from the patient, and in several of the other flexible hoses and connections throughout the operating rooms. 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 St. James Community Hospital in Butte, Montana on August 19 and 20th 1986, from exposures to ethrane, 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, isoflurane, and nitrous oxide.

II. INTRODUCTION

NIOSH received a request in June 1986 to evaluate the operating rooms for waste anesthetic gases at St. James Community Hospital, Butte, Montana. An environmental evaluation was conducted on August 19 and 20 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 in September 1986.

III. BACKGROUND

St. James Community Hospital in Butte, Montana has five surgery rooms. Four were in use during this evaluation. The recovery room was also evaluated. Scrub and circulating nurses were evaluated for nitrous oxide, ethrane and isoflurane. One anesthetist and several recovery room nurses were also monitored for the anesthetic waste gases. During this evaluation all the surgical operations monitored were using a mixture of either ethrane, 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 primarily 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 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. The criteria used in this evaluation are:

	Recommended Exposure Limits 8-Hour Time-weighted Exposure Basis (ppm)
Nitrous Oxide	25.0 (NIOSH)
Ethrane	0.5 (NIOSH)
Isoflurane	0.5 (NIOSH)

ppm = parts of vapor or air per million parts of contaminated air.

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 acute exposures to 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 halogenated anesthetic exposure 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 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 of 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 have 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

Five of 13 air samples (38 percent) taken for ethrane exceeded the NIOSH criteria of 0.5 ppm. Three of 13 air samples (23 percent) taken for isoflurane exceeded the NIOSH criteria of 0.5 ppm. Two of 20 (10 percent) air samples collected for nitrous oxide exceeded the NIOSH criteria of 25 ppm. Some leakage was found when checking the operating rooms with the direct reading nitrous oxide monitoring equipment (See Tables I, II, III). Operating room personnel were informally interviewed. Complaints were very few and none of the workers had medical problems that they thought were work related. 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, isoflurane and nitrous oxide were found at St. James Community Hospital. This is one of the cleanest surgical departments that the NIOSH investigator has evaluated from the anesthetic waste gas aspect. All of the rooms appear to have sufficient air changes and the anesthetic administering equipment is in good condition. The level of all waste anesthetic gases could be better controlled with closer monitoring of all high and low pressure connections and maintenance of exhaust ventilation hookups for the pop-off scavenging ventilation hoses. This facility has done a remarkable job in controlling worker exposure to the waste anesthetic gases.

VIII. RECOMMENDATIONS

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

2. Continued maintenance of the flexible hose going to the ventilation system from the pop-off valve should be undertaken.

IX. REFERENCES

1. Cohen, E.N., et al, ad Hoc Committee on the Effect of Trace Anesthetics on the Health of Operating Room Personnel: Occupational Disease Among Operating Room Personnel: A National Study. Anesthesiology 41:321-340, 1974.

2. Criteria for a Recommended Standard...Occupational Exposure to Waste Anesthetic Gases and Vapors. DHEW (NIOSH) Publication No. 77-140, 1977, 194 pp.

3. Vaisman, A.I. (Working conditions in surgery and their effect on the health of anesthesiologists). Eksp Khir Anest 3:44-49, 1967 (Rus.).

4. Adkrog, V., and Harvald, B. (Terateogenic effect of inhalation anesthetics). Nord Med 83:498-504, 1970.

5. Corbett, T.H., Cornell, R.G., Endres, J.L., and Millard, R.I. Effects of Low Concentrations of Nitrous Oxide on Rat Pregnancy. Anesthesiology 39:299-301, 1973.

6. Doenicke, A., Wittman, R., Heinrich, H., and Pausch, H. (Abortive Effect of Halothane). Anesth Analg (Paris) 32:47-51, 1975 (Fre).

7. Bruce, D.L. Murine Fertility Unaffected by Traces of Halothane. Anesthesiology 38:473-77, 1973.

8. Knill-Jones, R.P., Moir, D.D., Rodrigues, L.V, and Spence, A.A. Anesthetic Practice and Pregnancy--Controlled Survey.

9. Corbett, T.H., Cornell, R.G., Lieding, K., and Endres, J.L. Incidence of Cancer AMong Michigan Nurse-Anesthetists. Anesthesiology 41:34-44, 1974.

10. Chang, L.W., Lee, Y.K., Dudley, A.W., Jr., and Katz, J. Ultrastructural Evidence of the Hepatotoxic Effect of Halothane in Rats Following In-Utero Exposure. Can Anesth Soc J. 22:330-37, 1975.

11. Chang, L.W., Lee, Y.K., Dudley, A.W., Jr., and Katz, J. Ultrastructural Studies on the Pathological Changes in the Neonatal Kidney Following In-Utero Exposure to Halothane. Environ. Res 10:174-89, 1975.

12. Chang, L.W., Dudley, A.W., Jr., and Katz, J., Martin, A.H. Nervous System Development Following In-Utero Exposure to Trace Amounts of Halothane. Teratology 9:A-15, 1974.

13. Bruce, D.L., and Bach, M.H. Trace Effects of Anesthetic Gases on Behaviorial Performance of Operating Room Personnel. HEW Publication No. NIOSH 76-169, 1976, 33pp.

14. Uhlirova, A., and Pokorny, J. (Results of questionnaire survey of health damage to anesthesiologists). Rozhl Chir 53:761-70, 1976 (Cze).

15. Chang, L.W., Lee, Y.K., Dudley, A.W., Jr., and Katz, J. Ultrastructural Changes in the Nervous System After Chronic Exposure to Halothane. Exp Neurol 45:209-19, 1974.

16. Quimby, K.L., Aschkenase, L.H., Bowman, R.E., Katz, J., and Chang, L.W. Enduring Learing Deficits and Cerebral Synaptic Malformation From Exposure to Ten PArts of Halothane Per Million. Science 185:625-27, 1974.

17. Redhar, K., and Sessler, A.D. Biotransformation of Halothane. Int Anesthesiol Clin 12:41-53, 1974.

18. Sawyer, D., and Eger, E., II. Hepatic Metabolism of Halothane. Int Anesthesiol Clin 12:55-62, 1974.

19. Cascorbi, H.F. Factors Causing Differences in Halothane Biotransformation. Int Anesthesiol Clin 12:63-71, 1974.

20. Van Dyke, R.A. Biotransformation of Volatile Anesthetics with Special Emphasis on the Role of Metabolism in the Toxicity of Anesthetics. Can Anesth Soc J 20:21-33, 1973.

21. Mazze, R.I., and Cousins, M.J. Biotransformation of Methoxyflurane. Int Anesthesiol Clin 12:93-105, 1974.

22. Cousins, M.D., and Mazze, R.I. Biotransformation of Enflurane (Ethrane) and Isoflurane (Forane). Int Anesthesiol Clin 12:111-119, 1974.

23. Cohen, E.N., et al, Occupational Disease in Dentistry and Exposure to Anesthetic Gases 1980. This research supported by the National Institutes of Health OH-00775, and a grant in aid from the American Dental Association.

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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. St. James Community 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 and Isoflurane in
the Surgical Suites at
St. James Community Hospital
in Butte, Montana
August 19 - 20, 1986

Sample #	Nurse	Operating Room	PPM Ethrane	PPM Isoflurane
1	Scrub	ALL	0.72	0.15
2	Scrub	1	0.46	0.57
3	Scrub	4	0.84	0.09
4	Scrub	1	0.41	*
5	Circ.	4	0.13	0.13
6	Scrub	5	0.21	0.24
7	Circ.	5	0.60	4.1
8	Recov.	-	1.0	1.6
22	Scrub	4	0.4	*
200	Circ.	2	*	*
201	Scrub	2	*	*
203	Scrub	5	2.5	*
204	Scrub	1	0.2	*
Evaluation Criteria			0.5	0.5

* Non Detected:
Laboratory Limit of Detection = 0.01 mg/sample, which is approximately 0.0006 mg/M^3 or 0.00008 ppm.

Circ. = Circulatory
Recov. = Recovery

Table II

Breathing Zone Air Concentrations of
Nitrous Oxide in
the Surgical Suites at
St. James Community Hospital
in Butte, Montana
August 19 - 20, 1986

Sample #	Nurse	Operating Room	PPM Nitrous Oxide
02	Scrub	1	8
06	Scrub	5	25
07	Circ.	5	50
01	Scrub	ALL	12
03	Scrub	4	8
05	Circ.	4	20
08	Nurse	Recov.	20
04	Scrub	1	12
015	Nurse	Recov.	8
011	Scrub	1	8
014	Scrub	1	8
016	Scrub	1	8
017	Circ.	1	8
012	Circ.	2	8
010	Anesth.	-	8
013	Nurse	Recov.	16
020	Scrub	1	16
021	Scrub	4	315
019	Nurse	Recov.	12
022	Circ.	4	8
Evaluation Criteria			25
Instrument Limit of Detection			1.0

Circ. = Circulatory
Recov. = Recovery

Table III

Leak Checks for
Nitrous Oxide in
the Surgical Suites at
St. James Community Hospital
in Butte, Montana
August 19, 1986

Operating Room	Area	PPM Nitrous Oxide
(2)	Pop-off Scavenger Exhaust Hose	25
(2)	Scavenger Hose pulled out of wall	5000
(2)	Pop-off valve	34
(2)	High pressure hose to Patient	42
	Low pressure hose from Patient to pop-off	42
(2)	Ventilator Bag	34
(2)	Wall Connector to scavenger	42
(1)	Scavenging Connection	70
(1)	Breathing zone of Anesthetist	34
(1)	Pop-off valve	34
(1)	Scavenging hose connection	34
(1)	Scavenging hose to smaller hose	70