U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES PUBLIC HEALTH SERVICE CENTER FOR DISEASE CONTROL NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION REPORT HE 80-56-743

ST. ANTHONY'S HOSPITAL DENVER, COLORADO

September 1980

I. SUMMARY

In March 1980 the National Institute for Occupational Safety and Health (NIOSH) received a request from employees to evaluate exposures to nitrous oxide, ethrane, and halothane in the Department of Surgery at St. Anthony's Hospital, Denver, Colorado (SIC 8070). Breathing zone and general room air samples were taken on nurses and anesthesiologists for nitrous oxide, ethrane, and halothane. All the anesthesiologists' equipment was monitored during surgical procedures for leakage. This monitoring was done by portable infra-red analyzer. A medical history was taken on most surgical personnel.

Seven of 21 ethrane air samples (33%) exceeded the NIOSH evaluation criteria. Ethrane concentrations ranged from less than 0.01 parts per million (ppm) to 1.6 ppm. None of the 21 halothane air samples exceeded the NIOSH evaluation criteria. Values ranged from less than 0.01 ppm to 0.4 ppm. Nitrous oxide breathing zone air samples exceeded the NIOSH evaluation criteria in approximately 50% of the samples taken. (Range was from 5.0 to 128.0 ppm; NIOSH criteria is 25 ppm.)

Questionnaires were received from 6 anesthesiologists, 57 of 73 (78.1%) operating room staff (35 registered nurses, 22 other) and 19 of 19 (100%) recovery room staff (15 registered nurses, 4 other). See Table 1 for the surveyed population's characteristics.

Twenty-five (44%) operating room respondents reported one or more acute symptoms versus 15 (79%) recovery room respondents. Recovery room respondents had a statistically significant excess of acute symptoms prevalence (P less than .05) reporting headache, light headedness, dizziness, and fatigue than operating room staff. See Tables 2 and 3 for breakdowns. Thirteen (39%) operating room females reported menstrual or related irregularities versus zero recovery room females. Five (9%) operating room workers reported kidney or liver disease history (nephrectomy, pyelonephritis, kidney stone) versus four reported disease history in recovery room workers. Of 26 reported pregnancies in operating room staff, three miscarriages versus four pregnancies and zero miscarriage in recovery room staff were reported. Those with acute symptoms did not differ significantly from those without acute symptoms with respect to smoking status and job duration.

Analysis by job specific rates for chronic disease and reproductive effects revealed numbers too small for analysis or for accurate evaluation. However, the number of miscarriages in operating room and recovery room personnel were less than the number expected using rates reported by Cohen, et al (1974). (Reference 1)

On the basis of the environmental and epidemiological data, it was concluded that a health hazard existed in the operating rooms at St. Anthony's Hospital from overexposures to ethrane and nitrous oxide. Recommendations on work practices and ventilation necessary to control these hazards are included on page 7 of this report.

II. INTRODUCTION

NIOSH received a request in March 1980 for a health hazard evaluation from the employees at St. Anthony's Hospital, Denver, Colorado, to evaluate waste anesthetic gas exposure in their operating rooms.¹ An environmental and epidemiological survey was conducted on March 11-12, 1980, to evaluate potential overexposures. Results of the survey were discussed with the hospital staff and employees soon after receiving the laboratory results and the epidemiological data.

III. BACKGROUND

The operating room department of St. Anthony's Hospital is located on the second floor of the hospital with eight operating rooms situated off one main corridor. Six operating rooms were in use the dates of the evaluation survey. The average number of operations per day varies and includes both inpatient and outpatient procedures. For February 1980, the average number of procedures per day was 27 (range 4-46) of the monthly total of 790; 87% were inpatient and 13% were outpatient. The types of surgery and anesthesia conducted are listed in Table 4. Surgical patients remain in a holding area near the room following premedication prior to surgery. They are then transported after surgery to a recovery room. Post-operative patients are attended to in an open ward room by recovery room registered nurses and aides until recovered from anesthesia. The minimum recovery room stay is estimated to be one hour. The average number of recovery room patients based on 1979 census is approximately 30-35 per day (range 25-45).

Staffing consists of approximately 73 persons for the operating room department and 19 for the recovery room. Job turnover for the operating room staff is 29% per annum and for the recovery room is 21% per annum. Work week is 7 days per week, 24 hours per day.

lSection 20(a)(6) of the Occupational Safety and Health Act of 1970, 19 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by any employer or authorized representative to employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

Anesthesiologists and surgeons are from a number of different practice groups and are in and out of the department. All anesthesiologists were using nitrous oxide and either ethrane or halothane. Low flow anesthesiology was practiced by a majority of the anesthesiologists.

IV. METHODS AND MATERIALS

A. Environmental

Nitrous oxide samples were collected in 20 liter mylar bags using a vacuum pump operated at 300 cubic centimeters (cc) per minute. These samples were analyzed immediately on the surgical floor by infrared spectrometry using a Wilks Miran IA with a sensitivity of 5 ppm. Instrument settings were wave length 4.47 microns, path length 5.25 meters, and slit width 0.5 millimeters (mm). Halothane and ethrane samples were collected on charcoal tubes using vacuum pumps operated at 200 cc per minute. Analysis of these samples was performed using gas chromatography and P&CAM Method No. 127. Breathing zone air samples of operating room personnel were collected during each surgical procedure for the above anesthetic gases.

B. Epidemiological

A self-administered questionnaire directed at acute and chronic waste anesthetic gas effects was used to survey the operating and recovery room personnel. Non-respondents, which included people not at work and people who failed to return questionnaires, were mailed questionnaires for completion.

V. EVALUATION CRITERIA

A. Environmental

One source of criteria was used to assess workroom concentrations of air contaminants: NIOSH Criteria for a Recommended Standard for Occupational Exposure...Occupational Exposure to Waste Anesthetic Gases and Vapors. (Reference 2)

	Permissible Exposure Limits 8-Hour Time-Weighted Exposure Basis (ppm)
Nitrous Oxide	25.0 (NIOSH)
Ethrane	0.5 (NIOSH
Halothane	0.5 (NIOSH)

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

Occupational health standards are established at levels designed to protect individuals occupationally exposed to toxic substances on an 8-hour per day, 40-hour per week basis over a normal working lifetime.

B. 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 congential abnormal-ities in the offspring of females workers and the wives of male Risks of hepatic and renal diseases are also increased workers. 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 of anesthetic gases have been associated with headaches, nausea, 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 Knill-Jones, 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 gases and to wives of men with similar exposures. While most animal exposure studies have been conducted at anesthetic levels, one study (References 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 indicated an increase in spontaneous abortion and congenital abnormalities also indicated an increase in liver and kidney 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 with resulting urinary excretion 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 enflurance anesthesia. While epidemio-logical 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

A. Environmental Results

Seven of 21 (31%) of the ethrane breathing zone air samples exceeded the NIOSH evaluation criteria. Ethrane concentrations ranged from less than 0.01 ppm to 1.6 ppm. None of the 21 halothane environmental samples exceeded the NIOSH evaluation criteria. Overexposures to nitrous oxide were observed in approximately 50% of the samples taken. These operating rooms have a maximum of 15 air changes per hour. Ventilation was probably adequate. High exposures were perhaps due to leaks in the anesthetic cart and at the mask of the patient. Results may be reviewed in Tables 5 through 10. Scavenging equipment was present on all anesthetic carts.

B. Epidemiological Results

The findings in this cross-sectional study did not establish a strong association of acute symptom occurrence and any index of operating room anesthetic gas exposure (i.e. operating room shift duration, operating room job duration). Prevalence of symptoms was significantly higher in recovery room personnel than operating room personnel. The occurrence of symptoms (i.e. fatigue, headache) might be explained by the general occurrence of these symptoms or by the demands of the jobs of these persons, e.g. standing on feet for long periods of time. Although the environmental data do not show any excess levels of nitrons in oxide in the recovery room, it is possible that continuous low level exposures that could be seen in a recovery room with constant anesthetized patient exhalation exposure versus intermittent low and high nitrous oxide exposures as seen in operating room personnel might explain the symptoms seen in these recovery room personnel. Eight-hour time-weighted average (TWA) exposure measurements might be able to answer this question.

It should be noted the numbers studied in this survey were relatively small and would not be sensitive to small differences in groups. This limited study could not detect any excess of excess chronic disease or adverse fertility effects in this worker population; however, because the numbers in this survey are small such effects would not be expected to be seen here. The menstrual disorders reported are difficult to interpret since the number of irregularities are not uncommon, subject to variable influences, and . a "normal" prevalence is not known. Skin irritation was mentioned by seven respondents and in some cases was believed to be associated with "scrubbing" and/or using Betadine. Since Betadine contains iodine, hypersensitivity to iodine may occur to susceptible individuals.

VII. CONCLUSIONS

Excessive levels of ethrane and nitrous oxide were detected in all operating rooms. Although the epidemiological data showed no excess chronic health effects, the small number of employees surveyed preclude a definite conclusion about waste anesthetic gas associated chronic health hazards.

VIII. RECOMMENDATIONS

- 1. All workers should have annual physical examinations including liver function (SMA-12 or equivalent) and complete blood count.
- 2. Any worker experiencing skin irritation associated with "scrubbing" with iodine disinfectant should use an alternative disinfecting agent to reduce the likelihood of sensitization.
- 3. Anesthesiologists should check slip connections and high pressure nitrous oxide connections since these are areas where high concentrations were observed.
- Air monitoring should be continued in order to eliminate exposures and ensure proper maintenance of the ventilation system and scavenging systems.

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X. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared By:

Bobby J. Gunter, Ph.D. Regional Industrial Hygienist NIOSH - Region VIII Denver, Colorado

Arthur S. Watanabe, Pharm.D. Medical Investigator Medical Section, Hazard Evaluation and Technical Assistance Branch NIOSH, Cincinnati, Ohio

Paul Pryor Regional Industrial Hygienist NIOSH - Region VIII Denver, Colorado

Pierre Belanger Regional Industrial Hygienist NIOSH - Region IX San Francisco, California

Hazard Evaluation and Technical Assistance Branch (HETAB) Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS) NIOSH, Cincinnati, Ohio

Marilyn K. Schulenberg NIOSH - Region VIII Denver, Colorado

Evaluation Assistance:

Originating Office:

Report Typed By:

XI. DISTRIBUTION AND AVAILABILITY

Copies of this determination report are currently available upon request from NIOSH, Division of Technical Service, 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. Anthony's Hospital.
- 2. U.S. Department of Labor/OSHA Region VIII.
- 3. NIOSH Region VIII.
- 4. Colorado Department of Health
- 5. State Designated Agency

For the purpose of informing all 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 1

Population Characteristics of Surgery Department

St. Anthony's Hospital Denver, Colorado

March 11-12, 1980

		EMPLOYEES		AGE	JOB DURATION (Yrs.)			
G	ROUP/JOB	No.	MALE	FEMALE	Mean (Range)	Mean	(Range)	SMOKERS
OPERATI	NG ROOM (OR)						9	
a.	RN	45	2	43	33.9 (7.1)	5.7	(5.7)	14
b.	Non-RN Techs Aides	9 10	6	11	29.7 (10.4)	6.9	(6.9)	7
с.	All OR	62	8	54				21
ANESTHE	SIOLOGY	5	5	0	49 (33-60)	14.7	(3-31)	1
RECOVER a. b. c.	RN RN Non-RN All RR	15 4 19	$\frac{1}{3}$	13 <u>3</u> 16	39.8 (24-64) 37.3 (20-47)	5.4 9.1	(.2-16.7) (1.3-6.7)	2 1 3
TOTAL		86	16	70			16	25

TABLE 2

Symptom History by Department & Personnel Surgery Department

St. Anthony's Hospital Denver, Colorado

March 11-12, 1980

	Acute	No	Chi	ronic	10.00	Fe	rtil	ity*	
13	Symptoms	Symptoms	Liver	Kidney	PG	LB	SB	MC	ABO
OPERATING ROOM									
RN Non-RN Total	17 <u>8</u> 25 (43.9%)	18 <u>14</u> 32 (56.1%)	1 0 1	000	26	23	0	3	0
RECOVERY ROOM	¥	8							
RN Non-RN Total	12 <u>3</u> 15 (78.9%)	$\frac{3}{\frac{1}{4}}$ (21.1%)		1 0 1	4	4	0	0	0
ANESTHESIOLOGY	1 (20%)	4 (80%)	l	0	3	3	0	0	0

* PG = Pregnancy LB = Live Birth

SB = Still Birth

MC = Miscarry

ABO = Therapeutic abortion

TABLE 3

Types of Acute Symptoms in Operating Room Personnel

St. Anthony's Hospital Denver, Colorado

March 11-12, 1980

	HA	LH/DZ	Fatique	Nausea	Skin Irritation	Sleepiness
OPERATING ROOM	600-140-140-000-00-0					
RN Non-RN	14 2	2 1	13 3	3 1	4 2	0
ANESTHESIOLOGY	0	1	1	0	0	0
RECOVERY ROOM						
RN Non-RN	8 1	5 1	12 2	2 0	1 0	4 0
TOTALS	19	4	27	5	7	2

HA = Headache

LH/DZ = Lightheadedness/Dizziness

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TABLE 4

Types of Surgery Per Year (percent)

St. Anthony's Hospital Denver, Colorado

26.5%
26.25%
11%
4.5%
12.5%
3.5%
5.5%
1.5%
6.5%
1.5%
. 5%
.5%

Types of Anesthesia for 1979

General	84.1%
Local/IV	13.1%
Spinal	1.2%
Other	1.6%

TABLE 5

Breathing Zone Air Concentrations of Ethrane and Halothane in the Operating Rooms

St. Anthony's Hospital Denver, Colorado

March 11-12, 1980

Sample			p	mqu
Number	Job Classification	Sampling Time	Ethrane	Halothane
1	Circulating Nurse	7:30 AM - 1:00 PM	0.1	0.3
2	Scrub Nurse	7:40 AM - 1:00 PM	0.7	0.2
3	Circulating Nurse	7:40 AM - 11:15 AM	1.6	0.1
4	Circulating Nurse	7:40 AM - 11:30 AM	0.1	*
5	Scrub Nurse	7:30 AM - 11:45 AM	0.1	*
6	Scrub Nurse	7:30 AM - 12:10 PM	*	*
7	Circulating Nurse	7:40 AM - 1:15 PM	0.1	0.2
8	Scrub Nurse	7:40 AM - 1:14 PM	0.9	*
9	Scrub Nurse	12:20 PM - 2:00 PM	0.1	0.2
11	Anesthesiologist	9:20 AM - 11:10 AM	0.2	*
12	Circulating Nurse	7:40 AM - 11:30 AM	1.6	*
13	Circulating Nurse	7:13 AM - 12:00 N	0.1	0.4
14	Circulating Nurse	7:05 AM - 12:10 PM	0.1	0.2
15	Scrub Nurse	7:00 AM - 1:00 PM	0.3	0.07
16	Scrub Nurse	7:05 AM - 12:20 PM	0.6	*
17	Scrub Nurse	9:30 AM - 1:00 PM	0.2	0.05
18	Scrub Nurse	7:15 AM - 1:10 PM	0.3	0.1
19	Circulating Nurse	7:29 AM - 1:00 PM	0.7	0.05
20	Circulating Nurse	7:30 AM - 1:50 PM	0.3	0.4
23	Scrub Nurse	7:05 AM - 11:30 AM	0.7	*
30	Scrub Nurse	7:10 AM - 12:15 PM	*	*
	NIOSH EVALUATIO	IN CRITERIA	0.5	0.5

NIOSH EVALUATION CRITERIA LABORATORY LIMIT OF DETECTION mg/sample

0.5 0.01

0.01

* = below laboratory limits of detection

1

TABLE 6

Elevated Readings of Nitrous Oxide in the Operating Rooms

St. Anthony's Hospital Denver, Colorado

March 11, 1980

Operating Room	Job Classification	Nitrous Oxide
6 1 3 6 3 8 3 Recovery Room Recovery Room Recovery Room Recovery Room Recovery Room Recovery Room Recovery Room	Circulating Nurse Scrub Nurse Circulating Nurse Circulating Nurse Scrub Nurse Scrub Nurse Area (bedside) Area (front desk) Nurse Area (front desk) Nurse Nurse	98 60 70 50 45 45 45 65 45 40 35 40 40 40
	March 12, 1980	
Operating Room	Job Classification	ppm Nitrous Oxide
1 2 6 1 6 1 6 8 1 1 1	Anesthesiologist Scrub Nurse Scrub Nurse Scrub Nurse Scrub Nurse Scrub Nurse Scrub Nurse Circulating Nurse Anesthesiologist Scrub Nurse	35 128 40 35 35 35 40 93 50 80
	NIOSH EVALUATION CRITERIA	25

LABORATORY LIMIT OF DETECTION

25

TABLE 7

Breathing Zone Air Concentrations of Nitrous Oxide in Operating Room Personnel (Scrub Nurses, Circulating Nurses, Anesthesiologists)

St. Anthony's Hospital Denver, Colorado

March 11, 1980

Operating Room Sampling Time Nitrous Oxide 6 7:30 AM - 8:10 AM 98 3 7:40 AM - 8:17 AM 5 7 7:35 AM - 8:18 AM 25 6 7:30 AM - 8:20 AM 15 6 7:30 AM - 8:20 AM 10 1 7:40 AM - 8:26 AM 60 4 7:30 AM - 8:30 AM 15 4 7:30 AM - 8:30 AM 15 4 7:30 AM - 8:30 AM 18 2 7:30 AM - 8:32 AM 18 2 7:30 AM - 8:32 AM 18 3 8:10 AM - 8:33 AM 10 3 8:10 AM - 8:32 AM 10 6 9:00 AM - 9:00 AM 10 7 8:15 AM - 8:47 AM 15 4 8:30 AM - 9:07 AM 15 7 8:15 AM - 9:07 AM <			ppm
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4 9:15 AM - 10:23 AM 10	8	9.05 AM - 10.20 AM	45
	4	9.15 AM - 10.23 AM	10
	73	9.15 AM - 10.25 AM	10
7 10.05 AM - 10.35 AM 15	7	10.05 AM - 10.35 AM	15

1

TABLE 7 (continued)

		ppm
Operating Room	Sampling Time	Nitrous Oxide
Operating Room 6 6 3 6 Recovery Room 6 6 8 Recovery Room Recovery/front desk 3	Sampling Time 10:25 AM - 10:50 AM 10:05 AM - 10:53 AM 10:00 AM - 10:55 AM 9:50 AM - 11:00 AM 10:20 AM - 11:01 AM 10:30 AM - 11:04 AM 10:30 AM - 11:08 AM 10:50 AM - 11:09 AM 10:50 AM - 11:10 AM 10:50 AM - 11:10 AM 10:50 AM - 11:12 AM 10:50 AM - 11:13 AM 10:50 AM - 11:12 AM 10:30 AM - 11:21 AM 10:30 AM - 11:25 AM 11:00 AM - 11:26 AM	Nitrous Oxide 13 20 15 20 15 15 30 15 10 30 40 30 40 30 25 25 25
Recovery Room Recovery/front desk Recovery Room 6 Recovery Room Recovery Room Recovery/front desk 6	11:05 AM - 11:32 AM 11:05 AM - 11:38 AM 11:05 AM - 11:42 AM 11:05 AM - 11:52 AM 12:00 N - 12:16 PM 11:40 AM - 12:24 PM 11:40 AM - 12:26 PM 12:05 PM - 12:31 PM	45 30 30 40 10 35 40 15
6 7 Recovery Room Recovery Room 6 Recovery Room Recovery Room 6 6 Recovery Room Recovery Room Recovery Room 6	12:30 PM - 12:31 PM 12:30 PM - 12:38 PM 12:25 PM - 12:48 PM 12:10 PM - 1:10 PM 12:30 PM - 1:15 PM 12:20 PM - 1:20 PM 12:30 PM - 1:21 PM 1:00 PM - 1:23 PM 12:30 PM - 1:25 PM 12:45 PM - 1:37 PM 1:00 PM - 1:55 PM 1:30 PM - 2:00 PM 12:45 PM - 2:00 PM	20 15 30 40 15 30 40 30 40 30 40 30 20 20 20 20

NIOSH EVALUATION CRITERIA

33

25

70 samples collected on March 11, 1980 -- 41% exceeded the Evaluation Criteria.

 $\sim -\infty$

TABLE 8

Breathing Zone Air Concentrations of Nitrous Oxide in Operating Room Personnel (Scrub Nurses, Circulating Nurses, Anesthesiologists)

St. Anthony's Hospital Denver, Colorado

March 12, 1980

		ppm
Operating Room	Sampling Time	Nitrous Oxide
1	7:24 AM - 8:00 AM	35
3	7:35 AM - 8:12 AM	20
2	7:24 AM - 8:00 AM	128
6	7:05 AM - 7:30 AM	25
6	7:15 AM - 7:45 AM	30
6	7:15 AM - 7:30 AM	32
1	7:05 AM - 7:45 AM	. 25
8	-8:45 AM - 9:23 AM	25
2	7:10 AM - 7:45 AM	25
6	7:30 AM - 8:16 AM	40
6	7:30 AM - 8:00 AM	35
1	7:45 AM - 8:15 AM	35
. 6	8:05 AM - 8:40 AM	35
2	8:05 AM - 8:23 AM	20
1	8:05 AM - 8:45 AM	20
5	8:05 AM - 8:50 AM	25
8	8:12 AM - 9:15 AM	40
5	8:12 AM - 8:50 AM	30
1	8:15 AM - 8:45 AM	20
6	8:16 AM - 8:40 AM	20
2	8:23 AM - 8:50 AM	20
Recovery Room	8:25 AM - 9:20 AM	25
6	8:40 AM - 9:05 AM	25
6	8:40 AM - 9:00 AM	15
5	8:50 AM - 9:20 AM	23
2	8:55 AM - 9:28 AM	25
5	8.55 AM - 9.23 AM	35
ĩ	9:00 AM - 9:38 AM	93
ī	9:00 AM - 9:38 AM	50
a da	9.15 AM - 9.50 AM	20
8	9.23 AM - 9.55 AM	20
5	9.23 AM _ 9.59 AM	20
6	9.31 AM 10.10 AM	20
0	2:21 AM 10:10 AM	10
0	9:31 AM - 10:10 AM	, 20
2	9:22 AM - 10:00 AM	56

TABLE 8 (continued)

		ppm
Operating Room	Sampling Time	Nitrous Oxide
1	9:38 AM - 10:30 AM	80
l	9:38 AM - 10:20 AM	30
8	9:51 AM - 10:25 AM	35
Recovery Room	9:20 AM - 10:22 AM	25
5	9:59 AM - 10:35 AM	30
8	10:15 AM - 11:00 AM	105
1	11:05 AM - 11:40 AM	105

NIOSH EVALUATION CRITERIA

25

42 samples collected March 12, 1980 -- 69% exceeded the Evaluation Criteria.

TABLE 9

The High, Low, and Mean Breathing Zone and General Room Air Concentrations of Nitrous Oxide

St. Anthony's Hospital Denver, Colorado

March 11, 1980

	Nitrous Oxide in ppm		
Operating Room	High	Low	Mean
1	60		
2 .	18	15	17
3	70	5	31
4	15	10	12
6	98	10	22
7	30	15	20
8	45	10	22
Recovery Room	45	20	32

March 12, 1980

	Nitrous Oxide in ppm		
Operating Room	High	Low	Mean
1	105	20	49
2	128	20	44
3	20	20	20
5	38	25	29
6	15	40	27
8	105	20	40
Recovery Room	25	25	25

NIOSH Evaluation Criteria for Nitrous Oxide is 25 ppm.

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TABLE 10

Direct Readings of Nitrous Oxide of Patients in Recovery Room

St. Anthony's Hospital Denver, Colorado

March 11, 1980

Background - Floor = 30 ppm. Background - 5 feet above ground = 25 ppm.

Patient	Sampling Time	Nitrous Oxide
1	5 minutes post surgery	> 250
2	90 minutes post surgery	> 250
3	70 minutes post surgery	> 35
4	40 minutes post surgery	> 250
5	50 minutes post surgery	> 250
6	105 minutes post surgery	> 30
7	45 minutes post surgery	> 250

nnm

nnm

Maximum of 7 patients observed in room at one time.

March 12, 1980

Background - Floor = 15 ppm. Background - 5 feet above ground = 15 ppm.

Patient	Sampling Time	Nitrous Oxide
1	10 hours, 30 minutes post surgery (patient on respirator)	15
2	35 minutes post surgery	> 250
3	5 minutes post surgery	> 250
4	25 minutes post surgery	55-200
5	60 minutes post surgery	40
6	75 minutes post surgery	150