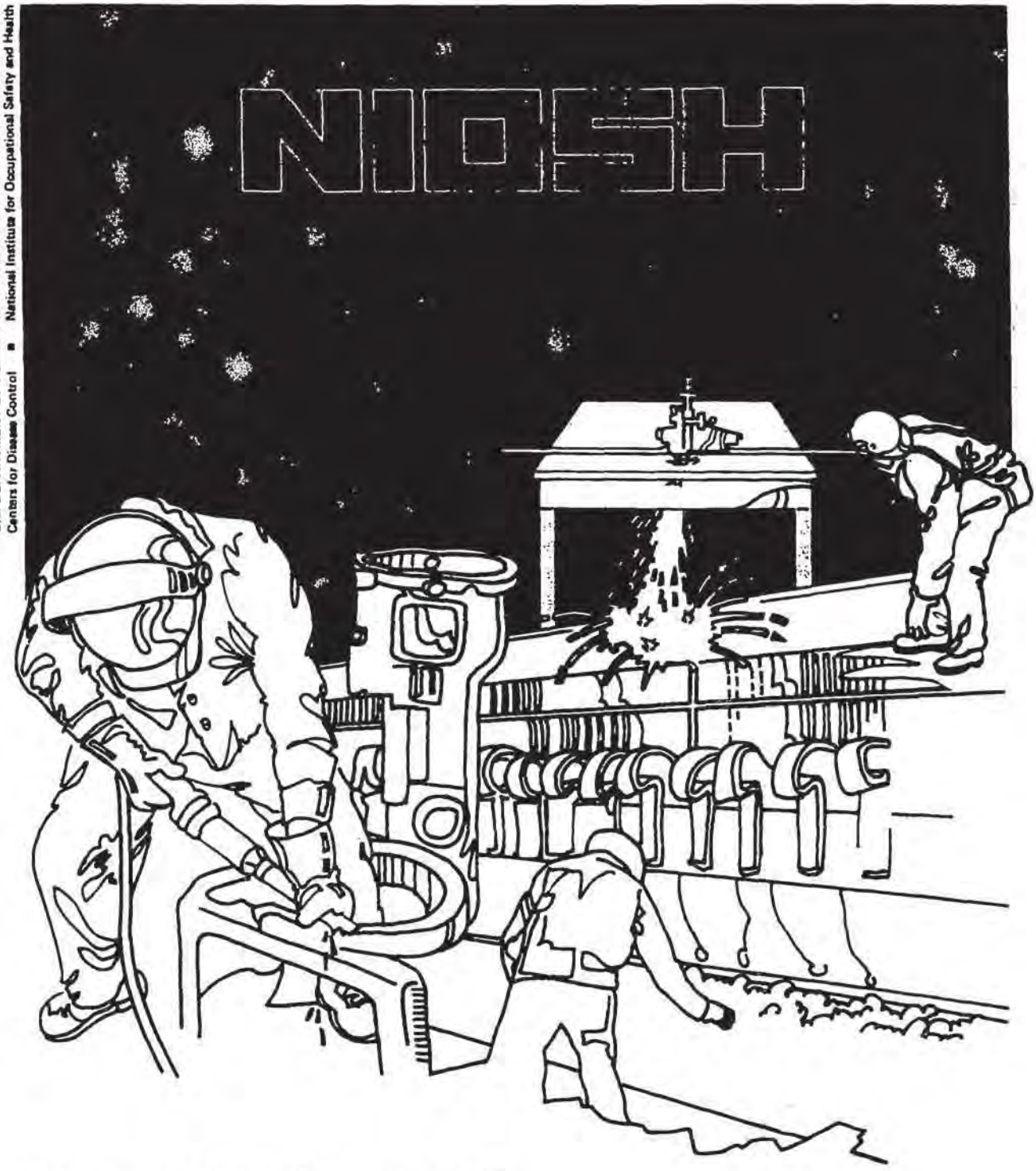
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 83-153-1510
SWEDISH HOSPITAL
SEATTLE, WASHINGTON

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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SEPTEMBER 1984
SWEDISH HOSPITAL
SEATTLE, WASHINGTON

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I. SUMMARY

In February 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request from Swedish Hospital, Seattle, Washington, to determine if the surgical nurses' exposures to methyl methacrylate, used in hip surgery, and anesthetic gases (nitrous oxide and isoflurane) were the cause of reported headaches.

On May 17, June 22-23, and July 13, 1983, NIOSH investigators collected samples to measure workers' exposures to isoflurane, methyl methacrylate and nitrous oxide . In June a questionnaire was distributed to all operating room nurses in order to obtain information regarding their exposure to these substances and associated symptoms. In November, and again in January, the operating room staff maintained daily logs of health effects, type of surgery performed and anesthetic gases used, as well as personal characteristics, such as use of medications and cigarettes.

The scrub nurses' exposure to methyl methacrylate ranged from 1.1 to 3.1 ppm; the assistant surgeons' was <1.1 to 3.3 ppm; and the anesthesiologists' exposure was <0.4 to 1.1 ppm. These concentrations are well below the methyl methacrylate criterion of 100 ppm. Their exposure to nitrous oxide during one survey was 3.5 to 4.5 ppm and to isoflurane was <0.07 to 0.39 ppm. During a second survey the scrub nurses' average exposure to nitrous oxide was 45 ppm and their anesthesiologist was 90 ppm; isoflurane exposure was 1.13 and 2.4 ppm, respectively. The nitrous oxide exposure of 45 and 90 ppm exceeded the NIOSH recommended criterion of 25 ppm during anesthetic administration. The isoflurane average concentration of 2.4 ppm exceeded the NIOSH recommended criterion of 2 ppm for any hour of exposure. The high concentration that occurred during the second surgery was caused by the failure to connect a hose from the scavenger unit to the exhaust system prior to surgery.

The recovery room nurses' exposures to nitrous oxide ranged from 4 to 20 ppm with a time-weighted average of all samples of 14 ppm.

Questionnaires were completed and for two months daily logs were maintained by the surgical nurses listing their exposure to methyl methacrylate and the symptoms they experienced. Although an association between reported headaches and direct exposures to methyl methacrylate was not documented, it is possible that some workers may be more sensitive than others to methyl methacrylate.

On the basis of this investigation it was determined that a health hazard existed at Swedish Hospital. The operating room personnel were exposed to concentrations of nitrous oxide and isoflurane (anesthetic gases) that exceeded the NIOSH recommended criteria during one of the surgeries that was monitored. However, no association between reported headaches and direct exposure to methyl methacrylate was found. Recommendations to reduce exposure to sensitive workers by means of scheduling assignments are included in their report.

Keywords SIC 8062 (General Medical and Surgical Hospitals) anesthetic gases, isoflurane, methyl methacrylate, nitrous oxide.

II INTRODUCTION

In February 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request from the management at Swedish Hospital, Seattle, Washington, to determine if the surgical nurses' exposure to methyl methacrylate and anesthetic gases (nitrous oxide and isoflurane) were the cause of reported headaches.

NIOSH investigators collected samples to measure workers' exposures to isoflurane, methyl methacrylate and nitrous oxide on May 17, June 23, 1983 and July 13, 1983. In June a questionnaire was distributed to all operating room nurses in order to obtain information regarding their exposure to these substances and any associated symptoms. In November, and again in January, the operating room staff maintained daily logs of symptoms experienced, type of surgery performed, anesthetic gases used, as well as personal characteristics, such as use of medications and cigarettes. An interim report was submitted to the hospital on August 22, 1983.

III BACKGROUND

Swedish Hospital is a general hospital. This request involves the Surgery Department which consists of the south and north main surgery areas, pavilion surgery area and day surgery area. Specifically, the request involved hip surgery procedures where methyl methacrylate (MMA) was used. During the initial visit NIOSH was also requested to determine the recovery room nurses' exposure to nitrous oxide.

A. Surgical Rooms

Methyl methacrylate monomer is mixed with a powdered polymer to make a bone cement used in hip surgery. The mixing is a timed and precise procedure and after mixing,the cement has to be used within a precise time frame. The scrub nurse mixes the cement in a small 12" exhaust ventilation hood that is connected to the surgery room suction system. The amount of methyl methacrylate released is the greatest during the first few minutes of the mixing procedure. Mixing in the hood prevents the vapors from entering the room atmosphere. Two batches were mixed during each procedure, one when the socket prosthesis was installed and the other when the femoral head prosthesis was installed. The time from the first mix to the time the implant was completed was approximately 45 to 60 minutes.

The anesthetics used during these procedures are either a spinal block or anesthetic gases which consist of 50% nitrous oxide and 1 to 2% of isoflurane (a halogenated anesthetic gas). When anesthetic gases are used, the waste gases are captured by a scavenger system which is connected to the local exhaust ventilation system present in each surgical room.

There are 5 or more workers in the room during the procedure. They are the surgeon, assistant surgeon, anesthesiologist, scrub nurse, circulating nurse and there can be several others. The workers' exposure may consist of just methyl methacrylate when a spinal block anesthetic is used and a combination of methyl methacrylate, nitrous oxide and isoflurane when anesthetic gases are used.

There are 78 nurses who work in surgery and, of these, 23 reported work with surgical procedures where methyl methacrylate is used.

B. Recovery Room

Surgery patients who have been administered anesthetic gases continue to exhale these gases until they are completely removed from the blood stream. The recovery room nurses are exposed to these exhaled gases while tending the patients. There are nine nurses who work in the main recovery room.

IV EVALUATION DESIGN

A. Environmental air samples were collected for methyl methacrylate, nitrous oxide and isoflurane during total hip surgery. These samples were collected in the breathing zone of the assistant surgeon, anesthesiologist and scrub nurse. Air samples were collected for nitrous oxide in the breathing zone of the recovery room nurses while attending patients who had just returned from surgery. The sampling was conducted on May 17, June 22, 23 and July 18, 1983.

Listed below are the sampling and analytical methods used in this evaluation.

Substance	Collection Method	Flow Rate	NIOSH Analytical Method
Isoflurane	Charcoal	100cc/min	P&CAM 127
Methyl methacrylate	XAD-2 Resin	100cc/min	P&CAM 127
Nitrous oxide	Mylar Sampling Bags	100cc/min	Wilks Miran 1A Infrared Analyzer

B. Medical

In June a questionnaire was distributed to all operating room staff in order to obtain information regarding their exposure to methyl methacrylate and any symptoms they may have experienced. During the month of November, and again during January, the nurses were asked to maintain a daily log prepared by NIOSH that listed the type of surgery performed, length of surgery, anesthetics used, and whether they were using medications or cigarettes, as well as any symptoms experienced.

V EVALUATION CRITERIA

A. Environmental 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. The 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 becomes 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), 3) the U.S. Department of Labor (OSHA) occupational health standards, and 4) the Washington State 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.

Substance	NIOSH Recommended Criteria	Washington State or OSHA Standard 8 Hour TWA
Isoflurane	2 ppm for any 60 min period	None
Methyl methacrylate	none	100 ppm
Nitrous oxide	25 ppm TWA during anesthetic administration	None

B. Toxicological Information

Nitrous Oxide and Halogenated Anesthetic Gases

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 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 systsem 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 a maximum TWA exposure of 25 ppm nitrous oxide during anesthetic administration and 2 ppm halogenated anesthetic for any 60 minute period.

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 bearing children with 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).

C. Methyl methacrylate

MMA vapor is an irritant to the skin and respiratory tract. Both the monomer and the polymer are reportedly capable of causing an allergic skin reaction. Dust produced from mechanically processing polymethyl methacrylate may also be irritating to the skin or may enter the eyes.[17] A recent study has suggested that MMA causes certain alterations in blood and urine biochemical parameters.[18]

Routledge[19] reported two human studies conducted by Karpov that inhalation exposures had resulted in irritability, tiredness, drowsiness, headache, anorexia, and hypotension. Routledge also reported that irritation of the mucosae occurred at 62 ppm, and had suggested that a maximum permissible level for methyl methacrylate be set at 12.5 ppm, rather than the current TLV of 100 ppm. The effects of methyl methacrylate vapors on workers employed for more than 10 years were studied in the Soviet Union by Blagodatin et al.[20] Those workers were exposed to a range of airborne concentrations of methyl methacrylate from 0.5 to 50 ppm. Out of 152 workers in the study, 119 had complaints of headache, 45 pain in the extremities, 32 excessive fatigue, 30 sleep disturbance, 30 loss of memory, and 25 irritability.

A study conducted by the National Institute for Occupational Safety and Health revealed that in five plants manufacturing polymethyl methacrylate sheets, the mean 8-hour time-weighted-average exposures to methyl methacrylate ranged from 4 to 88 ppm. Airborne concentrations and biological samples such as blood pressure, pulmonary function, urine, blood counts, etc. from the workers were assessed. Their conclusion showed no detectable acute toxic signs or symptoms.[18]

Current literature does not implicate MMA as a known carcinogen. The odor threshold of MMA is less than 1.0 ppm,[21] a value which is just a fraction of the environmental criteria (100 ppm).

VI RESULTS

A. Environmental

Air samples were collected in the breathing zone of the scrub nurses, assistant surgeons and anesthesiologists to determine their exposure to methyl methacrylate, nitrous oxide and isoflurane during surgery. Air samples were also collected to determine the recovery room nurses' exposure to nitrous oxide.

The results of the environmental sampling are shown in Tables 1, 2, and 3. The scrub nurses' exposure to methyl methacrylate ranged from 1.1 to 3.1 ppm; the assistant surgeons' was 1.1 to 3.3; and the anesthesiologist was <0.4 to 1.1 ppm. The criteria for an 8 hour average exposure is 100 ppm. The concentrations are well below the criteria. The lower level for the anesthesiologist shows that as one is farther away from the cement, the exposure is reduced.

One reason the air concentrations are low is that the cement is mixed in a small hood. Air concentrations were measured using a direct reading infrared analyzer during mixing of several batches of the cement that had just passed their expiration date. During these test mixes, the concentrations were lower than 3 ppm, when the hood was used for mixing. When the mix was taken out of the hood, the concentration rose immediately to over 70 ppm. This shows that the hood must be used when mixing the cement.

The workers' exposure to nitrous oxide during one surgery was 3 to 4.5 ppm and to isoflurane was <0.07 to 0.39. This is less than the criteria of 25 ppm for nitrous oxide and 2 ppm for isoflurane. During the second surgery, the anesthesiologist had a nitrous oxide exposure of 90 ppm and the scrub nurse of 45 ppm. This is 2 to 4 time the NIOSH recommended criteria of 25 ppm, during anesthetic administration. Their exposure to isoflurane was 2.4 and 1.13 ppm respectively. The anesthesiologists' exposure of 2.4 ppm exceeds the NIOSH recommended criteria of 2 ppm for any hour of exposure. Since the nitrous oxide sample was analyzed immediately after surgery, the cause for high concentration was investigated. The investigation revealed that the hose from the scavenger unit had not been connected to the exhaust system. It was then connected and the entire system checked for leaks. No leaks were found, so it was assumed that the disconnected hose was the cause of the high nitrous oxide and isoflurane exposure.

Samples were collected in the recovery room to determine the recovery room nurses' exposure to nitrous oxide. Breathing zone samples were collected for 620 minutes on 7 nurses. The concentrations ranged from 4 to 20 ppm with a time weighted average of 14 ppm. The general area samples near the main desk ranged from 4 to 5 ppm. The major portion of the nurses' exposure occurs when they are near the patient's head and are exposed to the exhaled air. All the samples were less than the 25 ppm criteria recommended by NIOSH.

B. Medical

The objective was to determine if there was a relationship between the reported symptoms and exposure to MMA. This section presents the results of the June questionnaire and subsequent daily logs which were maintained during two one-month time periods.

In June 1983, 99 questionnaires were distributed to personnel working in four surgical areas (south main surgery, north main surgery, the pavilion, and the day surgery) and to anesthesia staff who worked in these areas. Procedures using MMA were done only in the south main surgical area, but workers from other surgical areas occasionally rotated to work assignments in the south main area.

The response rates were: overall, 62% (61/99); south main surgery, 50% (13/26); north main surgery, 52% (12/23); the pavilion, 93% (13/14); the day surgery area, 11% (1/9); and the anesthesia staff, 81% (22/27). The workers responding to the questionnaire ranged in age from 25 to 63 years, 46 (75%) were female, and 54 (88%) were Caucasian. For analysis of the questionnaire results, we defined a worker to be exposed to MMA if they had worked in a surgical area while MMA was being used in a procedure. Twenty-three of the responding workers had been exposed, 36 were not exposed, and for two the questionnaire data were incomplete.

Workers were asked if they had experienced symptoms including: headache, light-headedness, eye irritation, sore throat, hoarseness, nausea, or skin rash. Of the 59 workers whose questionnaires were complete, 39 (66%) reported experiencing at least one of the above symptoms. Among MMA-exposed workers, 87% (20/23) reported symptoms compared to 53% (19/36) of workers not exposed to MMA. Headaches were the most frequent symptom reported and MMA-exposed workers reported the symptom more frequently (16/23, 70%) than workers not exposed to MMA (13/36, 36%). These results suggested that there may be an association between exposure to MMA and experiencing symptoms, including headaches.

However, from the information reported on the questionnaires, we could not tell the exact temporal relationship between working with MMA and the time of onset of symptoms, nor whether the intensity or duration of exposure to MMA was related to the severity or duration of reported symptoms.

Also, we were concerned about the possibility of a reporting bias, i.e., the workers who had participated in hip and knee replacement surgeries had requested the investigation, had discussed symptoms among themselves, and therefore, may have been more likely to recall and report symptoms on the questionnaire. For these reasons, we chose to ask workers who had reported exposure to MMA (i.e., workers in an operating room while MMA was being used in a procedure) to maintain daily logs about their work activities (including work with MMA) and symptoms which they experienced during a three-week period.

In November 1983, we distributed daily logs to the workers. Of the 23 workers (16 of whom had perviously reported experiencing headaches) who had reported exposure to MMA in the June 1983 questionnaire, 17 (12 of whom had previously reported headaches) were working in November and December, and of these 15 (10 of whom had previously reported headaches) completed and returned daily log forms. Unfortunately, no MMA procedures were done during the

three-week survey period. In spite of this, 4 of the 10 workers who had previously reported headaches did so again. These 4 workers reported a total of 8 episodes of headache during the three-week period. In four instances the onset of symptoms was during surgery, while in the other four instances the headache onset was prior to going to the operating room. None of the 5 workers who had not previously reported headaches did so on this survey. Workers reporting headaches on this survey were indistinguishable from those not reporting symptoms with regard to type, frequency, or duration of surgical procedures with which they were involved.

In January 1984 daily logs were again distributed, this time to 13 workers whose work included participation in hip and knee replacement surgeries. Of these 13, 8 had reported exposure to MMA, and 6 had reported headaches on the June 1983 questionnaire; 8 had participated in the November survey, and of these 6 had reported headaches during that time. In January, 4 workers reported a total of 13 headache episodes, none of which had an onset during or within two hours after direct exposure to MMA. Three of the workers reporting headaches in January were among the four who reported headaches in the November survey.

Although we were not able to document an association between reported headaches and direct exposure to MMA, it is possible that some workers may be more sensitive than others to MMA exposure. Some symptoms may be related to the exposure. One worker, for example, reported on each survey that she regularly experienced "lightheaded" feelings during the time MMA was being mixed in the operating room. It would be prudent for operating room supervisors (to the extent possible) to not schedule workers like this one for procedures in which MMA would be used.

VII SUMMARY AND CONCLUSION

The operating room personnel were exposed to concentrations of nitrous oxide and isoflurane (anesthetic gases) that exceeded the NIOSH recommended criteria during one of the surgical procedurs that was monitored. The elevated concentrations were a result of an exhaust hose that had not been connected prior to surgery. During the other surgical procedures, these gases and the MMA concentrations were well below the evaluation criteria. There was no association found between reported headaches and direct exposure to MMA.

VIII RECOMMENDATIONS

1. Ensure that existing air contaminant control services (scavenger, etc.) are connected to the exhaust ventilation system prior to surgery.

2. Mix all MMA cement mixtures in the small exhaust hoods that are provided, as test results showed they were extremely effective in capturing the MMA vapor generated.

3. It would be prudent for operating room supervisors (to the extent possible) to not schedule workers who have a high sensitivity to MMA vapors for procedures where MMA is to be used.

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XI DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cinncinnati address. Copies of this report have been sent to:

1. Swedish Hospital, Seattle, Washington
2. Washington State Department of Labor and Industries, WISHA, Olympia, Washington.
3. U. S. Department of Labor, Occupational Safety and Health Agency (OSHA), Region X, Seattle, Washington.

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.

Table 1

METHYL METHACRYLATE AIR CONCENTRATIONS
DURING TOTAL HIP SURGERY

SWEDISH HOSPITAL
HHE 83-153

JOB	DATE	SURGICAL ROOM	CASE NUMBER	SAMPLE NUMBER	TIME MINUTES	VOLUME LITERS	METHYL METHACRYLATE PPM
Scrub Nurse	5-17-83	S-5	1	1	63	6.53	1.1
Asst. Surgeon	5-17-83	S-5	1	5	63	6.85	1.1
Anesthesiologist	5-17-83	S-5	1	3	63	5.88	<0.4
Scrub Nurse	5-17-83	S-5	2	21	50	5.00	2.5
Scrub Nurse	5-17-83	S-4	3	22	45	4.04	3.1
Scrub Nurse	6-23-83	S-5	4	8	40	4.06	2.4
Asst. Surgeon	6-23-83	S-5	4	13	40	2.24	2.2
Anesthesiologist	6-23-83	S-5	4	11	40	3.06	<0.8
Scrub Nurse	7-13-83	S-6	5	15	50	5.19	2.8
Asst. Surgeon	7-13-83	S-6	5	16	50	4.67	3.1
Anesthesiologist	7-13-83	S-6	5	17	50	4.33	1.1

NOTE: 2 separate mixes of Methyl Methacrylate were made during each procedure.

Table 2

ANESTHETIC GAS AIR CONCENTRATIONS
(NITROUS OXIDE AND ISOFLURANE)
DURING TOTAL HIP SURGERY

SWEDISH HOSPITAL
HHE 83-153

JOB	DATE	SURGICAL ROOM	CASE NUMBER	SAMPLE NUMBER	SAMPLE TIME MINUTES	NITROUS OXIDE PPM	ISOFLURANE PPM
Scrub Nurse	5-17-83	S-5	1	2	190	3	<0.07
Asst. Surgeon	5-17-83	S-5	1	6	178	4	0.08
Anesthesiologist	5-17-83	S-5	1	4	178	4.5	0.39
Scrub Nurse	6-23-83	S-6	5	25	143	45	1.13
Anesthesiologist	6-23-83	S-6	5	27	148	90	2.40

NOTE: The nitrous oxide concentrations on 6-23-83 were high because the hose from the scavanger system was not connected to the room exhaust system before surgery.

Table 3

NITROUS OXIDE AIR CONCENTRATIONS
IN THE RECOVERY ROOM

SWEDISH HOSPITAL
HHE 83-153

JOB OR LOCATION	DATE	SAMPLE NUMBER	TIME	SAMPLE TIME MINUTES	NITROUS OXIDE PPM	
GA Spot Sample In middle of Recovery room	5-17-83	1	10:00a	3	6	
GA Spot Sample In middle of Recovery room	5-17-83	2	4:00p	3	12	
GA Near Main Desk	6-22-83	3	9:35a-11:30a	115	4	
BZ Recovery Room Nurse	6-22-83	4	9:45a-11:30a	105	13	
BZ Recovery Room Nurse	6-22-83	5	10:15a-11:30a	65	20	
GA Near Main Desk	6-22-83	6	11:45a- 1:30p	105	4	
BZ Recovery Room Nurse	6-22-83	7	11:45a- 1:30p	105	17	
BZ Recovery Room Nurse	6-22-83	8	11:45a- 1:30p	105	13	
GA Near Main Desk	6-22-83	9	1:40p- 2:50p	70	4	
BZ Recovery Room Nurse	6-22-83	10	2:10p- 2:50p	40	4	
GA Near Main Desk	6-23-83	11	11:15a-12:00p	45	5	
BZ Recovery Room Nurse	6-23-83	12	11:00a-12:40p	100	12	
BZ Recovery Room Nurse	6-23-83	13	11:00a-12:40p	100	15	
BZ Time Weighted Average TWA of 7 Samples from Recovery room nurses	-	-	-	620	14 13 4-20	TWA Median Range

NOTE: The number of patients in the recovery room during the sampling periods varied from 2 - 8.