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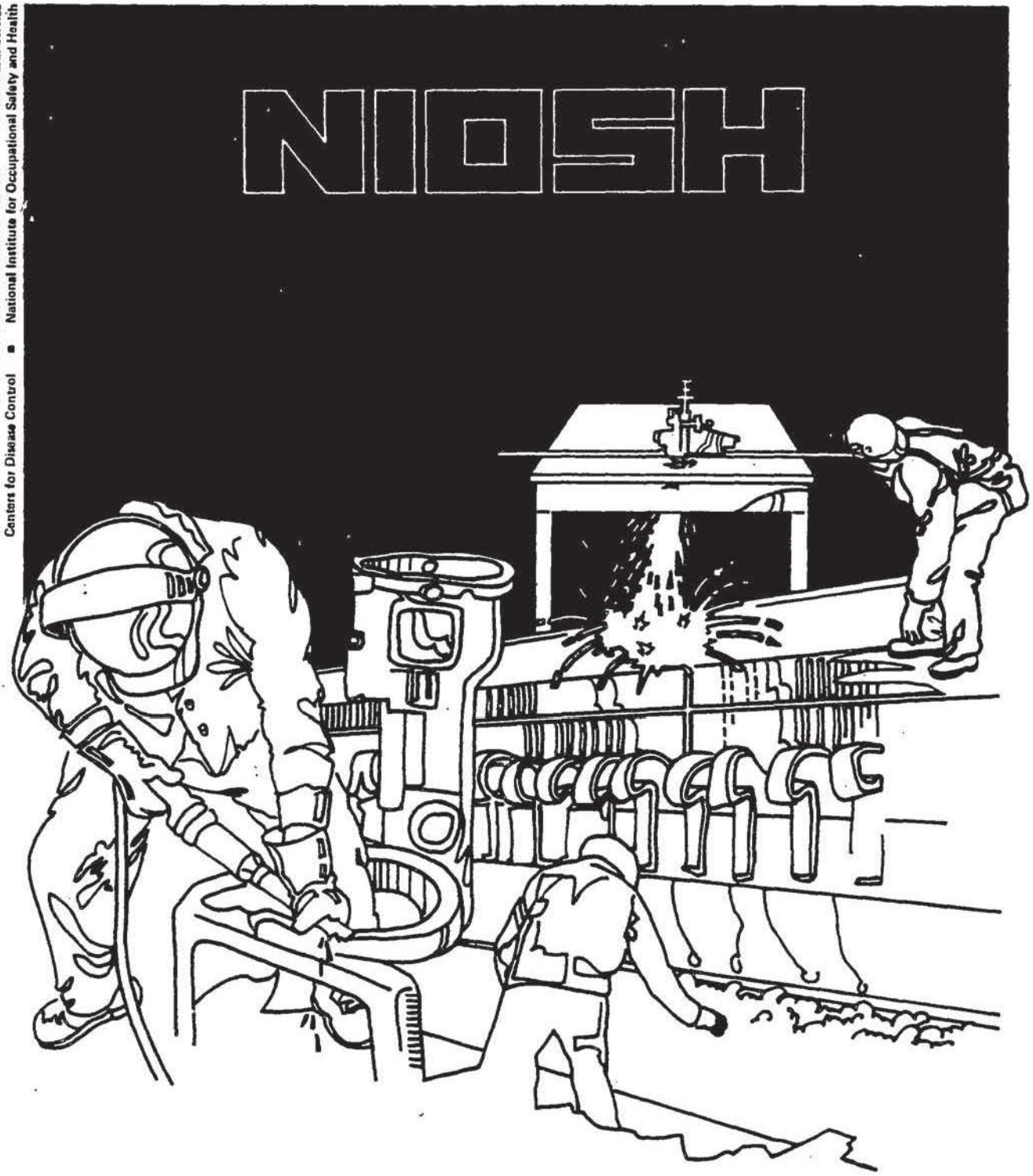
NIOSH



Health Hazard Evaluation Report

HETA 84-126-1555
DRS. SCHEER AND GARDNER
CINCINNATI, OHIO

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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DRS. SCHEER AND GARDNER
CINCINNATI, OHIO

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I. SUMMARY

On January 9, 1984, the National Institute for Occupational Safety and Health (NIOSH) was requested by Dr. Thomas R. Scheer and Dr. Wayne Gardner to evaluate the extent of nitrous oxide exposure at their two dental offices in Cincinnati, Ohio. Their Hyde Park Office was not equipped with a waste anesthetic scavenging system while their Beechmont Office had such a system installed prior to the NIOSH field survey. Mercury exposure was also evaluated.

To determine the extent of nitrous oxide exposure, NIOSH conducted site visits on March 29, 1984 at the Hyde Park Offices and on May 11 and June 8, 1984 at the Beechmont Offices. Air samples were obtained in mylar bags for subsequent analysis by portable infra red Miran 103® analyzer.

Exposure during the period of administration (14 minutes) at the Hyde Park Office where no anesthetic gas scavenging system was available, averaged 1300 parts per million (ppm) which exceeded the 50 ppm level that is achievable using engineering controls and good work practices. There is no OSHA standard for nitrous oxide. Nitrous oxide air concentrations ranged from 7 to 182 ppm in the 7 office areas tested the day of the survey.

Nitrous oxide exposures at the Beechmont Office, where a scavenging system had been installed, averaged 350 ppm in the breathing zone of the dentist during the 25 minute period when the gas was being administered. Concentrations of 20 to 30 ppm were detected in 6-hour samples obtained in other areas within the dental suite. The 350 ppm exposure resulted from the ineffective manner in which the scavenging system was used and the fact that the patient was very talkative (mouth-breathing was a source of nitrous oxide). After appropriate changes were instituted, exposure levels were reduced to 65 ppm during the period of administration and, if not for a malfunction in the scavenging system, the exposure would most likely have been below 50 ppm.

Mercury exposures, which were estimated using 3M® passive dosimeters, ranged from 0.004 to 0.008 milligrams per cubic meter (mg/m^3) which were below the OSHA standard (0.1 mg/m^3) and the NIOSH recommended standard of 0.05 mg/m^3.

The high exposures at the Hyde Park Office during the period of administration constitute a potential health hazard. The scavenging system installed at the Beechmont office is capable of adequately controlling nitrous oxide exposure if used properly. Recommendations are made to stop using nitrous oxide at the Hyde Park Office unless engineering controls are implemented. Section VII contains recommendations that will help to maintain good control of exposures through proper use of equipment and good work practices at the Beechmont Dental Office.

KEYWORDS: SIC 8021 (Dentists, Offices of) nitrous oxide, mercury, dental, anesthetic gases

II. INTRODUCTION

On January 9, 1984, NIOSH received a request from Doctors Scheer and Gardner to evaluate nitrous oxide exposure at two dental offices in Cincinnati, Ohio. The request was submitted because of a general concern regarding the extent of exposure considering that, at the time the request was submitted, neither office was equipped with a nitrous oxide scavenging system. The evaluation also provided an opportunity to evaluate the effectiveness of a scavenging system installed at one of the offices during the course of the investigation. Results and recommendations were provided by telephone following each survey and summarized in a letter forwarded in August, 1984.

III. BACKGROUND

Doctors R. Thomas Scheer and Wayne Gardner operate a general dentistry practice at two locations in Cincinnati, Ohio. The Hyde Park Office was started first and the majority of their patients are seen there. The Beechmont Office has been operating for several years, 2-3 days per week, to care for patients residing in the eastern part of the city. Each office is staffed with 3 to 4 dental hygienist/chairside assistants.

Nitrous oxide has been used for more than 10 years at the Hyde Park Office and has always been available at the Beechmont Office. Its use, at either office, has not been encouraged but reserved for those patients who feel a strong need for this type of sedation. It is normally not used on a daily basis and, when used, it is usually for one to two patients on a given day. Occasionally the use can exceed this level.

Nitrous oxide is purchased in high pressure cylinders and stored either in a closet (Beechmont) or in the basement (Hyde Park). It is delivered to a mixing unit at chairside via a high pressure line. The mixing unit allows the nitrous oxide to be mixed with oxygen (usually 50/50) and sent to a nasal mask which is placed on the patient. Flow rates vary from patient to patient but are set at a minimum level to maintain the desired effect. A typical flow sequence would be 5 to 6 liters per minute (lpm) each to attain initial sedation followed by 3 to 4 lpm to maintain the patient in a comfortable state. At some point during or after the dental procedure, the nitrous oxide is turned off allowing only oxygen to flow to the mask to help clean the nitrous oxide from the patient's system.

The office facilities differ in that the older, Hyde Park Offices are heated by hot water which is circulated to wall registers in each office and cooled by window A/C units. The Beechmont Office is heated and cooled via a centralized forced air, recirculating heating and air conditioning system.

IV. METHODS

In order to estimate nitrous oxide exposure, air samples were collected during the period of administration of the anesthetic gas and for the entire shift (8-hr TWA). The sampling method consisted of collecting composite air samples in 22 liter mylar bags for subsequent infra red analysis using a portable Miran 103®. This instrument was also used as a direct-reading field survey meter to evaluate the nitrous oxide delivery system for the presence of leaks. Preand post-survey instrument calibration was achieved by injecting known quantities of nitrous oxide gas (100%) into a closed-loop calibration system. Serial injections produced increasing concentrations in the closed-loop system thereby allowing a calibration curve to be drawn encompassing the range of exposures expected and/or found during the field survey.

Although the primary reason for the survey was to evaluate nitrous oxide exposure, air samples were also obtained to measure exposure to mercury vapor using 3M® Passive Dosimeters. Personal breathing zone samples were obtained by attaching the dosimeters to the lapel of a dentist and chairside assistant on each of two shifts at the Hyde Park Office and on one shift at the Beechmont Office.

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. 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 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.

B. Toxicological

1. Anesthetic Gases (including Nitrous Oxide)

Reports by Vaisman[1] and Askrog and Harvald[2] were among the first to identify an 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)[3]. The results of study indicate "that female members of the operating room-exposed group were subject to increased risks of spontaneous abortion, congenital abnormalities in their children, cancer, and hepatic and renal disease." This report also showed an increased risk of liver disease and congenital abnormalities in offspring 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.

In a study published by NIOSH[4], "nitrous oxide and halothane in respective concentrations as low as 50 parts per million (ppm) and 1.0 ppm caused measurable decrements in performance on 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 were also reported[5,6].

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

In an epidemiological study among dentists, Cohen et al.[7] compared exposed persons in that profession who used inhalation anesthetic more than 3 hours per week with a control group in the same profession who used no inhalation anesthetic. The exposed group reported a rate of liver disease of 5.9 percent, in comparison with a rate of 2.3 percent in the control group. Spontaneous abortions were reported in 16 percent of pregnancies of the wives of exposed dentists, in comparison with 9 percent of the unexposed. This difference was statistically significant. This study did not identify the specific anesthetic being used by the dentists surveyed, that is, whether they used N_2O alone or a halogenated agent. However, in a review of that study, NIOSH[8] concluded that "the halogenated anesthetics alone do not explain the positive findings of the survey and N_2O exposure must be an important contributing factor, if not the principal factor." This conclusion is based on a calculation which assumed that as many as 1 in 10 of the dentists using an inhalation anesthetic employes a halogenated agent. If the actual fraction is less than 1 in 10, then this conclusion would be even more significant.

In a document recommending a standard for occupational exposure to waste anesthetic gas, NIOSH[5] recommended a maximum exposure of 50 ppm on a time-weighted average basis during the anesthetic administration in dental offices. This recommendation is based primarily on available technology in reducng waste anesthetic gas levels.

In a recent study, Cohen et al.[9] reported results on questionnaires sent to 64,000 dentists and dental assistants. Respondents were asked to estimate their occupational exposure to anesthetic gases, e.g., N_2O, halothane, etc., and to complete a health history for the period 1968 to 1978.

Over 22,000 dental assistants and 23,000 pregnancies which occurred during the sample period were reported.

Among the dentists who responded, 42 percent said they used anesthetic gases regularly in their practices. Approximately one-third of that group were "heavy users," using agents more than 9 hours per week. The study concluded that:

(1) Among heavily anesthetic-exposed dentists, an increase in liver disease from 1.9 to 3.2 cases per 100, an increase in kidney disease from 2.4 to 2.9 cases per 100, and an increase from 0.35 to 1.35 cases per 100 in nonspecific neurological disease (numbness, tingling, and weakness) were reported relative to the group reporting no exposure to the anesthetic gases;

(2) Among heavily exposed female dental assistants, an increase in liver disease from 1.0 to 1.6 cases per 100, and an increase in nonspecific neurological disease from 0.45 to 1.98 cases per 100 were reported relative to the non-exposed group of assistants;

(3) The rate of spontaneous miscarriage was increased from 6.7 per 100 in the control to 11.0 per 100 among wives of heavy anesthetic-exposed dentists, and from 7.6 cases per 100 in the non-exposed to 17.5 cases per 100 in heavily exposed female dental assistants;

(4) Birth defects increased from 3.6 to 5.9 per 100 among children of exposed female assistants; however, no increase in birth defects was reported in children of exposed male dentists; and

(5) Cancer incidence was unchanged among male dentists, but the rate among exposed female assistants appeared somewhat higher than among those unexposed.

Finally, because dentists work close to the patient's mouth, and tend to use larger volumes of the gases to maintain effective anesthetic, they may receive two to three times the dose of anesthetic gases as operating room personnel. Also, a study of individual anesthetic gases used in dental offices revealed that nitrous oxide was the sole agent reported by 81 percent of those dentists using anesthetic gases. Cohen concluded that nitrous oxide, commonly known as "laughing gas," has always been considered to be inert and nontoxic. However, this study indicated that "significant health problems appear to be associated with the use of nitrous oxide alone."

Although OSHA presently does not have a permissable exposure level for anesthetic gas such as nitrous oxide, NIOSH recommends that exposures be maintained below 50 ppm in dental offices.[8] This level is believed to be achievable with current engineering control systems and good work practices.

2. Inorganic Mercury

Mercury can enter the body through the lungs by inhalation, through the skin by direct contact, or through the digestive system.[10]

Acute or short-term exposure to high concentrations of mercury causes tightness and pain in the chest, difficulty in breathing, coughing, inflammation of the mouth and gums, headaches, and fever.[10,11] Acute mercury poisoning is, however, relatively rare in industry today.

Chronic or long-term exposure to lower concentrations of mercury is more common. Chronic mercury poisoning is known to cause kidney damage (nephrosis), tremors and shaking (usually of the hands), inflammation of the mouth and gums, metallic taste, increase in saliva, weakness, fatigue, insomnia, allergic skin rash, loss of appetite and weight, and impaired memory. These symptoms generally occur gradually and may be associated with personality changes such as irritability, temper outbursts, excitability, shyness, and indecision.[10,11]

NIOSH currently recommends that exposure to inorganic mercury be limited to 50 micrograms per cubic meter (ug/m^3) as an 8-hour time-weighted average (TWA).[12] The American Conference of Governmental Industrial Hygienists (ACGIH) also recommends that inorganic mercury exposure be limited to 50 ug/m^3 as an 8-hour TWA.[13] The current Occupational Safety and Health Administration (OSHA) standard for inorganic mercury is a ceiling level of 100 ug/m^3.[14]

VI. RESULTS AND DISCUSSION

A. Hyde Park Office (no scavenging system)

1. Nitrous Oxide

The nitrous oxide concentrations measured at the Hyde Park dental offices are presented in Table 1. Nitrous oxide was only used on one patient and this was in room #1. A sketch of the dental office complex is shown in Figure 1. Nitrous oxide exposure during the 14 minute period of administration averaged 1300 ppm. This far exceeds the 50 ppm NIOSH criteria but is typical of exposures where scavenging systems are not utilized. Area samples taken over a 6 hour period in each of the five dental treatment rooms ranged from 10 to 130 ppm (mean = 88 ppm). The highest value was expected in room #1 where the nitrous oxide was being administered, but actually was found in room #3. This was later determined to be due to a leak in the nitrous oxide/oxygen mixing unit. Even though this office system did not have a recirculating air handling system, the nitrous oxide levels of 8 and 7 ppm in the private office and reception area indicate that the gas is traveling with air currents created most likely by movement of dental personnel and patients around this area.

2. Mercury

Mercury exposure was monitored for two shifts (3/29 and 3/30/84) for a dentist and dental assistant. Mercury was detected on only one of the 4, 8 hour samples and this level (0.0008 mg/m^3) was well below the OSHA standard of 0.1 mg/m^3 and the NIOSH recommended standard of 0.05 mg/m^3. Factors contributing to this low exposure are the fact that pre-mix amalgam capsules were used and the offices had recently been re-carpeted.

B. Beechmont Office (scavenging system)

1. Nitrous Oxide

A Fraser-Horlake® nitrous oxide scavenging system was installed in May, 1984. The nitrous oxide/oxygen mixture is delivered to the inner compartment of a double-walled nasal mask via two hoses from a table-top gas mixing unit. When the patient breathes in, the anesthetic gas is inhaled through the nose. The patient exhales through an exhalation valve that connects the inner chamber of the mask to the space between the double wall of the mask which is under negative pressure via a splice connection in the normal chain vacuum line. The waste anesthetic gas is scavenged through the vacuum system and out the vent pipe for the sanitary sewer system.

The nitrous oxide air concentration measured at this office are presented in Table 2. Figure 2 presents a sketch of the dental suite and indicates approximately where the samples were obtained.

Only one patient was administered nitrous oxide for a 25 minute period. Air concentrations obtained from samples taken at the dental chair light (this would approximate the breathing zone of both the dentist and the dental assistant) and near a sink about 6 feet from the patients head were 350 and 210 ppm respectively during this period of administration. These values exceeded the 50 ppm NIOSH criteria. Samples taken over a six hour period on the same day documented air concentrations of 28 and 30 ppm in the dental treatment room and 20 ppm at the reception desk.

Even though the nitrous oxide air concentrations were 5 times less than those documented at the Hyde Park Office, they were higher than expected considering that a scavenging system was in use.

The following factors were determined to be major contributors for the higher-than-expected nitrous oxide air concentrations.

a. The nitrous oxide was turned on before the nasal mask was placed on the patient and before the vacuum was activated. While this was probably only a 15-20 second period, it becomes important since a 15 second release of nitrous oxide at 5 lpm will generate 69 ppm in a 10'x10'x8' room which is a common size for a dental treatment room.

b. The vacuum to the mask was turned down until the "hissing" sound was gone. This decreased the capture efficiency of the mask. There is a limiting orifice in the vacuum line to the mask that insures the proper vacuum is maintained when the throttle value is wide open. This hissing sound is necessary and can be used as an indicator that the mask vacuum is working properly.

c. The patient was very talkative before the dental procedure started (but after the nitrous was turned on) and during the dental procedure.

After correcting these problems, nitrous oxide exposure during the period of administration (22 minute) was reduce from 350 to 65 ppm. On this occasion, the vacuum hose spontaneously disconnected at the throttle control valve which interupted vacuum to the mask for about 7-8 seconds until it could be reconnected. This incident probably resulted in the exposure exceeding 50 ppm.

2. Mercury

The mercury vapor passive dosimeters were worn for 6 hours on May 11, 1984. Exposures for the one dentist and chairside assistant for that time period were 0.004 and 0.005 mg/m^3 respectively. Both exposures were below the NIOSH recommended standard (0.05 mg/m^3) and the OSHA standard (0.1 mg/m^3).

VII. RECOMMENDATIONS

A. Hyde Park Dental Offices

1. Even though the use of nitrous oxide is infrequent at the Hyde Park Office it is recommended that either a scavenging system be utilized or that the patients who rely on this treatment be referred to the Beechmont Office.

B. Beechmont Dental Office

There are three major factors that contribute to excessive nitrous oxide exposure. These are:

1. system leaks
2. poor work practices
3. patient mouth breathing.

The following recommendations which are directed at each of these points will help to minimize exposure to nitrous oxide.

1. System Leaks

   The high pressure side (tank to mixing unit) and the low pressure side (mixing unit to nasal mask) should be checked at least monthly for leaks using the soap solution technique demonstrated during the NIOSH survey on March 29, 1984.

   High pressure leaks can be easily detected by keeping a log of the line pressure when the nitrous oxide tank is turned off at night and of the pressure the next morning. A drop of more than 10% indicates a leak which should be found via the soap solution technique and corrected.

2. Work Practices

   The scavenging system does not efficiently capture the nitrous oxide flowing to the mask if the mask is not placed properly on the patient. The following sequence of actions will minimize the escape of nitrous oxide from the mask.

Nitrous Oxide Start Up Procedures

Start oxygen flow
Place nasal mask on patient
Activate vacuum to mask (throttle wide open)
Start nitrous oxide flow

Nitrous Oxide Shut Down Procedures

Turn off nitrous oxide flow at mixing unit
Maintain vacuum flow until oxygen is shut off
Remove mask and shut off vacuum

3. Mouth Breathing

   Instruct patient that for full effect breathe through nose and minimize talking.

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 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 NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Doctors Thomas R. Scheer and Wayne Gardner
2. NIOSH, Region V
3. OSHA, Region V

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

Nitrous Oxide

Hyde Park Office
HETA 84-126

March 29, 1984

Sample Location[1]	Sample Type[2]	Sampling Time	Concentration (ppm)[3]	Comments
Room #1	BZ (dentist)	8:30am-3:40pm	130	
Room #1	BZ (dentist)	2:45pm-2:59pm	1300[4]	Period of nitrous oxide administration
Room #2	A	8:30am-3:40pm	75	
Room #3	A	8:30am-3:40pm	182	Leak in mixing unit
Room #4	A	8:30am-4:10pm	42	
Room #5	A	8:30am-4:00pm	10	
Room #6 (office)	A	8:30am-4:00pm	8	
Basement	A	9:20am-9:40am	26	Suction outlet
Reception desk	A	9:30am-4:00pm	7	

NIOSH Recommended Criteria (during period of administration) <50

(1) Refer to Figure 1
(2) A = Area; BZ = Breathing Zone
(3) Time-weighted-average (TWA) concentration for the period of sampling
(4). TWA for period of administration

Table 2

Nitrous Oxide

Beechmont Office
HETA 84-126

May 11, 1984 and June 6, 1984

Date	Sample Location[1]	Sample Type	Sampling Time	Concentration (ppm)[2]
5/11/84	(A), chair light pole	Area	9:30am-2:50pm	28
	(B), window ledge	Area	9:05am-2:50pm	30
	(C), dental chair light	Area	10:02am-10:26am	350[2]
	(D), at sink	Area	10:02am-10:27am	210[2]
	(E), receptionist desk	Area	9:30am-3:00pm	20
6/8/84	(C), dental chair light	Area	9:42am-10:04am	65[3]
	(C), dental chair light	Area	8:50am-12:00pm	30
	(D), at sink	Area	8:50am-12:00pm	32
	(E), receptionist desk	Area	8:50am-12:00pm	20
NIOSH Recommended Criteria (during period of administration)				<50

(1) Refer to Figure 2 for sampling location on sketch of office area.
(2) TWA for period of sampling
(3) TWA for period of administration of the nitrous oxide.

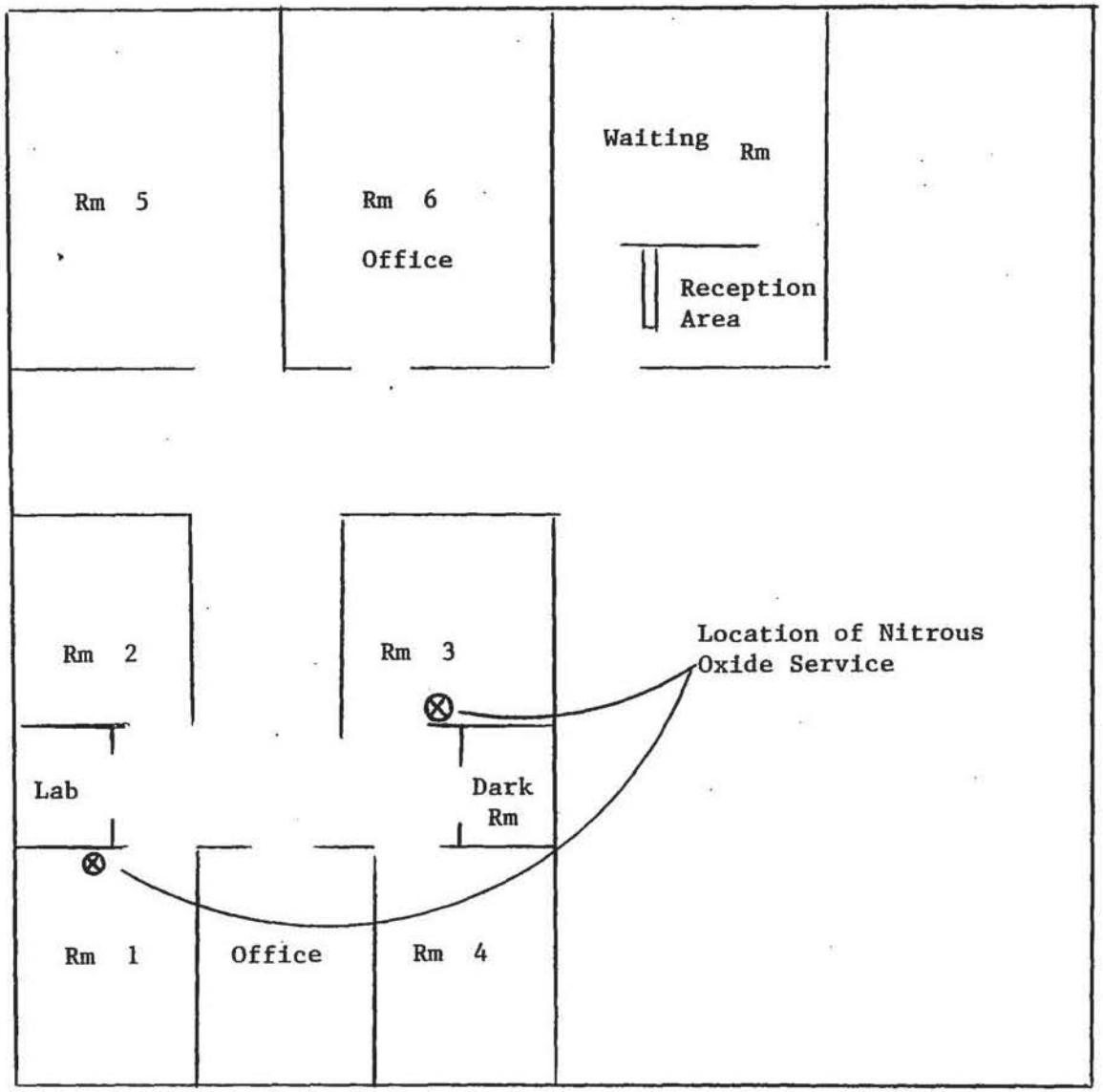

Figure 1
Hyde Park Office
HETA 84-126
March 29, 1984

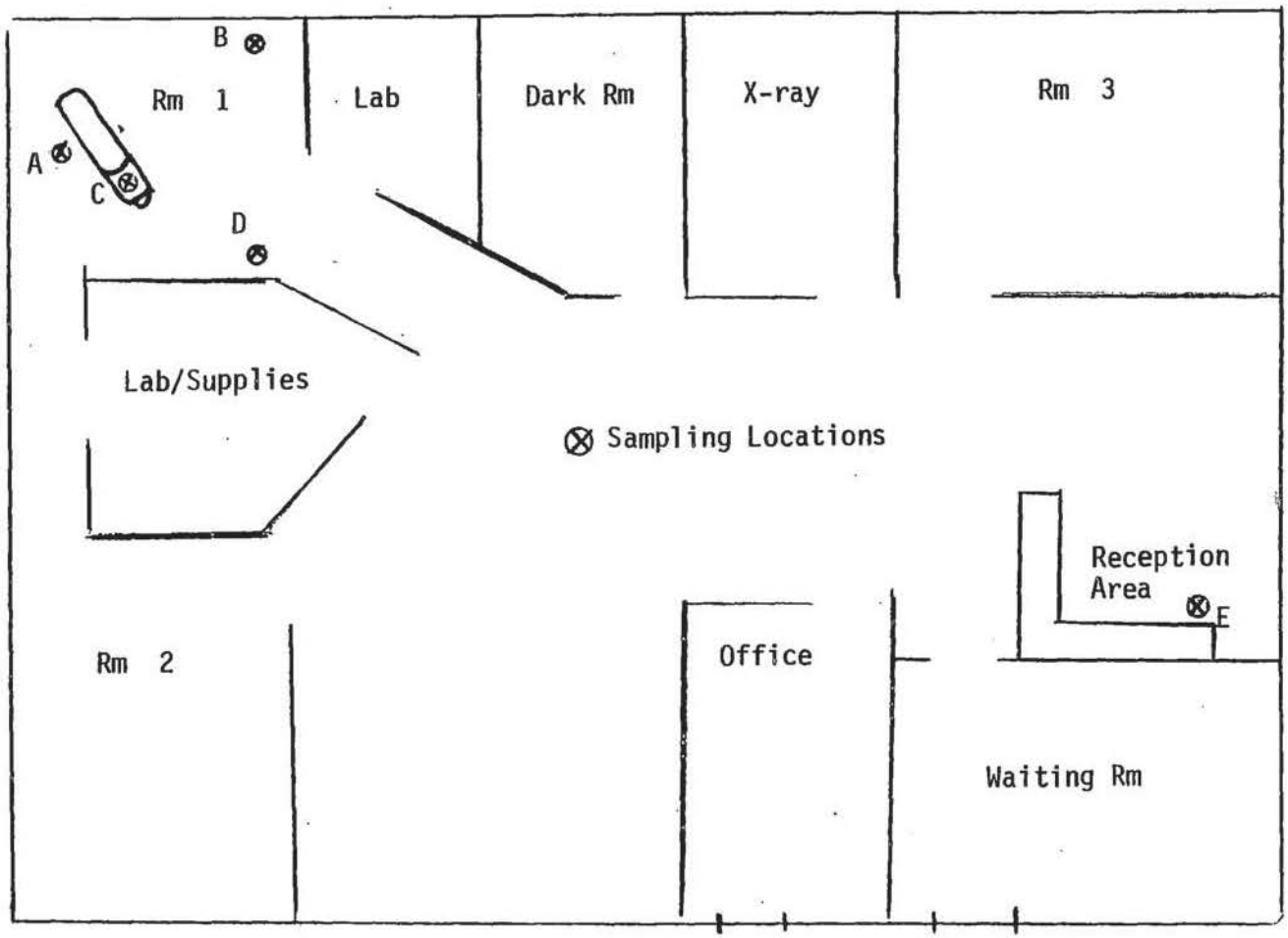

Figure 2
Beechmont Office
HETA 84-126
May 11, 1984
June 8, 1984

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