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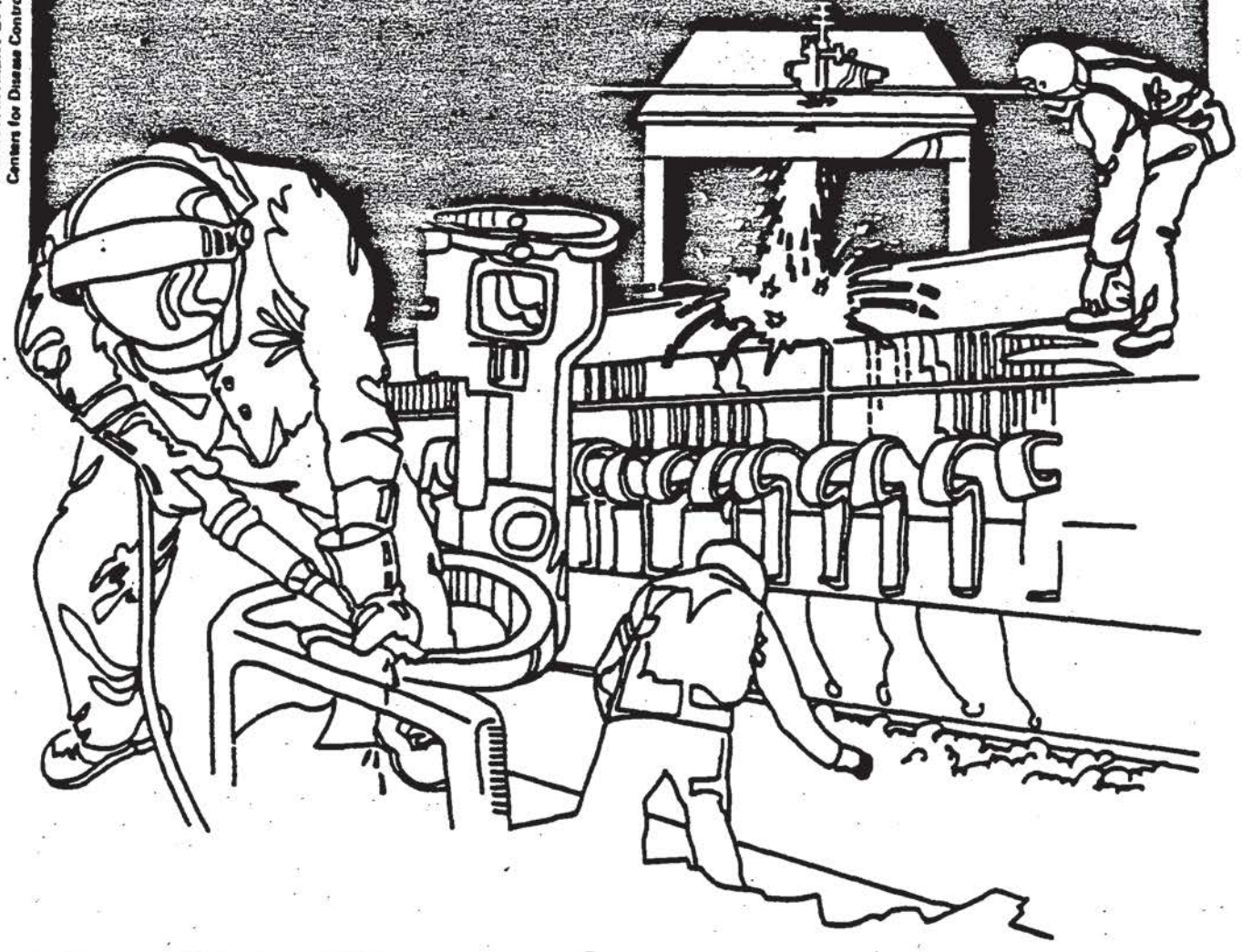

Health Hazard Evaluation Report

HETA 84-204-1600
DENTAL HEALTH ASSOCIATES
PAOLI, PENNSYLVANIA

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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HETA 84-204-1600
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DENTAL HEALTH ASSOCIATES
PAOLI, PENNSYLVANIA

NIOSH INVESTIGATOR:
Michael S. Crandall, M.S., C.I.H.

I. SUMMARY

On February 4, 1984, the National Institute for Occupational Safety and Health (NIOSH), was requested by Dental Health Associates to evaluate exposures to nitrous oxide at their Paoli, Pennsylvania clinic. On August 2, 1984, NIOSH investigators conducted a site visit to the clinic. Air samples were collected in Mylar® bags for subsequent field analysis for nitrous oxide content by a portable Miran 103® infrared analyzer.

Two dental procedures with nitrous oxide administration were monitored. During the first period of administration (50 minutes), the dentist received an average exposure to nitrous oxide of 2270 ppm during his 20 minutes in attendance. During the second period of administration (19 minutes), the dentist received a 1270 ppm exposure for 11 minutes. The dental assistant, present during the entire periods of administration, received a 670 ppm exposure each time. These exposures exceed the 50 ppm level which NIOSH recommended as achievable during routine dental anesthesia, using engineering controls and good work practices. There is no OSHA standard for exposure to nitrous oxide. Nitrous oxide concentrations ranged from 30 to 160 ppm in other clinic areas during the day of the survey.

The high exposures to nitrous oxide at the Dental Health Associates clinic during the period of administration constitute an occupational health hazard. A scavenging system should be installed at this office. Recommendations are made that will help to maintain good control of exposures through maintenance, proper use of equipment, and good work practices.

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

II. INTRODUCTION

On February 4, 1984, NIOSH received a request from a dental assistant at Dental Health Associates to evaluate exposure to nitrous oxide at their Paoli, Pennsylvania office. The request was submitted because of a general concern regarding the extent of exposure, since the office was not equipped with a scavenging system. An evaluation was conducted on August 2, 1984. Results and recommendations were forwarded in a letter on August 30, 1984.

III. BACKGROUND

Dental Health Associates is a general dentistry practice, with offices located in Paoli, and Bala Cynwyd, Pennsylvania, near Philadelphia. The Bala Cynwyd office was not evaluated. The Paoli office has been in operation for 12 years, and receives patients 4 days per week. This office is staffed with 2 dentists (1 part time), 3 dental assistants, 2 dental hygienists, 2 receptionists, and 1 business office worker.

Nitrous oxide has always been used at the Paoli office. Its use is reserved for those patients who feel a need for this type of sedation. It is not used on a daily basis and, when used, it is usually administered to one or two patients a day.

Nitrous oxide is purchased in high pressure cylinders and stored in an unused lab. 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 and sent to a nasal mask which is placed on the patient. A typical flow sequence would begin with sufficient nitrous oxide to attain initial sedation followed by a decrease in the flow to a point which maintains the patient in a comfortable state. After the dental procedure, the nitrous oxide flow is turned off allowing only oxygen to flow to the mask to help clear the nitrous oxide from the patient's system.

The Paoli office consists of a suite of rooms in a professional health care facility. This office is heated and cooled by a central, 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. The sampling method consisted of collecting composite air samples in 22 liter mylar bags for subsequent on site infrared 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. Pre- and 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.

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 - 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 the 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 along 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 dentistis, 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 employs 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 recommendtion is based primarily on available technology in reducing 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 "sufficiant health problems appear to be associated with the use of nitrous oxide along".

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

VI. RESULTS AND DISCUSSION

Nitrous oxide measurements are presented in Tables 1 and 2. The morning procedure required a 50-minute period of administration. The dental assistant, present during the entire procedure, received an exposure of 670 ppm nitrous oxide (Table 1). The dentist was present for 20 minutes and received a 2270 ppm nitrous oxide exposure. A later procedure required a 19 minute period of administration. The dental assistant was again exposed to 670 ppm for the entire period. The dentist received a 1270 ppm exposure for 11 minutes of this period. These exposures far exceed the 50 ppm NIOSH criteria, but are typical of exposures where scavenging systems are not in place. Exposures outside of the operatories were also elevated during the periods of administration. Results of 2 area samples, also in Table 1, collected over a 6 hour period, showed concentrations of 100 ppm in the reception area and 130 ppm in the corridor near room #3.

In Table 2, morning and afternoon measurements of background nitrous oxide concentrations are presented. In the morning, prior to any nitrous oxide use, a 20 ppm background concentration was measured. In the afternoon, subsequent to the two procedures using the anesthetic, 130 ppm was measured throughout the office area. A leak was detected in the nitrous oxide/oxygen mixing equipment in Room #2, which, most likely, contributed the high morning background concentration. The procedure rooms here are partitioned, not enclosed.

VII. RECOMMENDATIONS

1. The nitrous oxide delivery and mixing system should be checked for leaks at least monthly. The high pressure side (tank to mixing unit) and the low pressure side (mixing unit to nasal mask) can be checked using a soap solution. High pressure leaks can also be 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. Even though the use of nitrous oxide may be infrequent, it is recommended that a scavenging system with a dedicated exhaust be installed at this office.

3. A 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 practices will minimize the escape of nitrous oxide from the mask once the scavenging system is installed.

Nitrous Oxide Start-Up Procedures

Start oxygen flow
Place nasal mask on patient
Activate vacuum to mask
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.

Mouth Breathing

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

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:

Michael S. Crandall, M.S., C.I.H.
Industrial Hygiene Engineer
Industrial Hygiene Section

Environmental Field Assistance:

Richard W. Hartle, M.S., C.I.H.
Industrial Hygienist
Industrial Hygiene Section

Originating Office:

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies

Report Typed By:

Jacqueline Grass
Clerk/Typist
Industrial Hygiene Section

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1. Dental Health Associates, Paoli, Pennsylvania
2. Requestor
3. NIOSH, Region III
4. OSHA, Region III

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 Measurement

Dental Health Associates
Paoli, Pennsylvania
August 2, 1984

HETA 84-204

Sample Location[1]	Sample Type[2]	Sampling Time	Concentration,[3] PPM
Room #4, Dentist	BZ	1100-1120	2270
Room #4, Assistant	BZ	1035-1125	670
Room #4	A	1035-1125	750
Corridor, Near Room #8	A	1035-1125	160
Corridor, Near Room #3	A	1035-1125	200
Room #3, Dentist	BZ	1423-1434	1270
Room #3, Assistant	BZ	1415-1434	670
Room #3	A	1415-1434	530
Corridor, Near Room #8	A	1415-1434	130
Corridor, Near Room #3	A	1415-1432	330
Reception	A	0930-1530	100
Corridor, Near Room #3	A	0930-1530	130
Criteria: NIOSH (during period of administration)			<50

1. Refer to Figure 1
2. A = Area; BZ = Breathing Zone
3. Time Weighted Average (TWA) Concentration for the Sampling Period

Table 2

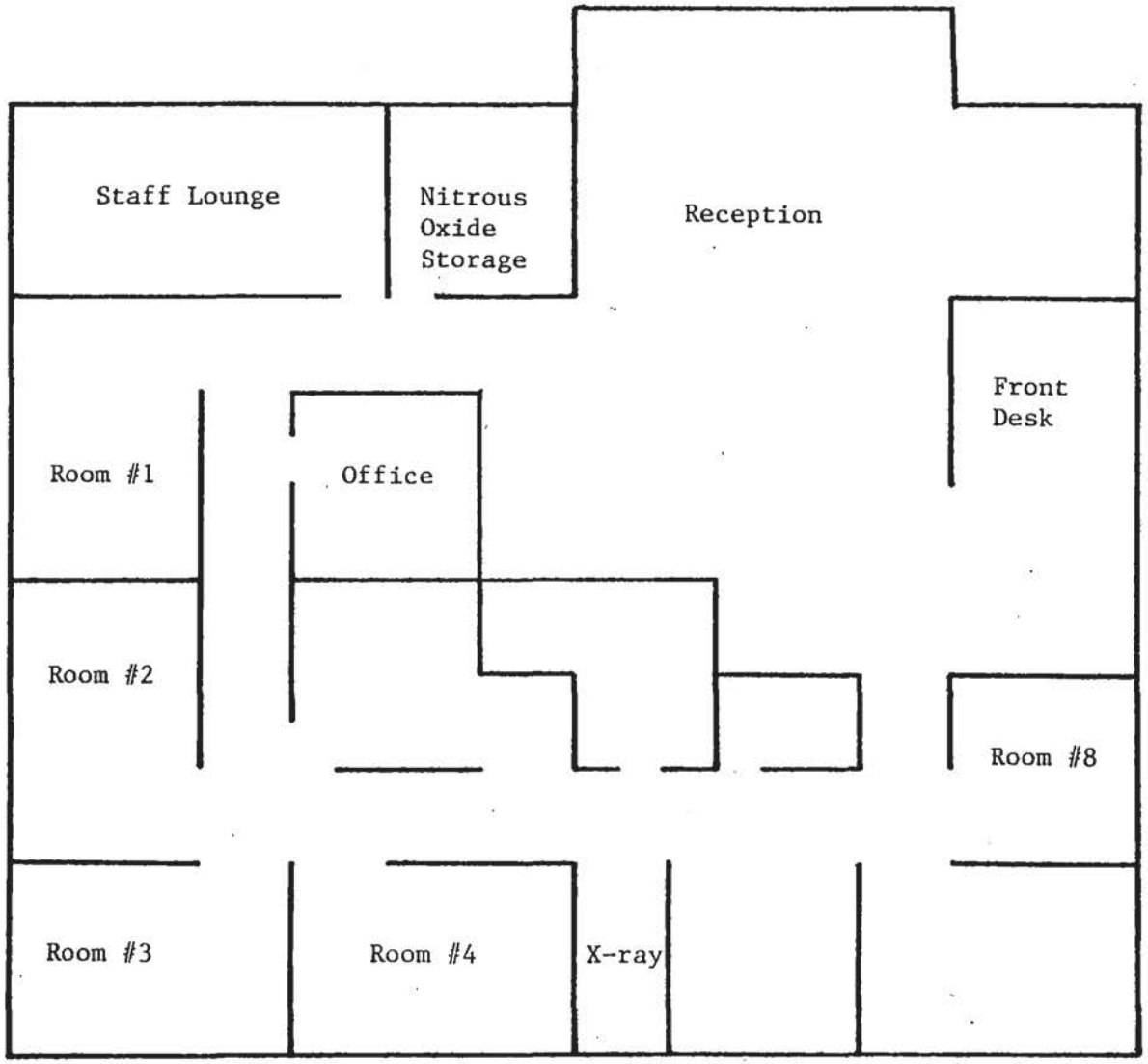
Nitrous Oxide Background Concentrations

Dental Health Associates
Paoli, Pennsylvania
August 2, 1984

HETA 84-204

Office Area	Morning Concentration (ppm)	Afternoon Concentration (ppm)
	10:00am	3:30pm
Room #2	20	130
Room #3	20	130
Room #4	20	130
Reception	20	130
Administrative Office	20	130
Corridor Near Room #3	20	130

Figure 1
General Clinic Floor Plan
Dental Health Associates
Paoli, Pennsylvania
HETA 84-204



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