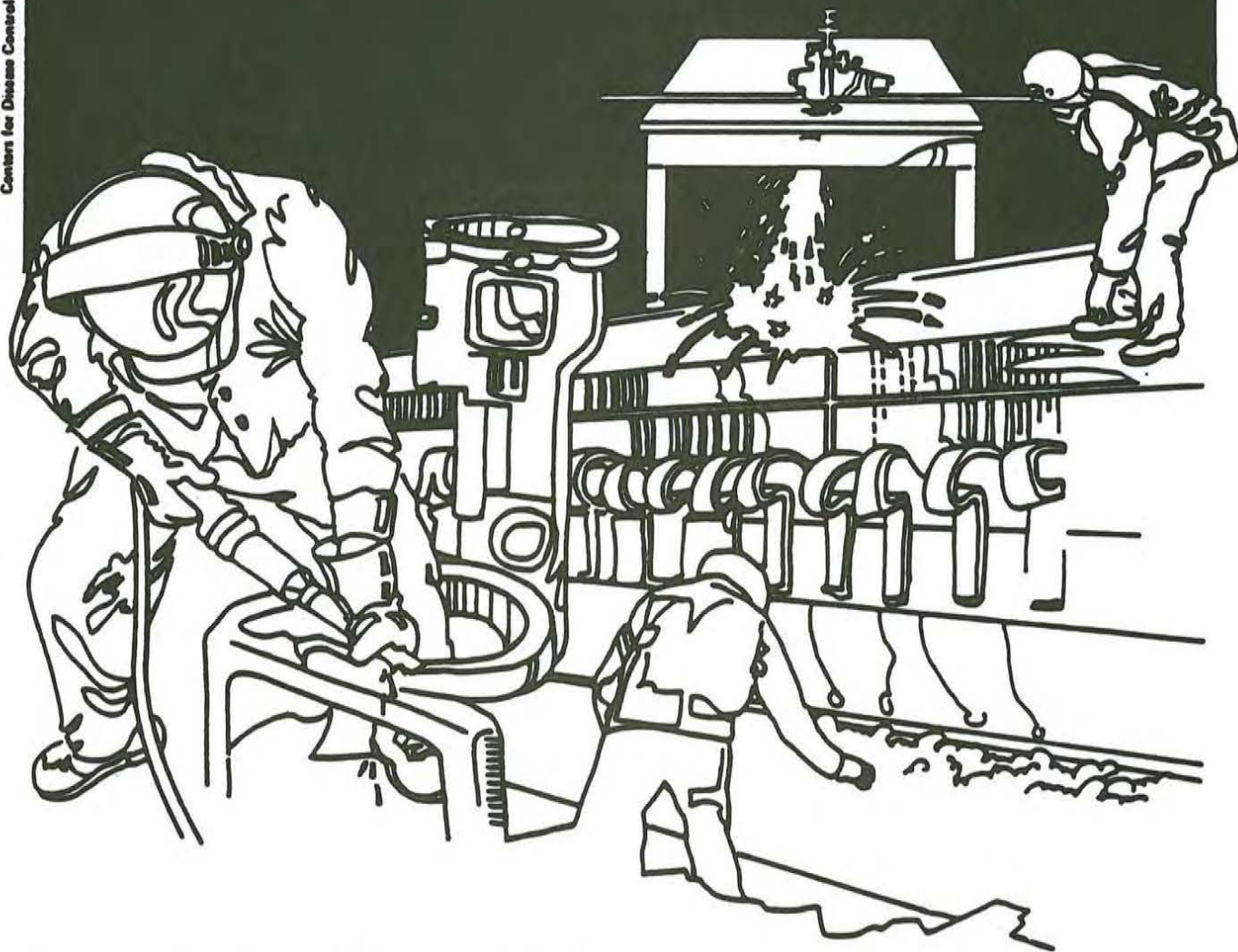


# NIOSH



## Health Hazard Evaluation Report

HETA 85-408-1666  
DOCTORS HIATT, METCALFE,  
AND SCHAAD  
DENVER, COLORADO

## 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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DOCTORS HATT, METCALFE, AND SCHAAD  
DENVER, COLORADO

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## I. SUMMARY

In July 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from the office manager of the Hatt, Metcalfe, and Schaad dental clinic, in Denver, Colorado to evaluate nitrous oxide (N<sub>2</sub>O) exposures during dental procedures.

In September of 1985, direct reading measurements were taken throughout all the dental offices for N<sub>2</sub>O levels. There were no procedures being performed on this visit, therefore, all N<sub>2</sub>O tubing, cylinders, and valves were checked for leaks. Several leaks were found in the basement in the area where the N<sub>2</sub>O cylinders were stored. These leaks were repaired in the fall of 1985. A follow up environmental survey was made on January 6, 1986. Two dental hygienists were using N<sub>2</sub>O on patients undergoing teeth cleaning procedures. N<sub>2</sub>O scavenging was not available in any part of the clinic during the NIOSH investigation.

Within five minutes of sampling for N<sub>2</sub>O in the dental hygienist's breathing zone, levels reached 1000 parts per million (ppm). These levels remained high for the remainder of the procedure, which lasted for one hour. Levels of N<sub>2</sub>O between the two hygienist rooms (secretarial areas) were 350 to 400 ppm for the same time period. Excessive levels were also found in other rooms where N<sub>2</sub>O was not in use. These levels ranged from 100 to 150 ppm. Nitrous oxide overexposures will continue to occur in these areas if no scavenging system is to be used for these procedures.

Two dental hygienists and three support type workers were informally interviewed. During the survey periods a brief explanation was given on the long term or chronic toxicological effects of N<sub>2</sub>O exposures.

On the basis of data obtained during this evaluation, it has been determined that personnel in this dental office were overexposed to N<sub>2</sub>O. Recommendations to reduce N<sub>2</sub>O exposures are presented in this report.

Keywords: SLC 8021 (office of dentist), nitrous oxide, dental operatories, waste anesthetic gas.



II. INTRODUCTION

In July 1985, NIOSH received a request from the office manager of the Hiatt, Metcalfe, and Schaad dental clinic, in Denver, Colorado to evaluate N<sub>2</sub>O exposures during various dental procedures. In September, 1985 and January, 1986, environmental investigations were performed in this clinic. Direct reading measurements were taken throughout the clinic for N<sub>2</sub>O concentrations. Verbal recommendations were given at this time for lowering N<sub>2</sub>O exposure levels.

III. BACKGROUND

The dentist and dental hygienist at this clinic routinely use N<sub>2</sub>O during various dental procedures. The time and amount of N<sub>2</sub>O used varies greatly. There are many days when N<sub>2</sub>O is not used. During the January 6, 1986, survey N<sub>2</sub>O was used for about 1.3 hours by two dental hygienists. There was no N<sub>2</sub>O scavenging system in this clinic. Except for the building's general heating system, the only dilution ventilation was an open window in one hygienist's room and this was routinely kept open during procedures which used N<sub>2</sub>O. The other hygienists cannot open the windows in their rooms.

IV. ENVIRONMENTAL DESIGN AND METHODS

All measurements for N<sub>2</sub>O were performed on site with a Wilks Miran<sup>R</sup> 103 Gas Analyzer at a wavelength of 4.5 micrometers and a pathlength of 13.5 meters. General area samples were taken on the N<sub>2</sub>O administering equipment throughout the dental operator, in the secretarial work area, and in the dental hygienist's breathing zone.

Work practices and techniques were observed; employees were informally interviewed.

V. 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 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.

### Toxicology

At present there is no OSHA standard for nitrous oxide; however, NIOSH has recommended a 25 ppm environmental limit for  $N_2O$  based on research gathered prior to April 1977. Also, NIOSH feels that based on present technology, personal exposure levels as low as 25 ppm of  $N_2O$  in dental operatories are attainable at this time. Present research on the effects of nitrous oxide, however, indicates that while the majority of the information available on occupational exposure to waste anesthetic gas concerns exposure to a combination of nitrous oxide and other halogenated agents, enough evidence is available on the effects of  $N_2O$  alone so that it should be considered potentially toxic under conditions of chronic exposure. The following is a summary of these investigations.

Nitrous Oxide -- Reports by Vaisman (1967), as well as by Askrog and Harvald (1970), were among the first to identify an increased incidence of spontaneous abortions 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). The results of this 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 increase incidence of hepatic disease similar to that in females was found.

In a study published by NIOSH (1976), "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.

Epidemiological studies have raised the question of human carcinogenicity of anesthetic gases, but data are presently insufficient to list nitrous oxide or halothane as suspected carcinogens.

In an epidemiological study among dentists, Cohen et al. (1975) compared exposed persons in that profession who used inhalation anesthetic more than three 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 nine 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 together with a halogenated agent. However, in a review of that study, NIOSH (1977) concluded that "the halogenated anesthetics alone do not explain the positive findings of the survey and that  $N_2O$  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 one in ten of the dentists using an inhalation anesthetic employs a halogenated agent. If the actual fraction is less than one in ten, then this conclusion would be even more significant.

In a document recommending a standard for occupational exposure to waste anesthetic gas, NIOSH (1977) recommends 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 reducing waste anesthetic gas levels.

In a recent study, Cohen et. al., (October 1979) 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<sub>2</sub>O, halothane, etc., and to complete a health history for the period 1968-1978.

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 nine 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 0.35 to 1.35 cases per 100 in non-specific neurological disease (numbness, tingling, and weakness) occurred 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 non-specific neurological disease from 0.45 to 1.98 cases per 100 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."



VI. ENVIRONMENTAL RESULTS

Nitrous oxide levels measured directly with the Miran 103 infrared gas analyzer showed levels ranging from 100 to greater than 1000 ppm (the highest reading on the scale is 1000 ppm). The average level was approximately 500 - 600 ppm in the breathing zone of the hygienist during the cleaning procedure. Both hygienists used 3.5 - 4.5 liters of nitrous oxide per minute. The dentist office was not evaluated since there was no N<sub>2</sub>O administered in these offices on either of the NIOSH visits.

VII. SUMMARY AND CONCLUSIONS

Based on data obtained during this evaluation, a health hazard existed from overexposures to N<sub>2</sub>O. A nitrous oxide scavenging system, lower flow rates, and a better dilution ventilation system should lower these levels. Refer to table 1 for average levels found during this evaluation.

VIII. RECOMMENDATIONS

The following recommendations are offered to assist in either reducing or eliminating exposures to N<sub>2</sub>O.

1. The most immediate concern for this environment is to install a working scavenging system. There are a number of such systems on the market today and some are better than others; however, the best system is one that will remove the contaminant at the pop-off valve, as well as around the nose pieces. Nitrous oxide scavenging should be accomplished at a vacuum flow rate of approximately 45 liters per minute.
2. Routine maintenance should be performed on all anesthetic and suction equipment. Periodic visual checks should be made of tubing, masks, breathing bag, connections, etc., and any cracked or broken items should be replaced. Leak tests should be made with soap solution at all high pressure fittings such as cylinder connections and the anesthetic machine inlet.
3. Once the engineering and/or exhaust systems have been instituted, a follow-up evaluation of the environment should be made.
4. All dentists and other personnel working in the dental clinic should be advised of the adverse health effects of overexposure to nitrous oxide.
5. More dilution ventilation should be installed; such as a large fan in the roof of the building that would periodically bring in fresh outside air.





X. AUTHORSHIP AND ACKNOWLEDGEMENTS

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. Hiatt, Metcalfe, and Schaad Dental Office.
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 affected employees, a copy of this report shall be posted in a prominent place accessible to the employees for a period of 30 calendar days.



Table 1

Direct Reading Levels of N<sub>2</sub>O Observed During  
the Cleaning of Teeth by Dental Hygienist  
Dr's. Hiatt, Metcalfe, and Schaad  
Denver, Colorado  
January 6, 1986

Location	Sampling Time	N <sub>2</sub> O ppm
(Breathing zone of Hygienist)		
Dental Hygiene Room 1	1:10p - 1:12p	1000*
Dental Hygiene I	1:30p - 1:40p	150
Window Open	1:30p - 1:40p	150
Window Closed	1:40p - 2:00p	450-500
Dental Hygiene Room 2	1:15p - 1:17p	1000*
Next to Patient		1000*
Door Out of Room		800
Secretarial Desk (between 2)	1:35p -	350
(Hygiene Rooms)		
Dental Hygiene Room 3	1:40p -	100
Not Using Nitrous Oxide		
Dr's. Surgery Room Without	1:45p -	100
Nitrous Oxide in Use		
<hr/>		
Evaluation Criteria		25
Laboratory Limit of Detection	1	

ppm = parts per million parts of air.

Note: These samples actually exceeded 1000 ppm.

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