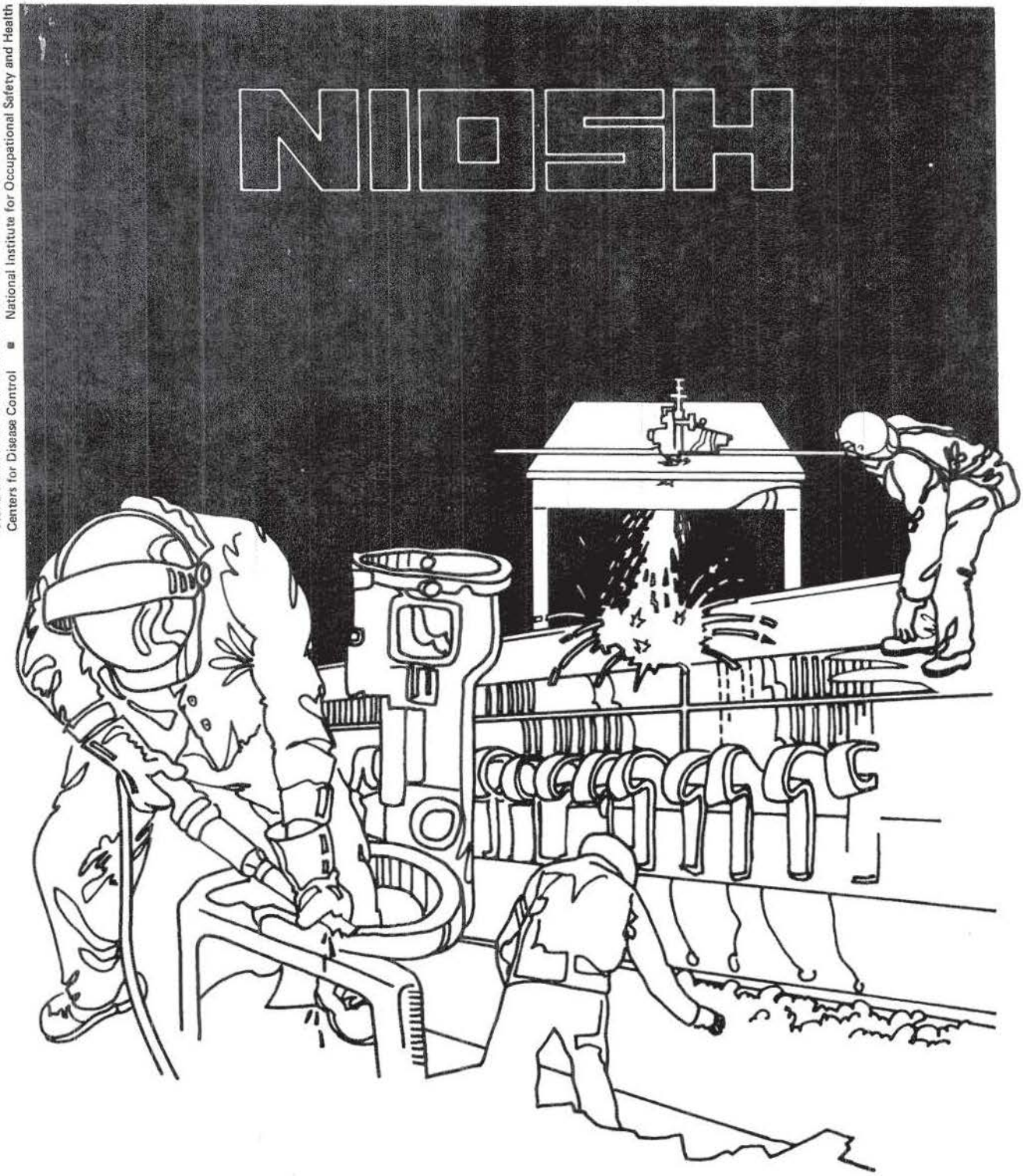
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HHE 80-249-833
ROBERT W. OLSON, D.D.S.
CONIFER, 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.

HE 80-249-833
MARCH 1981
ROBERT W. OLSON, D.D.S.
CONIFER, COLORADO

NIOSH INVESTIGATOR:
Bobby J. Gunter, Ph.D.,IH

I. SUMMARY

In September, 1980 the National Institute for Occupational Safety and Health (NIOSH) received a request from Robert W. Olson, D.D.S., Conifer, Colorado, to evaluate possible health hazards from exposure to waste anesthetic gas (nitrous oxide, N_2O) and mercury in his dental operatories. Direct reading breathing zone air samples were taken on the dentist and his assistant. Area samples were taken in the clinic. Leak testing was also performed on the anesthetic gas administering machine. Work practices and techniques were observed; employees were informally interviewed.

Direct reading area samples indicated personnel were exposed to breathing zone N_2O concentrations which exceeded 1000 parts per million (ppm) during administration to background levels of 200 ppm approximately one hour after administration. These exposures were well above the NIOSH recommended standard for N_2O of 25 ppm, a time-weighted average concentration during anesthetic administration.

The scavenging system in use at the time of this evaluation did not adequately ventilate the N_2O. This system would perhaps work if a larger exhaust fan was installed to increase the capture velocity. With current control technology, exposure levels of 50 ppm and less are attainable in dental offices.

Direct reading mercury samples showed levels far below the evaluation criteria of 0.05 milligrams per cubic meter (mg/M^3). Mercury was not detected in the breathing zone of the dentist or his assistant. Trace quantities of 0.02 mg/M^3 to a high of 0.04 mg/M^3 of mercury were found inside the amalgamation area.

On the basis of the data obtained in this investigation, NIOSH has determined that the personnel in this dental office were overexposed to N_2O. Mercury levels did not pose a health hazard during the survey. Recommendations to reduce exposures were given at the time of the survey and are presented in Section VIII of this report.

KEYWORDS: SIC 8021 (Offices of Dentists), nitrous oxide, dental operatories, waste anesthetic gas, mercury.

II. INTRODUCTION

In September 1980 NIOSH received a request from Robert W. Olson, D.S.S. to evaluate the potential hazards of exposure to N_2O and mercury in his dental clinic at Conifer, Colorado. On January 8, 1981, a NIOSH investigator visited the clinic and direct reading breathing zone, area, and leak test samples for N_2O were obtained for one complete working day. Direct reading area and breathing zone air samples were also taken for measurement of mercury concentrations. Verbal recommendations were given at this time for lowering exposure levels.

III. BACKGROUND

The dentist at this clinic routinely uses N_2O on almost all dental procedures. A scavenging system was being used during the time of this evaluation for exhausting waste N_2O. The patients were receiving approximately two liters per minute of N_2O in conjunction with one liter per minute of oxygen. The use of N_2O lasts from an average of 10 to 45 minutes.

Mercury is mixed with powdered metal, agitated, and then used to fill cavities in teeth. During this process mercury exposures are often observed.

IV. ENVIRONMENTAL DESIGN AND METHODS

All measurements for N_2O were performed on site with a Wilks Miran^R 103 Gas Analyzer at a wavelength of 4.5 micrometers and a pathlength of 13.5 meters. A Bacharach^R Direct Reading Mercury Vapor Detector was used to perform direct reading mercury measurements. Throughout the evaluation direct reading air samples were taken at the breathing zone of the patient, dentist, and the chairside assistant. General area samples were taken on the N_2O administering equipment and throughout all areas of the dental operatory and waiting room.

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

V. EVALUATION CRITERIA

A. Environmental

Three sources of criteria were used to assess the workroom concentrations of chemical substances: (1) NIOSH criteria for a recommended standard; (2) American Conference of Governmental Industrial Hygienists Threshold Limit Values (TLVs); and (3) Occupational Safety and Health Administrations Standards.

	Permissible Exposure Limits Time-Weighted Average Exposure Basis
Nitrous oxide.....	25 ppm (NIOSH)
Mercury.....	0.05 mg/M^3 ceiling (NIOSH) 0.1 mg/M^3 (OSHA)

ppm = parts of vapor or gas per million parts of contaminated air by volume.

mg/M^3 = milligrams of substance per cubic meter of air.

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 50 ppm of N_2O in dental operatories are attainable at this time. Present research on the effects of nitrous oxide, however, state 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.

B. Toxicological

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 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). 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 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 an exposure limit of 25 ppm on a time-weighted average basis during the anesthetic administration. With current control technology, exposure levels of 50 ppm and less for nitrous oxide are attainable in dental offices.

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_2O, 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 2.4 to 2.9 cases per 100, and an increase from 0.35 to 1.35 cases per 100 in non-specific neurological disease (numbness, tingling, and weakness) 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."

Mercury -- Mercury is a general protoplasmic poison that can be absorbed by inhalation or by ingestion. Mercury and its inorganic compounds may also cause dermatitis, vision disorders, chronic gingivitis, and pharyngitis. Occupational poisoning due to mercury or its inorganic compounds is usually chronic in nature. Acute mercury poisoning may occur due to massive inhalation of mercury vapor. Acute conditions are limited to the bucco-pharyngeal area. Other acute symptoms of mercury poisoning include blood in sputum and stools. Cases of mercury poisoning with neurological symptoms have also been reported (Reference 16). Compliance with 0.05 mg/M^3 of mercury for an 8-hour day, 40-hour work week over a working lifetime should protect workers.

VI. ENVIRONMENTAL RESULTS

N_2O 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 200-300 ppm in the breathing zone of the dentist and chairside assistant during the procedures. Refer to Table 1 for results.

Mercury was not found in the breathing zone of the dentist and his assistant. Trace quantities were found in mercury storage and mixing areas. Levels ranged from 0.02 to 0.04 mg/M^3.

VII. DISCUSSION AND CONCLUSIONS

Based on the data obtained during this survey, a definite health hazard existed from overexposure to N_2O. The high levels found throughout the survey were due to an inadequate scavenging system. An improved scavenging system and better dilution ventilation would lower the exposures.

VIII. RECOMMENDATIONS

The following recommendations are offered to assist in reducing and/or eliminating exposures to nitrous oxide.

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 flowrate 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 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.

IX. REFERENCES

1. Industrial Hygiene and Toxicology, second edition, Frank Patty (editor), Interscience Publishers, 1967, Vol. II.

2. Industrial Toxicology, third edition, Hamilton and Hardy, Publishing Service Group, Inc., 1974.

3. "Threshold Limit Values for Chemical Substances in Workman Air", American Conferenace of Governmental Industrial Hygienist, (1980).

4. Encyclopedia of Occupational Health and Safety, International Labor Office, McGraw-Hill Book Company, New York.

5. Industrial Ventilation, A Manual of Recommended Practice, American Conference of Governmental Industrial Hygienists, 14th edition (1976).

6. U.S. Department of Health, Education, and Welfare. Occupational Diseases, A Guide to Their Recognition, Public Health Service Publication (NIOSH) No. 77-181.

7. Vaisman, A.E., Working Conditions in Surgery and Their Effect on the Health of Anesthesiologists. Eksp Khir Anest 3:44-49, 1974.

8. Askrog, V., Harvold, B.: Teratogenic Effect of Inhalation Anesthetics. Nord Med 83:498-504, 1970.

9. Cohen, E.N., Brown, B.W., Bruce, D.K., Cascorbi, H.F., Corbett, T.H., Jones, T.H., Whitcher, C.E.: Occupational Disease Among Operating Room Personnel -- A National Study. Anesthesiology 41:421-40, 1974.

10. Bruce, D.L., Bach, M.J.: Trace Effects of Anesthetic Gases on Behavioral Performance of Operating Room Personnel, HEW Publication No. (NIOSH) 76-179. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1976, 33 pg.

11. Cohen, E.N., Brown, B.W., Bruce, D.L., Cascorbi, H.F., Corbett, T.H., Jones, T.W., and Whitcher, C.: A Survey of Anesthetic Health Hazards Among Dentists: Report of an American Society of Anesthesiologists Ad Hoc Committee on the Effects of Trace Anesthetics on the Health of Operating Room Personnel. J. Am. Dental Assoc. 90:1291, 1975.

12. Control of Occupational Exposure to N_2O in the Dental Operatory, HEW Publication No. (NIOSH) 77-171, Cincinnati, National Institute for Occupational Safety and Health, 1977.

13. U.S. Department of Labor, Occupational Safety and Health Administration, (29 CFR 1910.1000), January 1, 1978.

14. Criteria for a Recommended Standard -- Occupational Exposure to Waste Anesthetic Gases and Vapors. HEW Publication No. (NIOSH) 77-140, Cincinnati, National Institute for Occupational Safety and Health, 1977.

15. Criteria for a Recommended Standard -- Occupational Exposure to Inorganic Mercury. HEW Publication No. HSM 73-11024, 1973.

16. International Labour Office, Geneva: Occupational Health and Safety, Volume II, 1972, pp. 860-863.

X. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared By:

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

Marilyn K. Schulenberg
Occupational Health Technician
NIOSH, Region VIII
Denver, Colorado

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

Report Typed By: Marilyn K. Schulenberg
NIOSH, Region VIII
Denver, Colorado

XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Technical Services, 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. Robert W. Olson, D.D.S.
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

Levels of N_2O Observed During Dental Repair Procedures

Robert W. Olson, D.D.S.
Conifer, Colorado

January 8, 1981

Location	Time of Sample	N_2O (ppm)
6 inches from patient's mask	11:00 AM	> 1000
6 inches from patient's mask	11:10 AM	700
Breathing zone of dentist	11:30 AM	250
Breathing zone of dentist	11:35 AM	250
Breathing zone of dentist	11:40 AM	500
Breathing zone of dentist	11:50 AM	400
General room concentration	11:55 AM	200
Background	11:55 AM	200
EVALUATION CRITERIA		25
LIMIT OF DETECTION		1

NOTE: The nitrous oxide levels in the dental operatories remain about 200 ppm when the dentist is not working on the patient's teeth. Levels increase when the dentist is working on the patient's mouth.

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
ROBERT A. TAFT LABORATORIES
4676 COLUMBIA PARKWAY, CINCINNATI, OHIO 45226

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

Third Class Mail

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF HHS
HHS 396