HETA 86-157-1678
March, 1986
STAG DENTAL CLINIC
BOULDER, COLORADO

NIOSH INVESTIGATOR:
Bobby J. Gunter Ph.D.

I SUMMARY

In February 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request from employees of the Stag Dental Clinic, in Boulder, Colorado to evaluate exposures to nitrous oxide (N_2O) during dental procedures.

On February 11, 1986, direct reading measurements were taken in the dental operatory in use, and in the surrounding areas for N_2O levels. Immediately after N_2O was administered, levels exceeded 1000 parts per million (ppm) in the breathing zone of the dentist and his assistant. These levels remained high for the remainder of the procedure, which lasted from about 11:30 a.m. until 12:20 p.m. The level of N_2O in the hallway outside the dental operatory was 300 ppm. The adjacent dental operatory had a background level of 150 ppm. The general room air in the dental operatory that was in use showed a consistent concentration of 800 ppm. The N_2O system was turned off at 12:20 p.m. Levels of N_2O decreased to 50 ppm by 1:50 p.m. The current (NIOSH) recommended time weighted average (TWA) is 25 ppm. No scavenging system is used in these operatories.

The dentist and three assistants were informally interviewed. During the survey period a brief explanation was given on the chronic toxicological effects of N_2O exposure.

On the basis of data obtained during this evaluation, it has been determined that there is a health hazard at the dental office due to high exposure to N_2O. Recommendations to reduce N_2O exposures are presented in this report.

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

II. INTRODUCTION

In February 1986, NIOSH received a request from employees of the Stag Dental Clinic in Boulder, Colorado to evaluate N_2O exposures during its use in the dental clinic. On February 11, 1986, an environmental investigation was performed in this clinic. Direct reading measurements were taken throughout the clinic for N_2O concentrations. Verbal recommendations were given at this time for lowering N_2O exposure levels.

III. BACKGROUND

Only the dentist at this facility uses N_2O. The time and amount of N_2O used varies. The average use is about three hours a day. The day of this survey was typical with N_2O being used about 3 hours. The N_2O was administered at 2.0 liters per minute with oxygen at 1.0 to 1.5 liters per minute. There was no N_2O scavenging system in this clinic. The windows could not be opened. There was a door that opened to the outside. It was opened so that the direct reading instrument used for N_2O measurements could be zeroed with fresh air containing no N_2O. The door was closed immediately due to very cold temperatures.

IV. ENVIRONMENTAL 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. General area samples were taken on the N_2O administering equipment and throughout the dental operatory.

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 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 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.

	Environmental Exposure Limits 8-Hour Time-Weighted Average (TWA)
Nitrous Oxide	25 ppm (NIOSH)

---

ppm = parts of nitrous oxide per million.
parts of air.

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 permissable exposure level of 25 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_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 0.35 to 1.35 cases per 100, and an increase 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 rage 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 from 50 to greater than 1000 ppm (the highest reading on the scale is 1000 ppm). The average level in the breathing

zone of the dentist and his assistant was about 950 - 1000 ppm. After the procedure was finished and the N_2O turned off levels decreased to 50 ppm in 1.5 hours.

VII. SUMMARY

Based on data obtained during this evaluation, it was concluded that a health hazard existed from overexposures to N_2O. A nitrous oxide scavenging system, lower flow rates, and a better dilution ventilation system should lower these levels.

VIII. RECOMMENDATIONS

The following recommendations are offered to assist in either reducing or eliminating exposures to N_2O.

1. The most immediate concern for this dental office 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.

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 Conference of Governmental Industrial Hygienists, (1981).

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.; Harvald, 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.W.; 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), July 1980.

14. Criteria for 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.

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared By:	Bobby J. Gunter, Ph.D. Regional Industrial Hygienist NIOSH, Region VIII Denver, Colorado
Originating Office:	Hazard Evaluation and Technical Assistance Branch (HETAB) Division of Surveillance, Hazard Evaluations, & Field Studies (DSHEFS) NIOSH, Cincinnati, Ohio
Report Typed By:	Marile Brewer Clerk Typist NIOSH, Region VIII Denver, Colorado

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. Stag Dental Clinic.
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_2O observed during the time
Dental work was being performed by a Dentist
Dr. Richard H. Stag, D.D.S.
Boulder, Colorado
February 11, 1986

Location	Sampling Time	N_2O PPM
Breathing Zone of Dentist	11:30 am	>1000
Breathing Zone of Dental Asst..	11:30 am	>1000
Adjacent Office	11:38 am	150
General Room Air	11:45 am	500
Breathing Zone of Dentist	11:45 am	>1000
Breathing Zone of Dentist with towel over patients nose	11:50 am	700
General Room Air	11:50 am	800
Hall outside Dental Operatory	11:50 am	300
Breathing Zone of Dentist & his Assistant	11:55 am	>1000
General Room Air	12:00 noon	700
Background	12:05 pm	800
Background	12:12 pm	800
Background	12:15 pm	690
Background	12:20 pm	300
System Turned Off		
Background	12:25 pm	240
Background	12:45 pm	150
Background	1:15 pm	75
Background	1:30 pm	60
Background	1:42 pm	50
Background	1:50 pm	50
Evaluation Criteria		25
Laboratory Limit of Detection		1