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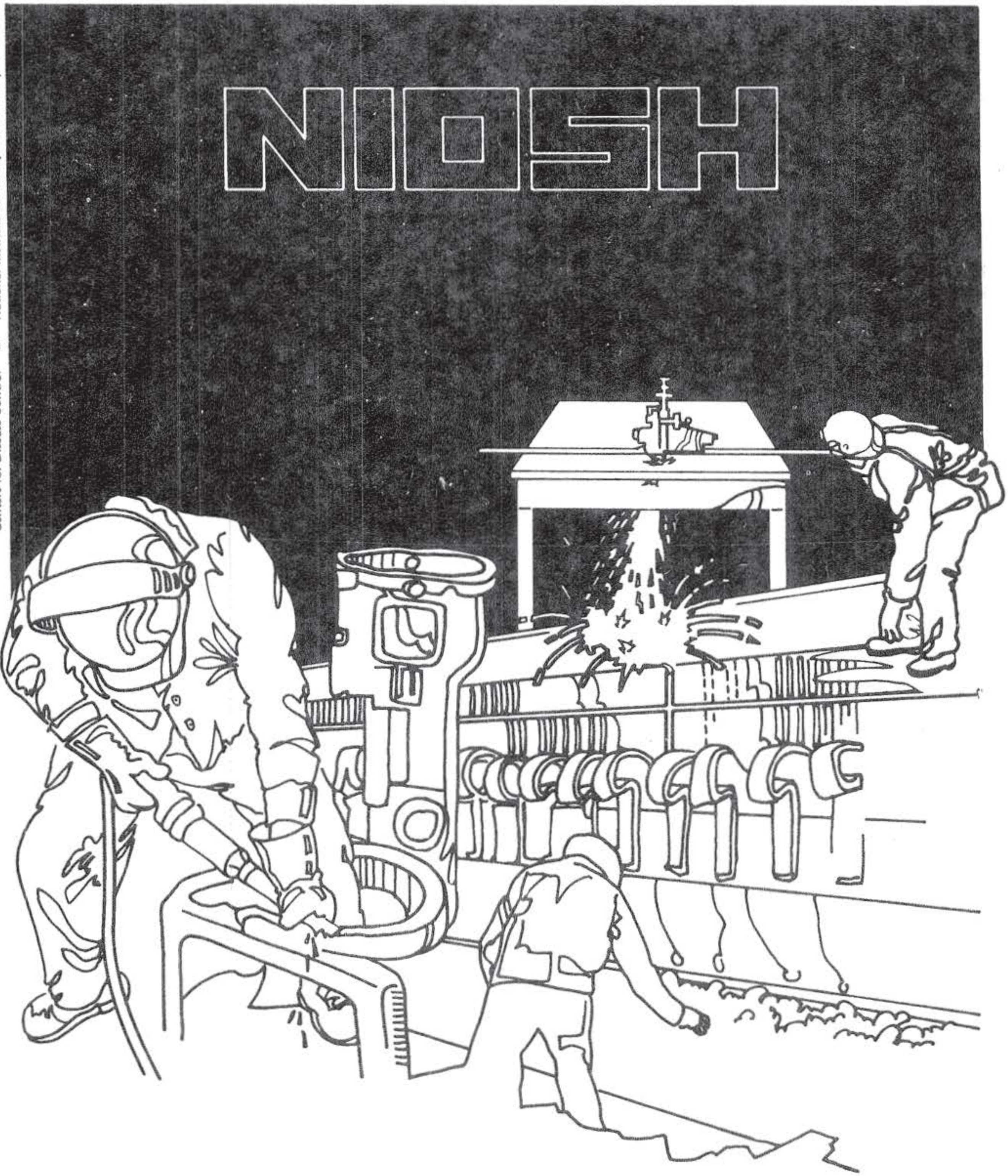

Health Hazard Evaluation Report

HETA 81-111-1471
STEPHEN GOLD, D.D.S.
PORT JEFFERSON STATION, NEW YORK

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.

HETA 81-111-1471
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Stephen Gold, D.D.S.
Port Jefferson Station, New York

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I. SUMMARY

On February 14, 1984, the National Institute for Occupational Safety and Health (NIOSH) evaluated the exposures of dental clinic personnel to nitrous oxide, an anesthetic gas at the dental clinic of Dr. Stephen Gold, D.D.S.

NIOSH monitored the nitrous oxide levels by collecting air samples in the breathing zones of dentists and dental assistants and at specific locations in the clinic throughout the day. A direct reading instrument was used to analyze samples at the working site. All fifteen breathing zone samples showed nitrous oxide concentrations in excess of 90 ppm. During sedation procedures the exposures of dentists exceeded 900 ppm. These exposures are well above the NIOSH recommended standard of 50 ppm for nitrous oxide without concurrent administration of other anesthetic gases.

At the time of this evaluation there was no circulation of room air from or to the outside of the dental clinic. The scavenging system could not be expected to adequately exhaust all of the nitrous oxide and thus levels in dental operatories were accumulating above 250 ppm. With current control technology, exposure levels of 50 ppm and less are attainable in dental offices.

Three mercury vapor monitor badges placed in the amalgamation areas showed 0.009, 0.009 and 0.017 mg/m^3 of mercury which is well below the evaluation criteria of 0.05 mg/m^3.

On the basis of data obtained in this investigation, it has been determined that the personnel in this dental clinic were overexposed to nitrous oxide. Recommendations to reduce exposures were given at the time of this survey and are presented in Section VII of this report.

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

II. INTRODUCTION

On January 1, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from Dr. Joan Korins, D.D.S. and Dr. Stephen Gold, D.D.S. to evaluate the potential hazards from exposure to nitrous oxide in their dental clinic at Port Jefferson Station, New York. On February 14, 1984 NIOSH investigators visited the clinic and obtained breathing zone and area bag samples for nitrous oxide which were analyzed by a direct reading instrument, for an entire working day. Limited area readings for mercury were also collected. Verbal recommendations were given at this time for lowering exposure levels.

III. BACKGROUND

The dental clinic of Drs. Gold and Korins consists of a waiting room area; three working areas each for the clerical personnel, the dental hygienists, and the dental assistants; two offices for the dentists; three dental operatories; an unused operatory serving as a storage room; and a closet for storing cylinders of nitrous oxide and oxygen and suction system equipment. The patients seen at this clinic are children and the dentists use nitrous oxide during most dental procedures with variable times of adminstration from a few minutes to as much as one hour. The rate of administration was variable also ranging from two liters to five liters per minute of nitrous oxide in concert with oxygen. In the two most frequently used operatories the gas is administered through a nasal mask which scavenges waste nitrous oxide. The waste gas is exhausted into the suction system. The third, less frequently used, operatory does not have a scavenging system. The clinic is located in a one story medical building which provides central air-conditioning and baseboard heating. No special ventilation or exhaust systems are provided to the dental clinic.

IV. MATERIALS AND METHODS

Area and breathing zone air samples were collected in inert, plastic bags. Two air samples were taken directly from the room where the analytical instrument was set-up. Four area samples were collected at 0.05 liters per minute with low flow pumps. Two of these covered two-thirds of the working day with one placed in the reception area and the other in the dental operatory that was in use the entire day of the survey. Two more area samples were from a dental operatory that was used for half the day, one sample for the morning, another for the afternoon. A shorter term (95 minutes) area sample was obtained from the location of the dental hygienists with a low flow pump at 0.2 liters per minute. Also a three minute sample using a high flow pump was taken from the closet where the gas cylinders are stored.

Eleven women and one man work in this dental clinic. One of the women and the man are dentists. Three of the women are dental hygienists (2 part-time), four are dental assistants (2 part-time), and three are clerical personnel. The dental assistants and dentists work closest to the nitrous oxide when it is administered. Fifteen samples were collected at the breathing zone of two dental assistants and the two dentists. Either a high flow pump set a 1 liter per minute and running for about 15-20 minutes or a low flow pump set at 0.2 liters per minute and running for about 45-60 minutes were employed. Tygon tubing connected the pumps to the bags; an additional 3-4 feet length of tubing was used from the pump for positioning the air sample inlet in the worker's breathing zone.

All bag and direct air samples were analyzed on-site using a long pathlength infrared spectrophotometer (Wilks-Miran 103 Gas Analyzer). The method used was the same as that described in the NIOSH Manual of Analytical Methods.(1) The analytical wave length was 4.48 micrometers and the path length varied from 0.5m to 40m depending on the concentration range. The lower limit of detection was 10ppm and the upper limit of detection was 1000ppm. Two concentration ranges were used, 10-250ppm and 100-1000ppm.

Three 3600-A 3M Mercury Vapor Monitor badges were placed where mercury is mixed in the amalgamation areas in each of the three dental operatories.

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.

Anesthetic Gases

A. Toxicological

Reports by Vaisman[2] and Askrog and Harvald[3] 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)[4]. 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 increased incidence of hepatic disease similar to that in the female was found.

In a study published by NIOSH[5], "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[6,7].

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.[8] 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[9] 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[6] 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.[10] 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. However, this study indicated that "significant health problems appear to be associated with the use of nitrous oxide alone."

B. Environmental

At present there is no Occupational Safety and Health Administration (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 believes that based on present technology personal exposure levels as low as 50 ppm of N_2O in dental operatories are attainable at this time.

Mercury

A. Toxicological

Mercury can enter the body through the lungs by inhalation, through the skin by direct contact, or through the digestive system.[11]

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.[11,12] 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.[11,12]

B. Environmental

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).[13] 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.[14] The current Occupational Safety and Health Administration (OSHA) standard for inorganic mercury is a ceiling level of 100 ug/m^3.[15]

VI. RESULTS AND DISCUSSION

Table 1 shows the nitrous oxide levels for all samples collected. This table refers to two types of dental procedures that were performed on patients. The first are routine procedures where nitrous oxide is administered initially to calm the child so that a local anesthetic may be injected. The second are sedation procedures which require administering nitrous oxide throughout the time the dentist works on the patient's teeth. Two of three sedation procedures exposed dentists to concentrations exceeding 1000 ppm (the upper limit of detection of the analytical instrument). Even though some patients did not move or cry during sedations the dentists were, nevertheless, exposed to levels above 900 ppm. Samples taken in the breathing zones of dental assistants during sedations ranged in concentration from 220 ppm to greater than 1000 ppm.

During routine procedures nitrous oxide levels exceeded 130 ppm for dentists and 90 ppm for dental assistants. For dentists routine procedure measurements averaged about 240 ppm but one routine procedure, immediately following a sedation, measured 470 ppm. When nitrous oxide was not used during a routine procedure, the sample collected in the breathing zone of a dental assistant showed a concentration of 30 ppm.

Long-term area samples collected in the dental operatories while they were being used showed levels above 250 ppm. While one of these operatories was not used in the morning the nitrous oxide concentration was 60 ppm. Similarly, the storage room next to an occupied operatory showed levels between 60 and 80 ppm. A long term sample in the reception area and a shorter term sample in the dental hygienist area were at or below the NIOSH recommended level of 50 ppm. Finally, after completion of two sedations the concentration of nitrous oxide in the cylinder storage closet was measured at 210 ppm. This closet was adjacent to the office of one of the dentists.

The exposures of dentists and dental hygienists to nitrous oxide exceeded the NIOSH recommended level of 50 ppm for all breathing zone samples collected during administration of nitrous oxide. Area samples taken where the dental hygienists and clerical personnel are located showed concentrations at or below this level. But employees entering dental operatories throughout the day when nitrous oxide has been used will be exposed to levels above 250 ppm as evidenced by area samples from occupied operatories.

In this dental clinic there is no air circulation except when the air conditioning is operating. The building does not provide a regular fresh air supply and exhaust system to the dental clinic. The general condition and maintenance of the scavenging system in the two most frequently used operatories were checked. No potential leak points could be detected visually or with a pressure check. The maintenance of the scavenging system by a manufacturer's representative was regular and fairly frequent.

The nitrous oxide levels in these operatories could be expected to build up to the levels observed given the size of the operatories, the absence of fresh supply and exhaust air, the average rate of administration and the scavenging system hypothetically operating at 90% efficiency. The situation in this dental clinic seems to indicate that the scavenging system is working properly, but that the lack of air supply and exhaust allows excessive levels of nitrous oxide to accumulate in the dental operatories.

The levels of mercury found on badges placed in the amalgamation areas in each dental operatory are given in Table 2. These concentrations are well below the NIOSH recommended level of 0.05 miligrams per cubic meter of air.

VII. RECOMMENDATIONS

The following recommendations are offered to assist in reducing and/or eliminating exposures to nitrous oxide. Some of these recommendations are already being carried out but others warrent closer attention:

1. The possibility of installing a special ventilation system in the rooms of the dental clinic which will bring in fresh outside air and exhaust contaminated room air should be investigated. If this cannot be accomplished, the option of moving to a building which can provide a special ventilation system should be considered.

2. The use of nitrous oxide should be reduced to the minimum compatible with performing dental procedures. Alternatives to using nitrous oxide such as substituting oral medications for calming and relaxing patients should be used whenever possible.

3. A nitrous oxide scavenging system should be installed in the third, less frequently used dental operatory.

4. All connections between components of the anesthesia system should be made as leakproof as possible by a qualified person.

5. It should be verified that the proper amount of suction (i.e. that recommended by the manufacturer) is being applied to the scavenging system.

6. The nosepiece should be positioned over the patient's nose before the nitrous oxide is turned on. Movement of the nosepiece should be minimized during the administration period.

7. Conversation with patients should be kept to a minimum during nitrous oxide administration. Patients should be advised to breathe through the nose as much as possible.

8. All personnel working in the dental clinic should be advised of the adverse health effects of overexposure to nitrous oxide.

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Drs. Stephen Gold and Joan Korins
2. U.S. Department of Labor/OSHA Region II
3. NIOSH, Region II

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 SAMPLING RESULTS

Dr. Stephen Gold, D.D.S.
Port Jefferson Station, New York
HETA 84-111
February 14, 1984

Location and Description	Sampling Time	Concentration (ppm)
Near dentist 1 - during routine dental procedure - patient quiet	9:06am-9:50am	160
Near dental assistant 1 - during routine dental procedure - patient quiet	9:16am-9:29am	90
Breathing zone dental assistant 1 - No. N_2O used during routine procedure	9:47am-10:05am	30
Breathing zone of dentist 1 - during sedation procedure - patient crying and moving	10:30am-10:47am	>1000
Breathing zone of dental assistant 1 - during sedation procedure - patient crying and moving	10:30am-11:19am	>1000
Breathing zone of dentist 1 - during sedation procedure - patient crying and moving	10:51am-11:05am	>1000
Breathing zone of dental assistant 1 - during two routine procedures - both patients quiet	11:20am-11:45am for lunch-11:45am-12:41 12:41pm-1:25pm	120
Breathing zone of dentist 1 - during routine procudure - patient quiet	1:10pm-1:25pm	130
Breathing zone of dental assistant 1 - during sedation procedure - patient quiet	2:10pm-2:30pm	220
Breathing zone of dentist 1 - during sedation procedure - patient quiet	2:05pm-2:58pm	920

(Continued)

Table 1 (continued)

Location and Description	Sampling Time	Concentration (ppm)
Breathing zone of dentist 2 - during sedation procedure - patient quiet	2:15pm-2:32pm	>1000
Breathing zone of dental assistant 2 - during sedation and two routine procedures - patients quiet	2:15pm-3:15pm	470
Breathing zone of dentist 2 - during routine procedure - patient quiet	2:39pm-2:59pm	470
Breathing zone of dentist 2 - during routine procedure - patient quiet	4:35pm-4:50pm	230
Breathing zone of dentist 1 - during routine procedure - patient quiet	4:12pm-4:27pm	190

(Continued)

Table 1 (continued)

Location and Description	Sampling Time	Concentration (ppm)
Reception area - on filing cabinet near clerical staff	9:09am-3:04pm	50
Dental operatory 1 - on window sill	9:05am-3:04pm	>250
Dental operatory 2 - on dental chair - not used in morning and early afternoon	9:45am-1:45pm	60
Dental operatory 2 - on window sill	2:00pm-4:55pm	>250
Dental hygienist area - on countertop near wall	1:30pm-3:05pm	40
In closet where O_2 and N_2O cylinders stored and scavenging system exhausted - after two sedation procedures	2:50pm-2:53pm	210
In storage room where N_2O analyzing instrument set-up	1:19 3:45	60 80

Table 2

MERCURY LEVELS AT AMALGAMATION AREAS

Dr. Stephen Gold, D.D.S.
Port Jefferson Station, New York
HETA 84-111
February 14, 1984

Amalgamation Area For:	Mercury Level (mg/m^3
Operatory 1 9:40 am - 4:55 pm	0.017
Operatory 2 9:45 am - 4:55 pm	0.009
Operatory 3 9:48 am - 4:55 pm	0.009

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