U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 78-129-544

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I. TOXICITY DETERMINATION

A Health Hazard Evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) in the dental office of Dr. Alvin Jacobs in Fort Lee, New Jersey. On October 5, 1978, environmental samples were collected to determine airborne concentrations of waste anesthetic gas (nitrous oxide) and mercury.

Breathing zone samples of nitrous oxide ranging to 430 ppm were measured during dental procedures. Atmospheric mercury concentrations up to 0.02 mg/M^3 were found. These findings indicate that mercury levels are within acceptable limits and are not believed to present a health hazard. Measures should be taken to reduce exposure to nitrous oxide to levels recommended as attainable by NIOSH, e.g., 50 ppm for dental operatories.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination 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:

a) Dr. Alvin Jacobs, DDS
b) U.S. Department of Labor, Region II
c) NIOSH, Region II

For the purpose of informing the approximately three "affected employees" the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an 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 National Institute for Occupational Safety and Health received such a request from Dr. Jacobs.

There were no specific alleged health problems at the time the request was generated. The recognition of the potential health hazard associated with chronic exposure to anesthetic gases was primarily responsible for the health hazard evaluation request.

IV. HEALTH HAZARD EVALUATION

A. Process Description

This dental facility includes a waiting room, a receptionist area, two operatories, a laboratory, an office and a coffee area. During the day of this evaluation, all procedures using nitrous oxide were done in the first operatory. The staff includes the dentist, one assistant, and one receptionist.

Nitrous oxide and oxygen are piped to the operatories from cylinders located in a closet, and the anesthesia machine is supplied with gas by connecting it to the outlets located in the wall. The anesthesia machine consists of a flow meter and control for nitrous oxide and another for oxygen. The gas mixture is supplied to the patient through flexible tubing terminating in a scavenging nosepiece. Suction for the scavenging nosepiece as well as for the dental instruments is provided by a vacuum pump located in a supply closet. The major source of nitrous oxide into the work environment is most likely to be the nosepiece, although every fitting in the system as well as cracks in the tubing are possible leaks.

The preparation of mercury amalgam dental fillings is accomplished by placing an alloy tablet in a plastic capsule, adding a drop of mercury, and agitating this mixture on a machine. Care must be taken in the preparation and use of amalgams to prevent exposure of employees and patients to mercury.

B. Evaluation Design

Area and personal breathing zone samples for nitrous oxide were obtained by filling inert plastic bags with air drawn from the desired location using battery powered sampling pumps. These samples were subsequently analyzed on site by infrared spectroscopy. Direct measurements were also made at various locations throughout the facility by placing

the inlet of the infrared analyzer at the desired point and drawing air into the analyzer. Using this method, short term exposures could be measured and sources of nitrous oxide contamination could be located. Quantitative nitrous oxide measurements were made at an analytical wavelength of 4.47μ (2240 cm^{-1}) and a pathlength of 5.25m. The instrument response time was approximately 15-30 seconds. The lower limit of detection in this mode of operation was 5 ppm. The instrument was calibrated on site.

While exposure to mercury vapor was not mentioned in the hazard evaluation request, screening measurements were made to determine if a comprehensive evaluation was needed. Measurements for mercury were made using a direct reading ultraviolet analyzer. This instrument was not used to determine long term personal exposures, but rather to detect areas of mercury contamination. The results of the screening measurements indicated that no further evaluation was necessary.

C. Evaluation Criteria

While the majority of the information available on occupational exposure to waste anesthetic gas is regarding exposure to a combination of nitrous oxide and a halogenated agent, enough evidence is available on the effects of N_2O alone so that it should be considered potentially toxic under conditions of chronic exposure.

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 American Society of Anesthesiologists (ASA)[3]. 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 increased risk of congenital abnormalities was also present among the unexposed wives 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 some 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 have also been reported.[1,5]

Mortality and epidemiological studies have raised the question of possible carcinogenicity of anesthetic gases, but sufficient data are lacking to list nitrous oxide or halothane as suspected carcinogens.

In an epidemiological study among dentists[6], Cohen et. al. 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 in their practice. 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 for the unexposed. These data are 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 if a halogenated agent was used. However, in a review of that study, NIOSH[7] concludes 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 assuming 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[8], NIOSH 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 document recommending a standard for occupational exposure to mercury[9], NIOSH recommends a maximum exposure of 0.05 mg/M^3. Mercury can be absorbed by inhalation or in the case of soluable mercury salts by ingestion. Mercury and its organic compounds may cause headache, fatigue, weakness, loss of memory, fine tremors, neurological disturbances, and personality changes. The OSHA standard for mercury exposure is 0.1 mg/M^3, and is a ceiling value[10].

D. Evaluation Results and Conclusions

The attached table shows the results of both bag samples and direct measurements taken for nitrous oxide. In addition to these samples, the infrared analyzer was used to check for leaks at various points in the system. Large leaks were detected where the high pressure nitrous oxide hose was connected to the anesthesia machine, and where the N_2O/O_2 mixture left the machine. The first leak was eliminated by tightening the fitting, although this adjustment was not made until late in the day, after other sampling had been done. The second leak was near an area where a repair had been made on the anesthesia machine. This repair was probably the source of the gas. No leaks were found near the N_2O cylinders or regulator connections, the high pressure wall connection or the breathing bag.

Measurement of mercury by direct reading instrument indicated up to 0.02 mg/M^3 in the air (the recommended maximum is 0.05), and slightly higher concentrations on counter tops, floors, etc. The highest concentrations were found on

the hands (0.1-0.2 mg/M^3) and soles of the shoes (0.4-0.5 mg/M^3) of the dental assistant. The recommended maximum of 0.05 does not apply to these types of samples. The doctor indicated that recent analyses of urine samples for mercury had been negative.

Findings indicate that mercury levels were within acceptable limits on the day of this evaluation and that measures should be taken to reduce exposure to nitrous oxide.

V. RECOMMENDATIONS

The following recommendations are made to achieve a reduction in nitrous oxide exposures:

1. Replace the broken piece on the anesthetic machine which had been repaired with plastic putty. This should eliminate the leak at that point.

2. Exhaust the suction pump to the outside. As it is now set up, this pump provides suction for all dental procedures as well as for the scavenging mask. It is located in a storage closet and exhausts into the wall and the area above the ceiling. The N_2O from this area can then permeate not only into this dental office but into any room on the same floor of the building.

3. The secondary (top) inlet and outlet for the suction pump should be blocked off if this is consistent with proper operation of that pump. This outlet is spilling N_2O into the storage area from which it can move into the office. The inlet is reducing the effective suction at the chair and therefore at the scavenging mask (see next comment).

4. The amount of air being drawn through the scavenging mask should be maximized. This can be done by number 3 above, as well as connecting the mask vacuum to the highest flow suction line at the chair. Also, suction to instruments should be turned off when those instruments are not in use.

5. 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.

Periodic urine analysis for mercury for all employees should be conducted. Spills of mercury should be promptly cleaned up either mechanically or chemically, not by blowing or dry sweeping. When vacuum cleaners are used, they should be equipped with mercury filters to prevent dispersal of mercury vapors into the air.

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10. OSHA Safety and Health Standards, 25 CFR 1910.

VII. AUTHORSHIP AND ACKNOWLEDGMENTS

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TABLE I

Nitrous Oxide Concentrations

Alvin Jacobs, DDS
Fort Lee, N.J.

October 5, 1978

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Sample Location	Type*	Duration	Concentration
Doctor's breathing zone	B	8:42am- 9:00am	110 ppm
Approx. 6 ft. in front of doctor	B	8:42am- 9:00am	50 ppm
Approx. 6 in. above nose mask	B	8:44am- 9:00am	>160 ppm
Receptionist's area	B	8:47am- 9:10am	5 ppm
Business office	D	9:20am	40-60 ppm
Doctor's breathing zone	B	9:47am-10:23am	430 ppm
Approx. 2 ft. above nose mask	B	9:48am-10:25am	60 ppm
Equipment closet	D	10:15am	up to 270 ppm
Equipment closet	D	10:35am	10 ppm
Business office	D	11:40am	10 ppm
Doctor's breathing zone	B	1:26pm- 1:55pm	90 ppm
Approx. 2 ft. above nose mask	B	1:26pm- 1:55pm	70 ppm
Waiting room	B	1:40pm- 2:10pm	20 ppm
Equipment closet - at top discharge part of vacuum system	D	1:30pm	>500 ppm
Inside wall into which vacuum is exhausted	D	1:35pm	>500 ppm
Above false ceiling of equipment closet	D	1:40pm	80-90 ppm
Business office**	D	3:00pm	10-15 ppm
Equipment closet**	D	3:10pm	10 ppm
Business office**	D	3:10pm	10 ppm
N_2O storage closet**	D	3:15pm	15 ppm

* "B" indicates samples were collected in bags and analyzed later.

"D" indicates samples were analyzed directly by drawing air into spectrometer chamber.

** These samples were taken approximately one hour after use of N_2O was discontinued.

RECOMMENDATIONS IN MERCURY HYGIENE, FEBRUARY 1974

1. Store mercury in unbreakable, tightly sealed containers.
2. Perform all operations involving mercury over areas that have impervious and suitably lipped surfaces so as to confine and facilitate recovery of spilled mercury or amalgam.
3. Clean up any spilled mercury immediately. Droplets may be picked up with narrow bore tubing connected (via a wash-bottle trap) to the low-volume aspirator of the dental unit.
4. Use tightly closed capsules during amalgamation.
5. Use a no-touch technique for handling the amalgam.
6. Salvage all amalgam scrap and store it under water.
7. Work in well-ventilated spaces.
8. Avoid carpeting dental operatories as decontamination is not possible.
9. Eliminate the use of mercury-containing solutions.
10. Avoid heating mercury or amalgam.
11. Use water spray and suction when grinding dental amalgam.
12. Use conventional dental amalgam compacting procedures, manual and mechanical, but do not use ultrasonic amalgam condensors.
13. Perform yearly mercury determinations on all personnel regularly employed in dental offices.
14. Have periodic mercury vapor level determinations made in operatories.
15. Alert all personnel involved in handling of mercury, especially during training or indoctrination periods, of the potential hazard of mercury vapor and the necessity for observing good mercury hygiene practices.

Recommendations in mercury hygiene

Council on Dental Materials and Devices

The Association, through its Council on Dental Materials and Devices, is publishing a series of recommendations concerning safety or proper practices in the dental office. The Council, in cooperation with the Council on Dental Research, sponsored and published an article titled "Significance to Health of Mercury Used in Dental Practice: A Review" in the June 1971 issue of THE JOURNAL (JADA 82:1401 June 1971).

Since mercury as a potential health hazard in dental practice cannot be dismissed or casually treated, the Council has continued to follow reports in this area. Reports of surveys in the US,[1-3] Canada,[4] and England[5] all show that at least 10% of dental offices have air levels of mercury vapor in excess of the threshold limit value (TLV) of 0.05 mg/m³. A summary of surveys made in the United States will be the subject of a subsequent report. Even though neither a dentist nor a dental assistant has been reported as suffering from chronic mercurialism, many exposures are sufficient to cause concern. This is especially true since the *British Dental Journal*[6] reported one fatality of a dental assistant that was attributed to acute mercury poisoning. This case was inadequately investigated so nothing is known concerning her medical history or the mercury hygiene of her work spaces. Consequently, the mercury hygiene observed in the office where she worked cannot be identified as the direct source of her mercury poisoning.

Much has been made over the materials and methods used in dental office construction to reduce the potential of mercury contamination. Impervious and seamless work and floor areas with edges lipped to confine spills have been universally recommended. Even so, many decorators continue to install rugs on the floors of dental operatories. Carpeting is not recommended, as decontamination in the event of spills is not possible. The mercury levels in these offices, however, are often lower than the mercury levels in offices decorated as recommended. The determining factor influencing vapor levels is the mercury hygiene observed by the dental personnel in the offices. Consequently, efforts to establish guidelines for proper mercury hygiene must center on the few minutes during proportioning of the mercury and alloy and mixing of the amalgam mechanically. Capsules fitted with friction grip caps and some preproportioned disposable capsules disperse free mercury during high-speed mechanical trituration.[7,8] This loss of mercury during trituration can be detected by wrapping adhesive tape around the capsule prior to the mechanical mixing. If the capsules are tight and no mercury is thrown out, the adhesive side of the tape will be clean after trituration. Drops of mercury, 0.1 mm in diameter and weighing approximately 0.01 mg, can be seen on the tape with the naked eye.[8] This test should be made on new capsules, as well as occasionally during the use of the capsule.

Von Nossek and Seidel[9] and Chandler and coworkers[10] observed a spray of mercury-rich particles during condensation with an ultrasonic instrument. Although no significant mercury vapor was detected, the dispersal of small particles, which can be inhaled by dental personnel and patients, is not considered to be good mercury hygiene.

These foregoing reports, along with Stewart and Stradling's[11] code of mercury hygiene for dental operatories, form the basis for the Council's recommendations of criteria for good mercury hygiene.

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