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LITTEKEN DENTAL CLINIC
ARDMORE, OKLAHOMA

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## I. SUMMARY

In May l987, the National Institute for Occupational Safety and Health (NIOSH) received a request from management of a dental clinic, in Ardmore, Oklahoma to evaluate mercury and nitrous oxide ($N_20$) exposures during routine dental procedures.

In September of l987, breathing and general room measurements were taken for $N_20$ and Mercury. The dentist and his three assistants were using $N_20$ during this evaluation. The dentist and one of his assistants were using mercury amalgams. On the day of this evaluation $N_20$ was used from 1:30 pm until 5:00pm. Levels of exposure ranged from 30 parts per million (ppm) to 220 ppm. The mean concentration was l05 ppm. The NIOSH recommended exposure limit (REL) for nitrous oxide is 50 ppm. All breathing zone and direct reading concentrations of mercury were either non detectable or well within the evaluation criteria of 0.05 ppm. The two breathing zone samples for mercury were 0.00l and 0.0009 ppm. and the one general room sample was 0.009 ppm.

This dental laboratory was equipped with a $N_20$ scavenging (ventilation system) and it was somewhat effective. In other dental clinics (HETA 8l-200 and HETA 84-085) levels of nitrous oxide exceeded l000 ppm 30 minutes after administration was started. The highest concentration found in this clinic was 220 ppm.

The three dental hygienists and the dentist were informally interviewed. All workers were very interested in the toxicology of mercury and $N_2O$.

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On the basis of environmental data obtained during this evaluation, it was concluded that a health hazard did exist from excessive exposures to nitrous oxide. Recommendation to reduce $N_20$ exposures are presented in this report.

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

## II. INTRODUCTION

In May l987, NIOSH received a request from the owner of the Litteken Dental Clinic in Ardmore, Oklahoma to evaluate mercury and $N_20$ exposures during various dental procedures. In September l987 an environmental investigation was performed in this clinic.

## III. BACKGROUND

The dentist and the dental assistants at this clinic routinely use $N_20$ and mercury during various dental procedures. The time and amount of both compounds varies with each procedure. There are days when $N_20$ is not used and there are days when it is used for 8 hours. Mercury is used throughout most days when metal fillings are amalgamated. There was a scavenging (ventilation) system to exhaust the $N_20$ lost during all procedures where $N_20$ was used. It is difficult to ventilate all the $N_20$ lost during dental work. The open mouth of the patient is continuously expelling $N_20$, the nose mask used for administering the $N_20$ usually does seal effectively, and the capture velocity of the scavenging system may be too low to ventilate all the escaping $N_20$.

## IV. ENVIRONMENTAL DESIGN AND METHODS

All breathing zone measurements for nitrous oxide were performed on site with an infrared analyzer. All direct reading mercury measurements were made on site with a portable mercury vapor analyzer. Time weighted average mercury measurements were performed using vacuum pumps and a hopkalite collection tube. The mercury tubes were analyzed by cold vapor atomic absorption spectroscopy.

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

## V. ENVIRONMENTAL CRITERIA

### A. Environmental

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<br>8-Hour Time-Weighted Average (TWA) |
|---|---|
| Nitrous Oxide (N20) Dentistry | 50 ppm (NIOSH) |
| Mercury ((Hg) | 0.05 mg/$M^3$ (NIOSH/OSHA) |

B. Toxicology

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

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. 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.[1,2,15,16]

B. Nitrous Oxide – In the NIOSH criteria document for a recommended standard for occupational exposure to anesthetic gases, NIOSH states: "Current scientific evidence obtained from human and animal studies suggests that chronic exposure to anesthetic gases increases the risk of both spontaneous abortion among female workers and congenital abnormalities in the offspring of female workers and the wives of male workers. Risks of hepatic and renal diseases are also increased among exposed personnel. In addition, physiological function may be impaired. A few studies have suggested increased risk of cancer. Effects on the central nervous system due to acute exposures to anesthetic gases have been associated with headaches, nausea, fatigue, irritability, etc." Control procedures and work practices presented in that document, however, should prevent the effects caused by acute exposure and significantly reduce the risk associated with long-term, low level exposure. A dose response relationship for halogenated anesthetic toxicity has not been defined.[2]

That same NIOSH publication recommends maximum exposures to 25 ppm nitrous oxide (eight-hour time-weighted average) and 2 ppm halogenated anesthetic when used alone, or 0.5 ppm when used with nitrous oxide. These recommendations are based upon available technology in reducing waste anesthetic gas levels.

Reports by Vaisman[3] and Askrong and Harvald[4] were among the first to identify 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).[1] The results of this study indicate "that female members of the operating room-exposed group were subject to increase 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."

While several investigators have reported increased rates of resorption in animals, particularly rats, most of these studies involved concentrations of anesthetic gases well above the levels found in occupational exposure. One investigator[5] showed increased fetal death rates in two groups of rats following exposures of 1,000 and 100 ppm of nitrous oxide.

Several epidemiological studies that indicate increased spontaneous abortions also indicate an increased rate of congenital abnormalities. The ASA study[1] (as well as surveys by Knilljones, et al.,[6] and Corbett, et al.[7] indicated an increased rate of congenital abnormalities in children of women with occupational exposures to anesthetic levels.

In a study published by NIOSH[8], "nitrous oxide and halothane in respective concentrations as low as 50 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[2,9].

A mail survey of 30,650 dentists and 30,547 chairside assistants grouped according to occupational exposure to inhalation anesthetic/sedatives in the dental operatory indicated increased general health problems and reproductive difficulties among anesthetic-exposed respondents. For heavily anesthetic-exposed male dentists, the increase in liver disease was 1.9-fold, kidney disease 1.2-fold, and neurological disease 1.9-fold. For wives of heavily anesthetic-exposed male dentists the increase in spontaneous abortion rate was 1.5-fold. Among heavily anesthetic-exposed female chairside assistants, the increase in liver disease was 1.6-fold, kidney disease 1.7-fold and neurological disease 2.8-fold. The increase in spontaneous abortion rate among heavily exposed assistants was 2.3-fold. Cancer rates in women heavily exposed to inhalation anesthetics were increased 1.5-fold but this finding was only borderline significant ($P = 0.06$). Separate analysis of the data for disease rates and birth difficulties by type of inhalation anesthetic indicates that in both dentists and chairside assistants chronic exposure to nitrous oxide alone is associated with an increase rate of adverse response.[10] It would not be correct to directly extrapolate nitrous oxide epidemiological data taken on dentists and dental assistants to surgical operations. Dentists and their assistants are much closer to their work and are breathing higher concentrations than surgeons, scrub nurses, and anesthesiologists.

In November, 1987 NIOSH performed a computer search of the scientific literature on the anesthetic waste gases. Information received from this search did not add additional light on the toxicology of this agent.

## VI. ENVIRONMENTAL RESULTS

Mercury levels posed no health problem during this survey. Mercury levels were either below laboratory detection limits or at levels that were far below the evaluation criteria of 0.05 ppm. Nitrous oxide levels ranged from 30 to 220 ppm. The average concentration was 105 ppm. Scavenging was being used on all $N_20$ administering devices and was very effective. Levels of $N_20$ without using a scavenging system world have easily exceeded an average concentration of l000 ppm.

## VII. SUMMARY AND CONCLUSIONS

Based on environmental data obtained during this survey a health hazard existed from overexposures to nitrous oxide. There was no exposure to mercury. Refer to table I and II for all environmental levels of mercury and nitrous oxide found during this survey.

## VIII. RECOMMENDATIONS

1. Continued use of the nitrous oxide scavenging system with special attention on proper flow rates for the adjustable ventilation system should be performed each time nitrous oxide is used. Increased dilution ventilation with more fresh air changes would lower $N_2O$ levels significantly.

2. Routine maintenance should be performed on all anesthetic and suction equipment. Periodic visual checks should be made on tubing, masks, breathing bag, connections and any cracked or broken items should be replaced. Leak tests using something as simple as a soap bubble should be performed on all high pressure nitrous oxide fittings and in the cylinder storage room.

3. All workers in the dental clinic should be advised of the possible adverse health effects of overexposure to nitrous oxide.

4. More dilution ventilation should be installed; such as a large fan on the roof of the building that would periodically bring in fresh outside air.

5. Watch children and make them leave the face piece on during the administration of the nitrous oxide. They were playing with the face mask during this evaluation and this accounted for some of the nitrous oxide pollution of the general air.

## IX. REFERENCES


1. Cohen, E.N., et al, ad Hoc Committee on the Effect of Trace Anesthetics on the Health of Operating Room Personnel: Occupational Disease Among Operating Room Personnel: A National Study. Anesthesiology 41:321-340, 1974.

2. Criteria for a Recommended Standard...Occupational Exposure to Waste Anesthetic Gases and Vapors. DHEW (NIOSH) Publication No. 77-140, 1977, 194 pp.

3. Vaisman, A.I. (Working conditions in surgery and their effect on the health of anesthesiologists). Eksp Khir Anest 3:44-49, 1967 (Rus.).

4. Adkrog, V., and Harvald, B. (Terateogenic effect of inhalation anesthetics). Nord Med 83:498-504, 1970.

5. Corbett, T.H., Cornell, R.G., Endres, J.L., and Millard, R.I. Effects of Low Concentrations of Nitrous Oxide on Rat Pregnancy. Anesthesiology 39:299-301, 1973.

6. Knill-Jones, R.P., Moir, D.D., Rodrigues, L.V, and Spence, A.A. Anesthetic Practice and Pregnancy–Controlled Survey.

7. Corbett, T.H., Cornell, R.G., Lieding, K., and Endres, J.L. Incidence of Cancer AMong Michigan Nurse-Anesthetists. Anesthesiology 41:34-44, 1974.

8. Bruce, D.L., and Bach, M.H. Trace Effects of Anesthetic Gases on Behaviorial Performance of Operating Room Personnel. HEW Publication No. NIOSH 76-169, 1976, 33pp.

9. Uhlirova, A., and Pokorny, J. (Results of questionnaire survey of health damage to anesthesiologists). Rozhl Chir 53:761-70, 1976 (Cze).

10. Cohen, E.N., et al, Occupational Disease in Dentistry and Exposure to Anesthetic Gases 1980. This research supported by the National Institutes of Health OH-00775, and a grant in aid from the American Dental Association.

## X. AUTHORSHIP AND ACKNOWLEDGEMENTS


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## XI. DISTRIBUTION AND AVAILABILITY

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Copies of this report have been sent to:

1. Dr. Litteken
2. U.S. Department of Labor/OSHA - Region VIII
3. NIOSH - Denver Region
4. Oklahoma State Health Department
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 I

Breathing Zone Levels of Nitrous Oxide observed during
Dental procedures by Dr. Litteken
Ardmore, Oklahoma
September 8, 1987

| Location | Sampling Time | $N_2O$ (PPM) |
|---|---|---|
| Assistant I | 1:30 pm | 95 |
| Assistant II | 1:30 pm | 30 |
| Assistant I | 2:00 pm | 85 |
| Assistant II | 2:00 pm | 70 |
| Background | 2:00 pm | 65 |
| Assistant I | 2:15 pm | 65 |
| Assistant II | 2:25 pm | 55 |
| Assistant I | 2:50 pm | 100 |
| Assistant II | 2:55 pm | 95 |
| Background | 2:30 pm | 75 |
| Assistant I | 3:00 pm | 110 |
| Assistant II | 3:15 pm | 220 |
| Assistant III | 3:25 pm | 120 |
| Background Lab | 3:30 pm | 130 |
| Assistant I | 3:30 pm | 120 |
| Assistant II | 4:00 pm | 160 |
| Assistant III | 4:00 pm | 140 |
| Background Lab | 3:30 pm | 120 |
| Background Work Area | 5:00 pm | 140 |
| Evaluation Criteria | | 50 |

Instrument Limit of Detection 1 ppm

Table II

Breathing Zone and General Room Air Concentrations of
Mercury at Dr. Litteken's Office
Ardmore, Oklahoma
September 8, 1987

| Sample # | Sample Location | Sampling Time | Hg/ppm |
|---|---|---|---|
| 1 | General Room (Triturator) | 8:43 - 12:00 | 0.009 |
| 2 | Assistant I | 8:50 - 12:00 | 0.001 |
| 3 | Assistant II | 8:56 - 12:00 | 0.0009 |
| Evaluation Criteria | | | 0.05 |

Laboratory Limit of Detection 0.003 ug/sample