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D. KURTZMAN, DDS
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NIOSH INVESTIGATOR:
Max Kiefer, CIH

SUMMARY

On April 20, 1994, the National Institute for Occupational Safety and Health (NIOSH) received an employer request to conduct a health hazard evaluation (HHE) at the D. Kurtzman, DDS dental office in Atlanta, Georgia. The request asked NIOSH to evaluate employee exposures to nitrous oxide (N_2O) during the administration of this anesthetic gas to patients, and to glutaraldehyde, used in disinfectant solutions for sterilizing dental tools. No health problems associated with exposure to these chemicals were reported.

In response to this request, the NIOSH investigator conducted a site visit on June 30, 1994. The purpose of this visit was to review dental practices regarding the use of N_2O and glutaraldehyde, inspect the anesthetic gas delivery system, and conduct personal air monitoring for N_2O and glutaraldehyde. Both real-time and integrated air monitoring were conducted. Because all offices on this floor are ventilated through a common mechanical room, monitoring to assess N_2O levels outside the dental office was also conducted.

During a one-hour root canal operation where N_2O was used, the dentist performing this procedure was exposed to an average N_2O concentration of 900 parts per million (ppm), with a range of 221 - 3860 ppm. The dental hygienist assisting with this procedure was exposed to an average N_2O concentration of 246 ppm (range = 216 - 264 ppm). The NIOSH Recommended Exposure Limit (REL) for N_2O is 25 ppm averaged over the duration of anesthetic administration. General dental office levels ranged from 7.5 - 97 ppm after N_2O had been dispensed, and 0.5 - 6.5 ppm prior to dispensing the anesthetic gas. This monitoring conducted prior to N_2O administration indicated the presence of leaks in the N_2O delivery system.

Monitoring in a common area outside the dental office found detectable levels of N_2O (11 - 48 ppm), indicating exfiltration of N_2O was occurring. Exposures of office personnel outside the dental office were not determined.

Ventilation measurements on two of the three N_2O scavengers found the flow rates to be near the recommended 45 liters per minute for nose-mask scavenging systems. The scavenging system in Operatory #2 was not functional. These scavenging systems, however, are not consistently used and there are no formal office policies requiring their use.

Detectable glutaraldehyde was found on two area samples, although the concentrations were below the NIOSH REL of 0.2 ppm (ceiling limit). No glutaraldehyde was detected on the personal breathing zone samples obtained during the disposal and replenishment of glutaraldehyde solutions.

Minimizing the use of N_2O whenever possible, correcting all system leaks, and ensuring the existing scavenging systems are properly used whenever N_2O is administered will help reduce exposure. Additional measures that should be considered include improved exhaust ventilation, and relocating the compressor or compressor exhaust outside the building.

Concentrations of nitrous oxide (N_2O) exceeded the NIOSH REL for all activities assessed in the dental office. N_2O levels exceeding the NIOSH REL were also found in common areas of the second floor. Insufficient use of proper controls and delivery system leaks were the primary contributors to the high N_2O levels. Exfiltration to other plaza level offices is due to the common return air system. As long as N_2O is used in this dental office with the existing ventilation system design, exfiltration of waste N_2O to other areas outside the dental office will continue to occur. No glutaraldehyde was detected on any of the personal samples, and concentrations found on the area samples were below the NIOSH REL. Recommendations to reduce exposure to N_2O, including ventilation and improved work practices, are provided in the Recommendation section of this report.

KEYWORDS: SIC 8021 (Offices and Clinics of Dentists) nitrous oxide, waste anesthetic gas, glutaraldehyde, ventilation, scavengers

INTRODUCTION

NIOSH received a request from the D. Kurtzman, DDS, dental office on April 20, 1994, to evaluate airborne concentrations of nitrous oxide (N_2O) during the administration of this anesthetic gas to patients, and assess employee exposure to glutaraldehyde, used as a cold disinfectant. Because all offices on the same floor as the dental office are ventilated through a common mechanical room, air monitoring for N_2O was also conducted in the elevator lobby.

On June 30, 1994, the NIOSH investigator conducted a survey at the dental office to determine airborne N_2O and glutaraldehyde concentrations during various dental procedures. Information on the anesthetic gas delivery system, work practices, and the existing ventilation system was also obtained. Pre- and post-survey meetings were held with dental office personnel, and building management was informed of the results.

On July 21, 1994, an interim report was sent to the dental office, building management, and all tenants on the Plaza Level.

BACKGROUND

Facility Description

The Kurtzman, DDS dental office is located on the second floor of a 16-story square office building (Building 1100) in a commercial office area on the northwest side of Atlanta, Georgia. Building 1100 is a 280,000 square foot (ft^2) facility constructed of reinforced concrete with precast architectural concrete facades and concrete floors. Construction was completed in 1982. Each floor has a common mechanical room, and the air distribution on each floor is isolated from other floors. Supply air is distributed to ceiling diffusers through flex ductwork leading from the main supply manifold. Return air (RA) is conveyed to the mechanical room by a common plenum above the false ceiling. There is no zone isolation for RA.

Dental Office

The dental office consists of a waiting room, 4 operatory rooms, an x-ray development darkroom, laboratory, breakroom, sterilization room, and two enclosed offices, one of which is used for patient consultation (Figure 1). In addition to the dentist, 2 full-time and 2 part-time dental hygienists, 2 receptionists, and 1 dental assistant work in this 1500 ft^2 suite. All operatory rooms are open and contiguous with the other areas. The suite has been occupied by the Kurtzman, DDS, dental firm since 1987. Activities conducted in the dental office include routine dental hygiene as well as more extensive dental work, administrative activities (record keeping, filing, etc.), preparatory work in the laboratory (preparing molds/casts, polishing, buffing, grinding), and x-ray development. A phenolic-based disinfectant is used for cleaning work surfaces in the operatories.

Nitrous Oxide Administration

Less than 10% of the patients at the Kurtzman, DDS, dental clinic use nitrous oxide (N_2O) as an anesthetic agent. N_2O is used infrequently by the dental hygienists, with each hygienist using the anesthetic gas approximately once a week. N_2O is delivered at 55 pounds per square inch (psi) pressure to three operatories (Operatory #4 is not equipped with N_2O) via copper piping from a cylinder located in the laboratory, and is administered to patients through 3/8" tubing connected to a nose-only mask. The N_2O system has been in use since 1987. The N_2O is mixed with oxygen just prior to delivery to the patient. In each operatory flow control is achieved by a dual rotameter (one for oxygen, one for N_2O). Each system is equipped with a breathing bag and a fail-safe device to shut off the N_2O if the oxygen flow is interrupted. Typical flow rates for a patient are 3 liters per minute (Lpm) N_2O, and 7 Lpm oxygen. Delivery flow rates may vary based on historical experience with a patient. The N_2O cylinder is only turned on when in use. Dental office personnel indicated that N_2O consumption averages approximately one standard cylinder every 4-5 weeks (approximately 140 cubic feet).

All three operatories are equipped with scavenging devices to control N_2O at the point of use. These scavenging devices consist of the "mask within a mask" design, with the exhaust tubing designed to ventilate the space between the two masks. The other end of the tubing is connected to the general suction system used for a variety of dental procedures. Suction is created by a compressor located in a closet in the center of the dental office. All suctioned materials are filtered and then flushed to the city sewer system. These scavengers, however, are not routinely used during the administration of N_2O, and there are no formal policies requiring their use.

The N_2O delivery system has been periodically leak checked in the past. However, procedures for routinely calibrating the flow control devices, and evaluating the effectiveness of the scavengers have not been developed. Dental office personnel indicated work practices with the N_2O system include not turning on the anesthetic gas until the nose mask is in place on the patient, and shutting off the N_2O (flowing pure oxygen) for 1-3 minutes prior to removing the mask.

Glutaraldehyde Use

Dental equipment is disinfected by passively soaking the instruments in a 2% glutaralde-hyde solution (ProCide®). The glutaraldehyde solutions are kept in 1-2 liter pans and/or beakers in the Sterilization room, X-ray room, and the Laboratory. Some, but not all, of the glutaraldehyde solution containers are covered. The solutions are changed every two weeks, and disposed of by aspirating the solution with the house suction system. This method of disinfection has been used for approximately 7 years. Employees wear gloves when pouring the solution into the disinfection containers.

EVALUATION PROCEDURES

The NIOSH investigation consisted of the following:

1. An inspection of the anesthetic gas delivery system, and a review of work practices, procedures, and protocols followed by dental office personnel regarding the use of N_2O.

2. Air sampling for N_2O and glutaraldehyde to assess personal exposures and area concentrations.

4. Evaluation of the exhaust ventilation system (scavenger) used to control N_2O concentrations during patient administration.

Environmental Monitoring

Nitrous Oxide

Air monitoring for N_2O was conducted using a Brüel and Kjaer (B & K) model 1302 multi-gas continuous monitor. The principle of detection is infrared absorption at a specific wavelength with subsequent analysis via the photoacoustic effect. The monitor records N_2O concentrations in parts per million (ppm) approximately every minute. In addition to monitoring in the continuous sampling mode, air sampling bags were used to collect samples. These bags were filled using a portable air sampling pump and subsequently analyzed with the B & K monitor. Personal samples were obtained by attaching the sample tube inlet of the B & K monitor to the collar of the individual being monitored. The sample tubing was of sufficient length to allow the person to move freely in his/her work area. When using the bag sampling technique, the inlet tube of the air sampling pump was attached to the collar of the individual being monitored to collect breathing zone samples.

Glutaraldehyde

Personal and area air samples for glutaraldehyde were collected using constant-volume SKC model 222 low-flow sampling pumps. Nominal flow rates of 75-200 cubic centimeters per minute (cc/min) were used to collect the samples. Sampling time ranged from 5 minutes to 1 hour. The pumps are equipped with a pump stroke counter and the number of strokes necessary to pull a known volume of air was determined during calibration. This information was used to calculate the air per pump-stroke "K" factor. The pump stroke count was recorded before and after sampling and the difference used to calculate the total volume of air sampled.

Treated silica gel sorbent tubes (SKC 226-119) were used as the collection medium, and analysis was conducted according to NIOSH 3rd. ed. method 2532.

Ventilation

A Gilian Gilibrator® with a 30 liter volumetric cell was used to measure flow rates of scavengers in each operatory. The Gilibrator® is an electronic bubble flowmeter that provides instantaneous air flow readings and a cumulative average of multiple readings. The time interval necessary for a soap bubble, stretched across a cell, to travel a known volume is calculated to determine the flowrate. The system is considered a primary standard airflow measurement device in that all values are absolute; a known and fixed volume divided by time provides the airflow.

EVALUATION CRITERIA

General

As a guide to the evaluation of hazards posed by workplace exposures, NIOSH field staff use established environmental criteria for the assessment of a number of chemical and physical agents. These criteria 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 should be noted, however, that not all workers will be protected from adverse health effects if their exposures are below the applicable limit. A small percentage may experience adverse health effects due to individual susceptibility, pre-existing medical conditions, and/or hypersensitivity (allergy).

Some hazardous substances or physical agents may act in combination with other work- place exposures or the general environment to produce health effects even if the occupational exposures are controlled at the applicable limit. Due to recognition of these factors, and as new information on toxic effects of an agent becomes available, these evaluation criteria may change.

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 (TLVs), and (3) the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) standards.[1-3] Often, NIOSH recommendations and ACGIH TLVs may be different than the corresponding OSHA standard. Both NIOSH recommendations and ACGIH TLVs are usually based on more recent information than OSHA standards due to the lengthy process involved with promulgating federal regulations. OSHA standards also may be required to consider the feasibility of controlling exposures in various industries where the hazardous agents are found; the NIOSH

Recommended Exposure Limits (RELs), by contrast, are based primarily on concerns relating to the prevention of occupational disease.

Nitrous Oxide

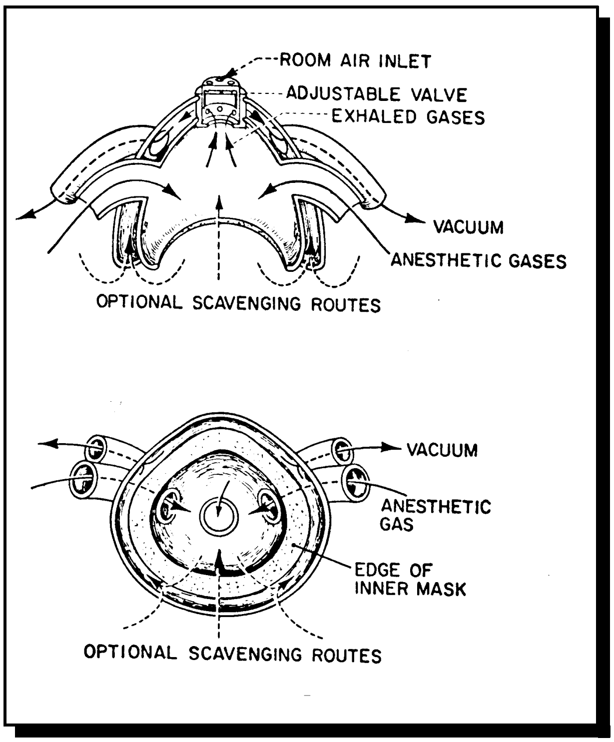
Nitrous oxide has been used as an anesthetic agent since 1844, and is often used in conjunction with other anesthetic gases.[2] However, with the development of more effective local anesthetics, N_2O is now used primarily to relieve anxiety in patients.[4] For many years, the only adverse health affects associated with exposure to N_2O have been those of asphyxiation when there was insufficient oxygen due to physical displacement by N_2O.[2,5] However, over the past 30 years, other specific toxic effects have been found in both animal and human studies. An early observation was that N_2O, when clinically used at very high concentrations (50% or 500,000 ppm) caused a generally reversible (within 4 days after discontinuing use) bone marrow depression.[6,7] Carcinogen studies with laboratory animals (mice) have not shown any increases in tumors.[2,5] Cancer studies of humans exposed to N_2O and other anesthetic gases have shown mixed results. Some suggest a small increase in the incidence of cancer in women, while others have reported a negative correlation.[2,5,8] Some laboratory studies have also shown adverse reproductive effects (smaller litter, increased incidence of fetal resorption and skeletal anomalies) among rats exposed to high (e.g., 1000 ppm or greater) N_2O concentrations during the early stages of pregnancy.[9] Human studies have reported a higher than expected incidence of spontaneous abortions among female workers directly exposed to N_2O and other anesthetic gases.[10] Other studies suggest the incidence of congenital abnormalities and spontaneous abortion is slightly higher in the offspring of wives of exposed dentists, as well as reduced fertility in women occupationally exposed.[11,12] Studies have shown that adverse neurologic effects (e.g. numbness, tingling, weakness, audiovisual performance decrements) appear to increase in persons occupationally exposed to N_2O, while other studies have not confirmed these findings.[13-16] It has also been suggested that mood factors (sleepiness, mental tiredness, etc.) may deteriorate following exposures to as low as 50 ppm.[16] In many of these human studies, exposure concentrations are poorly defined and dose-response relationships are difficult to identify.

Nitrous Oxide - Exposure Standards

The Occupational Safety and Health Administration (OSHA), the agency responsible for enforcing compliance with workplace safety regulations, has not established a standard for nitrous oxide. NIOSH has established a REL of 25 ppm averaged over the duration of anesthetic administration. The NIOSH REL is based on a report of decrements in audiovisual tasks following exposure at 50 ppm.[8] The ACGIH has recommended an 8-hour time-weighted average threshold limit value (TLV-TWA) of 50 ppm.[2] The ACGIH TLV-TWA is based on prevention of embryofetal toxicity (spontaneous abortion) in humans and significant decrements in human cognitive functions.

Nitrous Oxide - Control Measures

Nitrous oxide is not metabolized and, following absorption, is rapidly eliminated unchanged from the body through the lungs.[17] As such, dental office personal may be exposed to N_2O that has either escaped from the delivery system or exhaled by the patient. A wide range of N_2O exposure concentrations in dental operatories have been reported ($\leq$ 25 ppm - 6700 ppm).[8,18-20] Factors influencing ambient N_2O levels include work practices, type of procedure, anesthetic gas flow rates, type of delivery system, general room ventilation, and the presence or absence of controls. Although specific measures for reducing exposure to N_2O have been developed, studies in dental operatories conducted by NIOSH and others have generally found that existing control technologies do not consistently reduce N_2O concentrations to the NIOSH REL.[19,20]



COMMON NASAL MASK WITH SCAVENGER

Measures for controlling exposures to N_2O in dental operatories include effective scavenging devices, proper anesthetic gas delivery equipment, maintenance and routine leak checks of the N_2O delivery system, and good work practices by dentists and assistants. Scavenging systems to control N_2O at the point of use is the preferred method. A common scavenging system design is the "mask within a mask" unit, with tubes supplying oxygen and N_2O to the inside of the interior mask, and two tubes ventilating the space between the two masks (where the patient exhales). The recommended flow rate for this type of system, shown in the following figure, is 45 liters per minute (Lpm).[8] These types of scavenging systems, while shown to be effective in reducing anesthetic gas exposure, do not consistently reduce N_2O to concentrations to below the NIOSH REL of 25 ppm.[20] Providing additional auxiliary ventilation has shown mixed results.[19] Once ventilated, the collected anesthetic gas must be properly vented to a point away from personnel. Non-recirculating air-conditioning systems, the central office suction system, and a separate duct system have successfully been used to accomplish this.[8] Complete descriptions of scavenging systems, proper maintenance protocols, and work practices are detailed in the NIOSH Criteria Document on Waste Anesthetic Gases.[8]

Glutaraldehyde

Glutaraldehyde is used as a cold sterilant in hospitals and dental offices. It is used in pulmonary physiology units, at nurses' stations, and research laboratories to clean sputum mouthpieces, suction bottles, tubing, and other equipment.[21] Although glutaraldehyde is available in 50%, 25%, 10%, and 2% solutions, most health care facilities use 2% glutaraldehyde solutions buffered to pH 7.5 - 8.5. Glutaraldehyde solutions also contain surfactant to promote wetting and rinsing of surfaces, sodium nitrite to inhibit corrosion, peppermint oil as an odorant, and FD&C yellow and blue dyes to indicate activation of the solution.[21] One disadvantage of buffered glutaraldehyde solutions is that they are stable for less than 2 weeks, so solutions must be dated and made as needed.[22] Another disadvantage is that at 20° C (68° F), a 50% solution of glutaraldehyde has a vapor pressure of 0.015 mm Hg[23] and can generate an atmosphere that contains as much as 20 ppm glutaraldehyde. This concentration is well above that shown to cause adverse health effects in animals and humans.

Glutaraldehyde may be absorbed into the body by inhalation, ingestion, and skin contact. Extensive skin contact may cause allergic eczema and may also affect the nervous system. Glutaraldehyde has an odor threshold of about 0.04 ppm, is highly toxic, and is irritating to the skin and mucous membranes at concentrations of 0.3 ppm.[2] A NIOSH investigation determined that airborne glutaraldehyde concentrations of 0.4 ppm were responsible for symptoms of irritation in 9 of 11 (82%) exposed workers. Eye, throat, and lung irritation were reported among 45% of the workers. Other symptoms including cough, chest tightness, headache, skin irritation, and asthma symptoms, were also reported.[21]

In a study published by the National Toxicology Program (NTP) in 1993, groups of five rats and five mice of each sex were exposed to glutaraldehyde by whole-body inhalation at concentrations of 0, 0.16, 0.5, 1.6, 5, and 16 ppm for 6 hours per day, 5 days per week, for 2 weeks. All rats and mice exposed to 5 or 16 ppm glutaraldehyde died before the end of the studies; all mice exposed to 1.6 ppm also died. Deaths were attributed to severe respiratory distress. Mice appeared to be more sensitive than rats because the small airways of the nasal passage of mice were more easily blocked by cell debris and keratin. Lesions noted in the nasal passage and larynx of rats and mice included necrosis, inflammation, and squamous metaplasia. The no-observed-adverse-effect level (NOAEL) was 0.125 ppm for respiratory lesions in rats. A NOAEL was not reached for mice, as inflammation was found in the anterior nasal passage at concentrations as low as 0.0625 ppm.[23] The NIOSH REL and ACGIH TLV for glutaraldehyde is 0.2 ppm as a ceiling limit.[1,2] The ceiling limit designation indicates a concentration that should not be exceeded during any part of the workday.

Glutaraldehyde exposure has also been associated with fetotoxicity in mice, DNA damage in chickens and hamsters, and mutagenicity in microorganisms.[24]

RESULTS AND DISCUSSION

Monitoring Results: Nitrous Oxide

During the day monitored, N_2O was in use for 1 hour, which was considered normal. N_2O was used primarily by the dentist, although the dental hygienist and assistants were also exposed.

A summary of the air sampling results are shown in Table 1, and are graphically presented in Figures 2-3. As shown in Table 1 and Figure 2, during the root canal procedure monitored in Operatory # 1, both the dentist and dental assistant were exposed to N_2O concentrations significantly higher than the REL for the duration of anesthetic gas administration. Although the range varied considerably (221 ppm - 3860 ppm), the average exposure experienced by the dentist performing the root canal was 900 ppm, while the dental assistant was exposed to an average of 246 ppm. No range of exposure was available for the dental assistant, as the sample was collected in a sampling bag over the duration of anesthetic gas administration. The N_2O scavenging system was not used during this procedure.

N_2O concentrations in the general office area ranged from 7.5 - 97 ppm after the N_2O cylinder had been turned on and dispensed. Prior to dispensing the anesthetic gas, general office area concentrations ranged from 0.5 - 7 ppm.

Table 1
Air Sampling Summary: Nitrous Oxide Concentrations
Kurtzman, DDS: Building 1100, June 30, 1994
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Sampling location	Concentration Detected (ppm), 6/30/94	
	Range	Average
Dentist Administering nitrous oxide to patient	221 - 3860	900
Dental Office - general area (after N_2O had been dispensed	7.5 - 97	12.2
Dental Office - general area prior to dispensing N_2O	0.5 - 7	
Dental Assistant during root canal procedure	216-264	246
Second Floor Lobby adjacent elevator	11 - 48	NA
NIOSH REL (averaged over the duration of anesthetic administration) = 25 ppm		

NOTE: ppm = parts of gas per million parts of air
N/A = not applicable, only instantaneous samples were collected.

Measurements outside the dental office indicated N_2O was spreading throughout the second floor. A concentration of 11 ppm was detected in a bag sample collected at 9:30 a.m. on June 30 in the second floor elevator lobby. An average N_2O concentration of 48 ppm was detected in the same area at 10:30 a.m. (approximately 30 minutes after N_2O had ceased being administered). This sampling was conducted after N_2O had been used for approximately one hour in the dental office. This was expected given the common return air system on this floor.

The monitoring also indicated the N_2O delivery system was leaking; most likely at the valves, fittings and quick-connects in each operatory. Monitoring in the dental office, conducted in the morning prior to turning on the N_2O cylinder, showed an average level of 0.5 ppm, However, after turning on the N_2O cylinder, but prior to administering the gas to a patient, the concentrations of N_2O in the general dental office area increased to approximately 6.5 ppm within 8 minutes (Figure 3).

<u>Glutaraldehyde</u>

The results of the glutaraldehyde sampling are depicted in Table 2. As noted in the table, glutaraldehyde was detected in two area samples (Sterilization room, x-ray room). Although the concentrations detected in these area samples were below the NIOSH REL of 0.2 ppm as a ceiling limit, the results are not directly applicable for comparison with a ceiling limit REL as the samples were collected over a 60 - 80 minute time period. No detectable glutaraldehyde was found on short-term personal breathing zone samples collected from employees dispensing and replenishing glutaraldehyde solutions.

Table 2
Air Sampling Results: Glutaraldehyde Concentrations
Kurtzman, DDS: Building 1100, June 30, 1994
HETA 94-0227

Sample Description	Time (min)	Concentration Detected (ppm)
Area Sample: Sterilization Room, above sink	08:49-09:55 (66)	0.02
Area Sample: X-Ray Room, on counter	08:51-10:07 (76)	(0.008)
Area Sample: Lab, on counter	08:54-10:12 (78)	<0.01
Personal Sample: Disposing/replenishing glutaraldehyde solution in Lab.	13:32-13:37 (5)	<0.14
Personal Sample: Disposing/replenishing glutaraldehyde solution in Lab.	13:24-13:28 (4)	<0.08
Personal Sample: Disposing/replenishing glutaraldehyde solution in Lab	13:30-13:36 (6)	<0.06

NOTES: ppm = parts of gas or vapor per million parts of air
< = less than
( ) = values in parentheses indicate the concentration was between the analytical level of detection and the level of quantification.

Scavenger Ventilation Assessment

The flowrate of the scavengers in the three operatories was measured by removing one of the exhaust tubes from the nose mask and connecting this tube to the Gilibrator® electronic bubble meter. With the other exhaust tube still connected to the mask, multiple readings were obtained and averaged. This was repeated for the other exhaust tube and the two measurements combined to derive the total scavenger flow rate. The results of this assessment are shown in Table 3:

Table 3
Scavenger Flow Rates
Kurtzman, DDS: Building 1100, June 30, 1994
HETA 94-0227

Operatory	Flow Rate Side 1	Flow Rate Side 2	Flow Rate Total
#1	20.2 Lpm	21.0 Lpm	41.2 Lpm
#2	Not Functional	Not Functional	NA
#3	22.6 Lpm	23.3 Lpm	45.9 Lpm

As shown in the above table, flow rates on the scavengers in operatories #1 and #3 were near the recommended 45 Lpm for nose-mask scavenging systems. The scavenging system in operatory #2 was not operational.

CONCLUSIONS

All personal breathing zone exposures to N_2O exceeded the NIOSH REL of 25 ppm for the procedure monitored. Monitoring in a common area of the second floor of building 1100 also found N_2O levels that exceeded the NIOSH REL, although they were much lower than the levels found inside the dental office. Specific concentrations to which office personnel outside the dental office were exposed could not be determined and will vary based on the extent of N_2O usage and the length of time spent inside the office. Offices located on other floors would be expected to have negligible levels since they have separate air handling systems.

The primary contributors to the high N_2O concentrations in the dental office included insufficient use of proper controls for collecting waste N_2O and leaks in the delivery system. Exfiltration to other offices is due to the common return air system.

As noted, currently available control technology has not been found to consistently reduce N_2O exposures to below 25 ppm during the period of anesthetic gas administration. Additionally, as long as N_2O is used in this dental office with the existing ventilation system design, exfiltration of waste N_2O to other areas outside the dental office will continue to occur. However, minimizing the use of N_2O whenever possible, correcting all system leaks, and ensuring the existing scavenging systems are properly used whenever N_2O is administered will help reduce exposure.

Airborne glutaraldehyde concentrations were found to be below the NIOSH REL, or the analytical limit of detection, on all samples collected. As the solution contains 2% glutaraldehyde, and is used to passively soak instruments at room temperature, these results were expected. From the standpoint of good industrial hygiene practice, however, the glutaraldehyde solution containers should be covered when not actually disposing of or replenishing solution, and the containers should be labeled.

RECOMMENDATIONS

1. Limit the use of N_2O as much as possible. Investigate and utilize alternatives where possible. When using N_2O, be as conservative as possible (e.g., use minimum flow rates and decrease actual usage time).

2. All aspirated air from the scavenging units should be vented directly outside. One option may be to place the compressor outside the building, route the compressor exhaust outside, or enclose and ventilate the compressor cabinet.

3. Work with building management and qualified ventilation engineers to investigate alternative ventilation for the dental office. This may include providing additional local exhaust ventilation for each operatory. Ideally, the dental office ventilation should be isolated from the rest of the building (e.g., single-pass system).

4. Conduct a comprehensive leak check of the N_2O delivery system and repair all leak points. Implement a preventive maintenance program that includes reviewing the N_2O delivery system and conducting periodic leak checks. Every time a cylinder is changed, the connections should be checked for leaks. This can be accomplished by applying a soap solution to the fittings and observing for bubbles, which would indicate the presence of a leak. Periodic monitoring of ambient N_2O levels should also be conducted (quarterly for the first year and annually thereafter). Monitoring data should also be obtained whenever the N_2O delivery system is modified to ensure exposures are maintained below the NIOSH REL.

5. Repair the scavenger in Operatory #2 and ensure it is operating properly. Work practice controls should include inspecting the N_2O delivery system each time prior to use and insuring the scavenger exhaust is operating properly. Masks should be carefully fitted on the patient to reduce leakage. Continue with the practice of not flowing N_2O until the mask is placed on the patient, and flushing with oxygen prior to removal. Ensure all personnel who administer N_2O are trained on the correct work practices to follow to reduce N_2O concentrations.

7. Ensure all glutaraldehyde containers are labeled with the name of the contents and appropriate hazard warnings. The containers should be kept covered when not actually placing equipment in them or replenishing the solution.

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AUTHORSHIP AND ACKNOWLEDGMENTS

Evaluation Conducted and Report Prepared By:	Max Kiefer, MS, CIH Regional Industrial Hygienist
Originating Office:	NIOSH Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies NIOSH Cincinnati, Ohio
Laboratory Support	Staff Measurements Research Support Branch, NIOSH Cincinnati, Ohio

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