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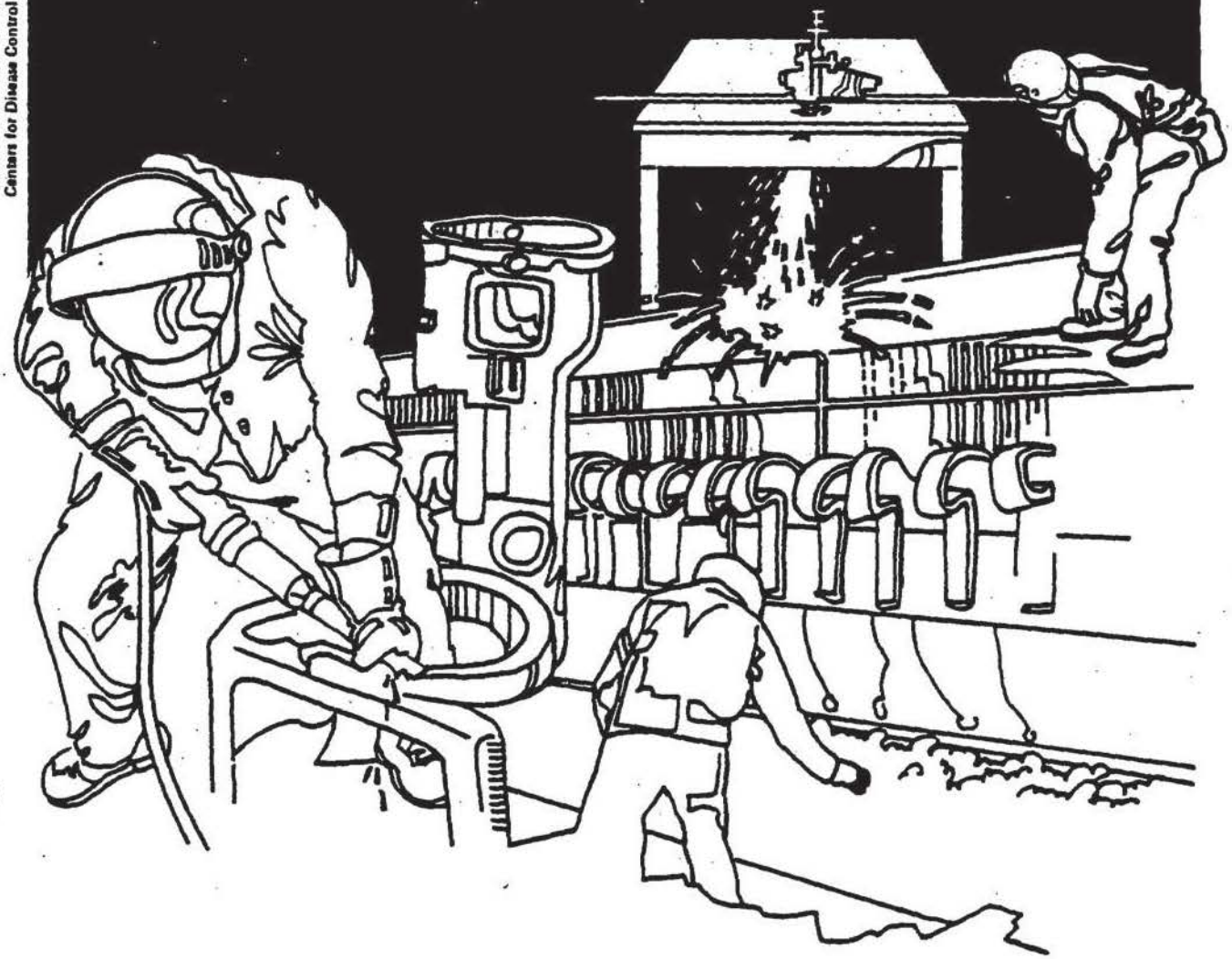

Health Hazard Evaluation Report

HETA 84-412-1612
DRS. YOUDELMAN AND TEIG
BRENTWOOD, 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.

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I. SUMMARY

On June 25, 1984, the National Institute for Occupational Safety and Health (NIOSH) was requested by Dr. Stanley A. Youdelman and Dr. Joel S. Teig to evaluate the extent of nitrous oxide exposure at their two oral surgery clinics in Holbrook, and Brentwood, New York. Their Brentwood clinic was equipped with a waste anesthetic scavenging system, while their Holbrook clinic was not.

NIOSH investigators conducted site visits on July 30, 1984 at the Holbrook office, and on July 31, 1984 at the Brentwood office. Air samples were collected in Mylar® bags, for subsequent analysis on site using a portable Miran 103® infrared analyzer, to determine the extent of exposure to nitrous oxide.

The dentist's exposure during the period of administration (6 minutes) at the Holbrook office, where no waste anesthetic scavenging system was in use, averaged 2400 parts per million (ppm). This greatly exceeded the 50 ppm which NIOSH has found to be achievable during routine dental anesthesia using engineering controls and good work practices. There is no OSHA standard for exposure to nitrous oxide.

The dentist's breathing zone exposure at the Brentwood office, where a scavenging system was in place, averaged 830 ppm for a 5-minute period of administration. Concentrations of 90 ppm were measured in 5-hour area air samples collected in other areas within the clinic.

The very high exposures at both oral surgery clinics during the periods of administration constitute a health hazard. Recommendations are made to stop using nitrous oxide at the Holbrook clinic unless engineering controls are implemented. Recommendations are made in Section VII which will help to achieve good control of exposures through proper use of equipment and good work practices at the Brentwood clinic.

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

II. INTRODUCTION

On June 25, 1984, NIOSH received a request from Dr. Youdelman to evaluate nitrous oxide exposure at two dental offices, one in Holbrook, and the other in Brentwood, New York. The request was submitted because of a general concern regarding the extent of exposure to this anesthetic. The Brentwood office was equipped with a scavenging system and the Holbrook office was not. Evaluations were conducted on July 30 (Holbrook), and July 31 (Brentwood), 1984. Results and recommendations were forwarded to Dr. Youdelman, in a letter, on September 17, 1984.

III. BACKGROUND

Doctors Stanley A. Youdelman and Joel S. Teig operate an oral and maxillo-facial surgery practice at two locations on Long Island, New York. Their Holbrook clinic is staffed with a receptionist and a chairside assistant. The larger Brentwood clinic has two receptionists and 3 to 4 technician/assistants.

Nitrous oxide is not normally used at either location on a daily basis, and when used may be administered alone or mixed with the anesthetic Fluorane®. Intravenously administered general anesthetics are frequently used.

Nitrous oxide is delivered to a mixing unit at chairside via a high pressure line from the cylinder storage area. The mixing unit allows the nitrous oxide to be mixed with oxygen and sent to a nasal mask which is placed on the patient. Flow rates are set at a minimum level to maintain the desired effect. At some point during or after the dental procedure, the nitrous oxide is turned off allowing only oxygen to flow to the mask to help clear the nitrous oxide from the patient's system.

Both offices were heated and cooled using centralized forced air, recirculating heating and air-conditioning systems.

IV. METHODS

In order to estimate nitrous oxide exposure, air samples were collected during the period of administration of the anesthetic gas and for the entire shift. The sampling method consisted of collecting composite air samples in 22 liter mylar bags for subsequent infrared analysis using a portable Miran 103®. This instrument was also used as a direct-reading field survey meter to evaluate the nitrous oxide delivery system for the presence of leaks. Pre- and post-survey instrument calibration was achieved by injecting known quantities of nitrous oxide gas (100%) into a closed-loop calibration system. Serial injections produced increasing concentrations in the closed-loop system thereby allowing instrument calibration encompassing the range of exposures expected and/or found during the field survey.

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 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.

B. Toxicological - Anesthetic Gases (including nitrous oxide)

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. In 1974, the American Society of Anesthesiologists (ASA) published the results of a study[3] indicating 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 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 in 1976[4], "nitrous oxide (N_2O) 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[5,6].

Mortality and other epidemiologic 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.[7] compared exposed persons who used inhalation anesthetic more than 3 hours per week with a control group 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[8] 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 employed a halogenated agent. If the actual fraction is less than 1 in 10, the conclusion has added strength.

In a document recommending a standard for occupational exposure to waste anesthetic gas, NIOSH[5] 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 reducing waste anesthetic gas levels in these environments.

In a recent study, Cohen et al.[9] 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. Cohen concluded that nitrous oxide, commonly known as "laughing gas", has always been considered to be inert and nontoxic. However, this study indicated that "significant health problems appear to be associated with the use of nitrous oxide alone".

Although OSHA presently does not have a permissible exposure level for anesthetic gas such as nitrous oxide, NIOSH recommends that exposures be maintained below 50 ppm in dental offices.[8] This level is believed to be achievable with current engineering control systems and good work practices.

VI. RESULTS AND DISCUSSION

A. Holbrook Office (no scavenging system)

The nitrous oxide concentrations measured at the Holbrook office are presented in Table 1. Nitrous oxide was used on only one patient. A sketch of the office area is in Figure 1. During the six-minute period of administration, the dentist was exposed to 2400 ppm nitrous oxide. This far exceeds the NIOSH recommended criteria of 50 ppm, but is not an uncommon exposure where scavenging systems are not in use. Area samples collected during the procedure showed concentrations near 300 ppm in the operatory, and from 70 to 85 ppm in other areas of the office. The nitrous oxide was either quickly distributed throughout the office by the recirculating air handling system, or there was a leak in the nitrous oxide delivery system. A leak was not detected. However the tubing on the low pressure side of the system was badly cracked. It was possible that other parts of the system were in need of repair.

B. Brentwood Office

A Fraser-Harlake® nitrous oxide scavenging system is installed in room #2 (brown) of the Brentwood clinic. The nitrous oxide/oxygen mixture is delivered to the inner compartment of a double-walled nasal mask via two hoses from the mixing unit. When the patient breathes in, the anesthetic gas is inhaled through the nose. The expired air travels through an exhalation valve that connects the inner chamber of the mask to a space between the double wall which is under negative pressure. The waste anesthetic gas is scavenged through the chair vacuum system.

The nitrous oxide air concentrations measured at this office are presented in Table 2. Figure 2 presents a sketch of the dental suite and indicates approximately where the samples were obtained.

The procedure monitored (in room #2) required a 5-minute period of administration of anesthetic gas. The dentist received a breathing zone exposure of 830 ppm nitrous oxide during this period. Area air samples in the room showed concentrations of 270 ppm near the mixing unit, and 65 ppm across the room. These values exceeded the 50 ppm NIOSH criteria. Area samples collected over a 5-hour period indicated a 90 ppm concentration of nitrous oxide throughout the offices. A nitrous oxide leak was discovered where the high pressure hose connects to the delivery system wall fitting in room #1 (blue room). This accounts for the high background concentrations.

Even though the dentist's nitrous oxide exposure concentration was 3 times less than at the Holbrook office, it was higher than would be expected with a scavenging system in use.

VII. RECOMMENDATIONS

At both the Holbrook and the Brentwood offices the nitrous oxide delivery and mixing systems should be checked for leaks at least monthly. The high pressure side (tank to mixing unit) and the low pressure side (mixing unit to nasal mask) can be checked using a soap solution. High pressure leaks can also be detected by keeping a log of the line pressure when the nitrous oxide tank is turned off at night and of the pressure the next morning. A drop of more than 10% indicates a leak which should be found via the soap solution technique and corrected.

A. Holbrook Office

Even though the use of nitrous oxide may be infrequent, it is recommended that a scavenging system with a dedicated exhaust be installed at this office.

B. Brentwood Office

Other than system leaks, there are two major factors that contribute to excessive nitrous oxide exposure. These are:

1. Work Practices

The scavenging system does not efficiently capture the nitrous oxide flowing to the mask if the mask is not placed properly on the patient. The following sequence of actions will minimize the escape of nitrous oxide from the mask.

Nitrous Oxide Start Up Procedures

Start oxygen flow
Place nasal mask on patient
Activate vacuum system to mask
Start nitrous oxide flow

Nitrous Oxide Shut Down Procedures

Turn off nitrous oxide flow at mixing unit
Maintain vacuum flow until oxygen is shut off
Remove mask and shut off vacuum

2. Mouth Breathing

Instruct the patient to breath through the nose and minimize talking for full effect of the anesthetic.

VIII. REFERENCES

1. Vaisman AI. Working conditions in surgery and their effect on the health of anesthesiologists. Eksp Khir Anesteziol 1967;3:44-9.

2. Askrog V, Harvald B. Teratogen effect of inhalations-anestetika. Nord Med 1970;83:498-504.

3. Cohen EN, Brown BW, Bruce DL, Cascorbi HF, Corbett TH, Jones TW, Whitcher C. Occupational disease among operating room personnel: a national study. Anesthesiology 1974;41:321-40.

4. National Institute for Occupational Safety and Health. Effects of trace concentrations of anesthetic gases on behavioral performance of operating room personnel. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1976. (DHEW publication no. (NIOSH) 76-179).

5. National Institute for Occupational Safety and Health. Criteria for a recommended standard--occupational exposure to waste anesthetic gases and vapors. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-140).

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

7. Cohen EN, Brown BW, Bruce DL, Cascorbi HF, Corbett TH, Jones TW, Whitcher C. A survey of anesthetic health hazards among dentists: report of an american society of anesthesiologists ad hoc committee on the effect of trace anesthetics on the health of operating room personnel. JADA 1975;90:1291.

8. National Institute for Occupational Safety and Health. Control of occupational exposure to N_2O in the dental operatory. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-171).

9. Cohen EN, Brown BW, Wu ML, et al. Occupational disease in dentistry and chronic exposure to trace anesthetic gases. JADA 1980;101:21--31.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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1. Drs. Youdelman and Teig
2. NIOSH, Region II
3. OSHA, 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 Measurements

Holbrook, New York Office
HETA 84-412

July 30, 1984

Sample Location[1]	Sample Type[2]	Sampling Time	Concentration ppm
Operatory, dentist	BZ	1636-1639	2400
Operatory, near mixing unit	A	1636-1642	315
Operatory, away from mixing unit	A	1636-1646	260
Corridor, between operatory and reception	A	1636-1641	70
Reception	A	1636-1642	85
Criteria: NIOSH (during period of administration)			<50

1. Refer to Figure 1
2. A = Area; BZ = Breathing Zone

Table 2

Nitrous Oxide Measurements

Brentwood, New York Office
HETA 84-412

July 31, 1984

Sample Location[1]	Sample Type[2]	Sampling Time	Concentration ppm
Room #2, dentist	BZ	1019-1024	830
Room #2, near mixing unit	A	1019-1024	270
Room #2, away from mixing unit	A	1019-1024	65
Reception	A	1005-1441	90
Sterile/preparation	A	1003-1440	90
Room #1 (blue)	A	0950-1000	90
Room #2 (brown)	A	0950-1000	30
Room #3 (yellow)	A	0950-1000	30
Reception	A	0950-1000	30
Room #1	A	1345-1355	150
Room #2	A	1345-1355	90
Room #3	A	1345-1355	90
Reception	A	1345-1355	90
Sterile/preparation	A	1345-1355	90
Criteria: NIOSH (during period of administration)			<50

1. Refer to Figure 2
2. A = Area; BZ = Breathing Zone

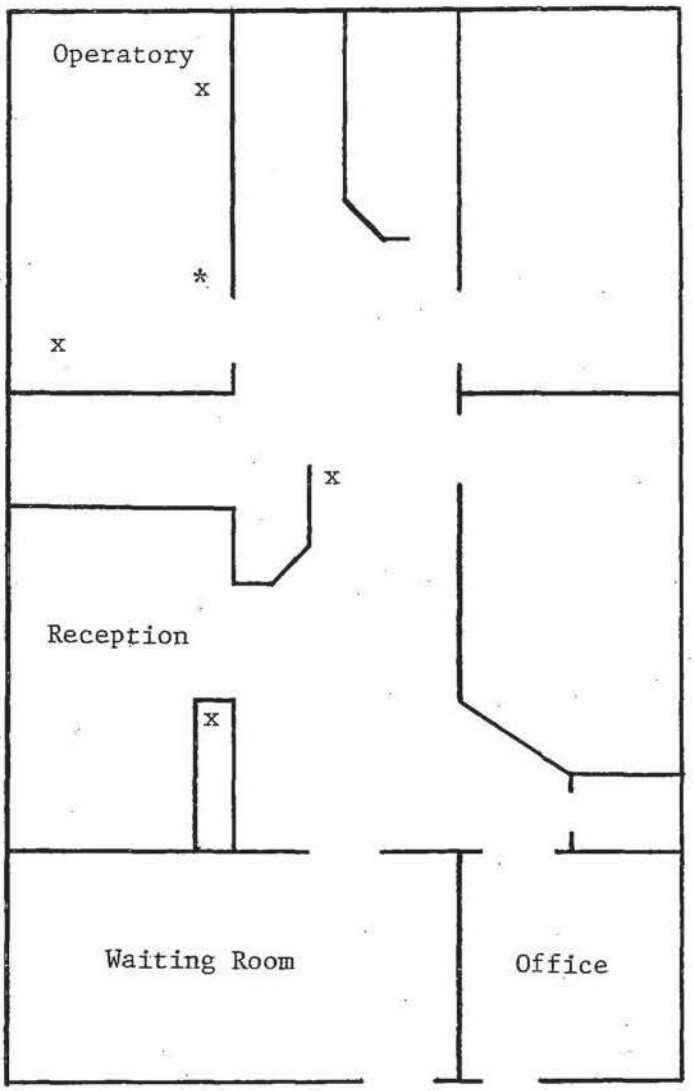

Figure 1. Floor Plan, Holbrook Office

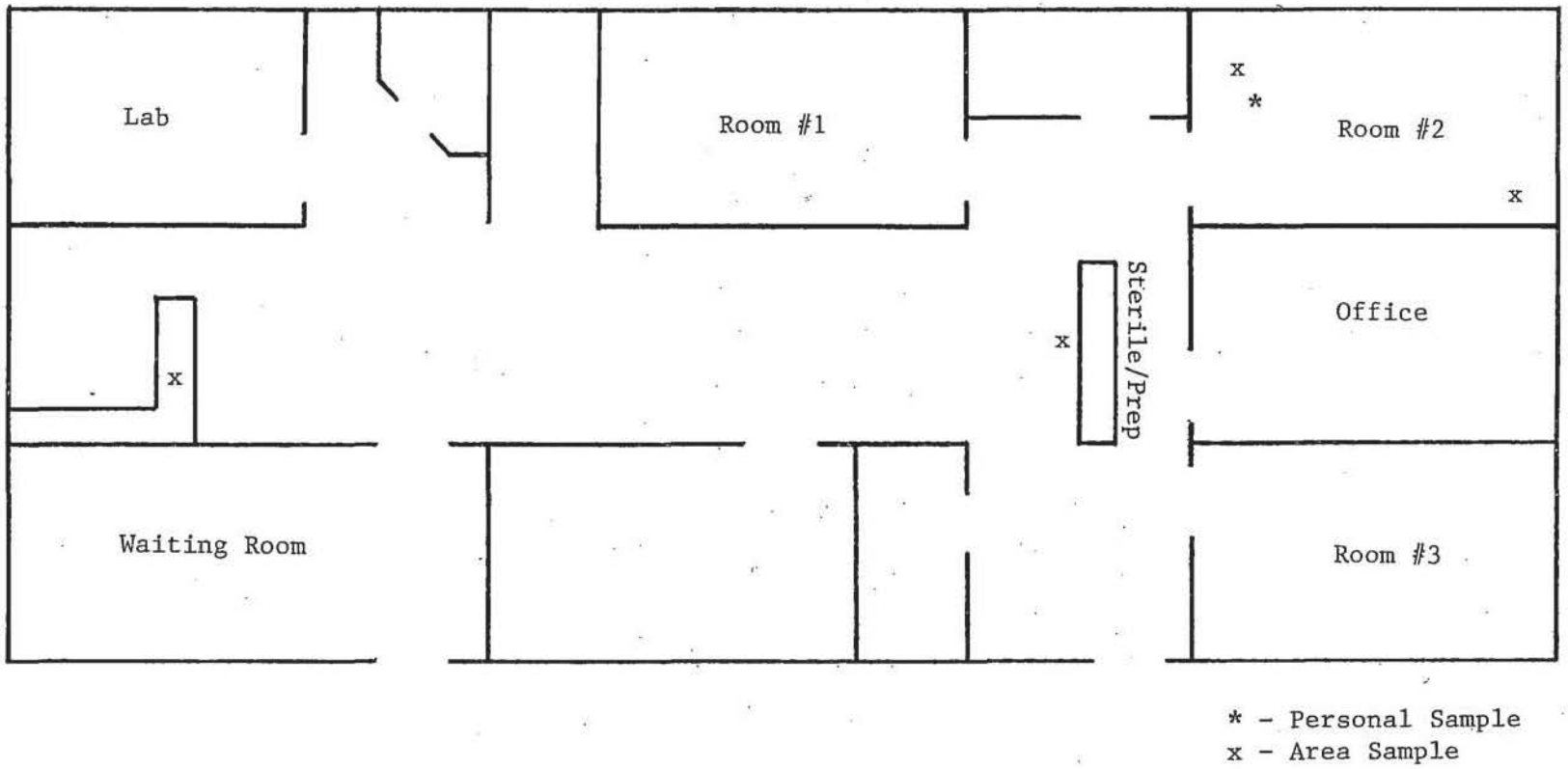

Figure 2. Floor Plan, Brentwood Office