HAZARD EVALUATION AND TECHNICAL ASSISTANCE REPORT
HETA 89-342-L2024
SOUTHWESTERN INDIAN POLYTECHNIC INSTITUTE CLINIC
ALBUQUERQUE, NEW MEXICO
MARCH 1990

Hazard Evaluations and Technical Assistance Branch
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I. INTRODUCTION

On August 11, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Chief of the Dental Program at the Albuquerque Service Unit of the Indian Health Service to investigate a problem at the dental clinic located at the Southwestern Indian Polytechnic Institute (SIPI) in Albuquerque, New Mexico. The requestor was concerned about employee health within the clinic where frequent employee complaints of headaches, mucous membrane irritation and mild nausea had been reported. Extensive investigation into the problem had already been undertaken by an industrial hygienist in the Albuquerque Service Area. On September 12-13, 1989, a NIOSH investigator conducted an initial and environmental survey at the building. During this survey, background information on the nature of the request was obtained, reports of previous environmental investigations were reviewed, a walk-through survey of the building was conducted, and environmental samples were collected in the building.

II. BACKGROUND

The SIPI dental clinic is a combination teaching clinic and care provider for the indians in the Institute and the surrounding area. The clinic functions include general dentistry, prosthetics, orthodontics, and ambulatory care. The clinic is a single story concrete masonry structure which was built in 1971. Figure 1 shows the layout of the clinic and the distribution of the staff.

Between March and May of 1989, three individuals working in the dental records section began complaining of increased discomfort while working in this area. The symptoms leading to this discomfort were later described as including headaches, mucous membrane irritation, and mild nausea. A number of actions were taken over the next few months including a thorough inspection of the heating, ventilating and air conditioning (HVAC) system, increasing outside air exchange, removal of the records personnel to other areas of the building, environmental monitoring of contaminants in the building, numerous adjustments to the HVAC system, complete inventory check of all materials used in the clinic (especially the lab), ventilation corrections to hoods in the lab, and numerous inspections by a variety of parties.

III. MATERIALS AND METHODS

The NIOSH evaluation consisted of: (1) an examination of the building's HVAC system; (2) an examination of the building for identifiable contaminant sources; (3) interviews with representatives from the building management and the employees in the building; (4) and an environmental survey designed to assess the building's air quality. The specific measurements and types of samples collected in the environmental survey are detailed in the following list.

A) Instantaneous measurements of carbon dioxide (CO_2) concentrations were made at several different times and locations throughout the building and outdoors. These measurements were made using a GasTech (Model RI 411) portable direct-reading CO_2 analyzer capable of measuring CO_2 concentrations from 50 to 5000 parts per million (ppm). The instrument was calibrated before use and checked against the outdoor levels at various intervals throughout the workday.

B) Measurements of dry bulb and aspirated wet bulb temperatures were made at several different times and locations throughout the building and outdoors using Bendix Model 566 Psychrometers. This data was used to determine relative humidity using a psychometric chart.

E) Concentrations of carbon monoxide and formaldehyde were measured using the following Draeger direct-reading colorimetric indicator tubes: carbon monoxide (5/c) and formaldehyde (0.2/a). These samples were collected using a Draeger hand pump according to the manufacturer's instructions.

F) An air sample was also collected for qualitative identification of general organics, sometimes referred to as volatile organic compounds (VOCs). The sample was collected in the medical record room where the most problems had been reported. This sample was obtained using a battery-powered sampling pump operating at 1.3 liters of air per minute (L/min). The sample was analyzed by gas chromatography/mass spectrometry for identifiable organics.

IV. EVALUATION 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 preexisting 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, such contact may increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of air contamination criteria generally consulted include: (1) NIOSH Criteria Documents and Recommended Exposure Limits (RELs); (2) the American Conference of Governmental Industrial Hygienist's (ACGIH) Threshold Limit Values (TLVs); (3) the U.S. Department of Labor (OSHA) federal occupational health standards; and (4) the indoor air quality standards included in the recommendations of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). The first three sources provide environmental limits based on airborne concentrations of substances to which workers may be occupationally exposed in the workplace environment for 8 to 10 hours per day, 40 hours per week for a working lifetime without adverse health effects. The ASHRAE guidelines specify recommended outside air ventilation rates needed to maintain acceptable indoor air quality for the majority (at least 80%) of a building's occupants.

Indoor air should not contain concentrations of contaminants sufficient to impair health, or to cause discomfort to a majority of the occupants. For application to the general population, lower evaluation criteria than those used in industry are generally applied. In the absence of a specific recommended level for a contaminant, it is recommended that the concentrations of these contaminants not exceed one-tenth of the limits which are used in industry. The rationale for this approach is that the general population is more varied than the industrial population in susceptibility to injury due to greater variation in age and health status. In addition, the industrial population is often under greater health supervision than the general population. The application of the one-tenth criteria may not be suitable in all cases.

The industrial criteria for the substances evaluated in this survey are presented in Table 1. 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 (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures. A discussion of the substances evaluated in this survey and the ASHRAE comfort and ventilation guidelines is presented below.

A. Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath, and, if monitored in the indoor air, can often be used as a screening technique to evaluate whether adequate quantities of fresh outdoor air are being introduced into a building or work area. The outdoor, ambient concentration of CO_2 is about 350 ppm. Typically the CO_2 level is higher inside than outside (even in buildings with few complaints about indoor air quality). However, if indoor CO_2 concentrations are more than 1000 ppm (3 to 4 times the outside level), the building may be receiving inadequate outside air, or the air may be poorly distributed by the HVAC system. Under these conditions, complaints such as headache, fatigue, eye and throat irritation may frequently be reported. Although the CO_2 is not responsible for these complaints, a high level of CO_2 does indicate that other contaminants in the building may also be increased and could be responsible for symptoms among building occupants.[1]

B. Aldehydes

Formaldehyde and other aldehydes may be released from a variety of common materials including; foam plastics, carbonless paper, particle board, plywood and textile fabrics. The fact that formaldehdye is found in so many home products, appliances, furnishings, and construction materials has prompted several agencies to set standards or guidelines for residential formaldehyde exposure. Symptoms of exposure to low concentrations of formaldehyde include irritation of the eyes, throat, and nose; headaches; nausea; congestion; asthma; and skin rashes. It is difficult to ascribe specific health effects to specific concentrations of formaldehyde to which people are exposed, because they vary in their subjective responses and complaints. Irritative symptoms may occur in people exposed to formaldehyde at concentrations as low as 0.1 ppm, but more frequently in exposures of 1.0 ppm and greater. Some sensitive children or elderly, those with preexisting allergies or respiratory diseases, and persons who have become sensitized from prior exposure may have symptoms from exposure to concentrations of formaldehyde between 0.05 and 0.10 ppm. Formaldehyde-induced asthma and bronchial hyperreactivity developed specifically to formaldehyde are uncommon.[2] Recent animal studies have prompted a concern with the potential carcinogenicity of this substance.[3]

C. Volatile Organic Compounds

Volatile organic compounds (VOCs) found in indoor air are aromatic and aliphatic compounds which are emitted from certain building materials, consumer products, and processes such as cleaning and smoking. In a recent study of four buildings conducted by the Environmental Protection Agency, at least 500 volatile organic compounds were identified.[4] While the concentrations of these compounds is generally low in respect to their occupational exposure criteria, the levels can be elevated several times above levels in outdoor air. Little information is available regarding the health effects of the combined exposure to low levels of these compounds. There are no official guidelines or exposure limits for VOCs in office environments. A draft guideline developed by the Indoor Air Quality Committee of the American Industrial Hygiene Association has suggested an indoor limit of 5 milligrams per cubic meter of air (5 mg/m^3). This recommendation is based mostly on a study by Molhave[5] which found that subjects exposed in a test chamber to a complex mixture of 22 VOCs at levels as low a 5 mg/M^3 could perceive that their mucous membranes were irritated, and that air quality had deteriorated. They also scored lower on tests of their short term memory. This study does not imply that office workers exposed to VOCs above 5 mg/M^3 will suffer adverse health effects, but suggests that complaints of poor indoor air quality would likely appear.[5]

D. Carbon Monoxide

Carbon monoxide can occur as a waste product of the incomplete combustion of carbonaceous fuels. Sources of carbon monoxide in indoor environments include tobacco smoke, malfunctioning or improperly vented heating systems, and the introduction of contaminated air from outside sources such as loading docks. Carbon monoxide exposure in sufficient concentrations can result in headache, dizziness, drowsiness, nausea, vomiting, collapse, coma, and death.[6]

E. Temperature and Relative Humidity

The majority of references addressing temperature and humidity levels as they pertain to human health frequently appear in the context of assessing conditions in hot environments. Development of a "comfort" chart by ASHRAE presents a comfort zone considered to be both comfortable and healthful. This zone lies between 73° and 77°F (23° and 25°C) and 20 to 60 percent relative humidity.[7]

F. Ventilation

Neither NIOSH nor OSHA have developed ventilation criteria for general offices. Criteria often used by design engineers are the guidelines published by ASHRAE. Until recently, the ASHRAE Ventilation Standard 62-73 (1973) was utilized, but recommendations were based on studies performed before the more modern, air-tight office building became common. These older buildings permitted more air infiltration through leaks and cracks around windows and doors, and through floors and walls. Modern office buildings are usually much more airtight and permit less air infiltration. Due to the reduced infiltration, ASHRAE questioned whether the 1973 minimum ventilation values assured adequate outdoor air supply in modern, air-tight buildings.

The minimum rate of outside air permitted under ASHRAE Standard 62-1989 is 20 cfm/person for general office areas.[8] Where smoking is permitted, ASHRAE Standard 62-1989 recommends an outside air supply rate of at least 60 cfm/p. The 60 cfm/person outside air (may include air transferred from adjoining spaces) supply rate is quite high and is usually implemented in isolated smoking lounges which exhaust directly to the outside. The basis of the outside air supply rates recommended by ASHRAE is for maintaining an indoor air quality that is considered acceptable by at least 80% of the building's occupants. However, unless referenced or specified by local building codes, building owners are not required to comply with these ASHRAE Standards. Most building codes refer to an earlier version of this standard (ASHRAE Standard 62-73) which was intended to conserve energy rather that promote adequate indoor air quality.

V. RESULTS

A. HVAC System Inspection

Ventilation for most of the clinic is provided by a single forced air HVAC system located in the eastern part of the building. The dental lab has a dedicated air conditioning system plus has air supplied by the main building system. The HVAC system did not provide any humidification and cooling was accomplished using cooling coils located outside the building. The system is rated at 55,000 cubic feet of air per minute (cfm). The outside air intake uses commercial fiberglass filters which had been changed recently. The ducts were visually inspected and were clean and free of any moisture. The HVAC system had been recently serviced by the equipment contractor and had received much attention by the mechanical service personnel in IHS. A slight dusty smell was pervasive throughout the HVAC system and the building.

B. Environmental Survey Results

The results of the measurements taken for carbon dioxide, temperature, and relative humidity are provided in Table 2. As evidenced by this data, the indoor concentrations of CO_2 ranged from 375 ppm to 500 ppm in the various areas of the building. These concentrations are below the guideline of 1000 ppm CO_2 used by NIOSH in indoor air quality investigations to indicate problems caused by lack of outside air ventilation.[1] The outdoor air concentration of CO_2 was found to average 300 ppm.

Measurements of temperature and relative humidity ranged from 71° to 74° Fahrenheit (F) and 36% to 45%, respectively. The temperatures were slightly below the guidelines of 73 to 77 degrees F, but the humidity levels were well within the 20 to 60 percent relative humidity range recommended by ASHRAE.[7] The lower temperature readings were found in the morning. The afternoon temperatures were all within the ASHRAE guidelines.

The detector tube samples which were collected indicated that each of the contaminants was found to be below its respective limit of detection which is 5 ppm for carbon monoxide and 0.05 ppm for formaldehyde.

Very low levels of several different volatile organic compounds (V)Cs) were found in the charcoal tube sample collected in the records room (Figure 2). Toluene was the major VOC detected, with other compounds identified as being present including various C_6-C_{14} alkanes, isopropanol, chloroform, butyl cellosolve, benzene, methyl methacrylate, xylenes, trichloroethylene, and 1,1,1-trichloroethane. The VOCs which were identified are similar to those which have been noted in other investigations of hydrocarbons in indoor environments.[4] All individual contaminant levels were estimated to be less than 20 micrograms per sample. Based on a sample volume in excess of 800 liters, the concentrations of total VOCs would be estimated to be less than 0.1 mg/M^3. For example, the toluene peak was the largest found in the clinic sample and the concentration is estimated to be on the order of 0.05 ug/M^3.

C. Results of Interviews

Anecdotal interviews with employees of the SIPI clinic indicated episodic complaints of nonspecific symptomatology; i.e., headache, forgetfulness, nausea, eye irritations, sinus problems, nasal irritation and drainage, bitter taste in the mouth, irritability, and fatigue which was felt to be related to the building. In addition to the various nonspecific symptoms, the employees and management related specifc incidences of carbon monoxide reentrainment from the boilers, times when the fresh air intake was automatically shut down (when outside temperature was greater than 70°F), and possible pesticide getting into the ventilation due to the proximity of the storeroom where pesticide is kept and the HVAC mechanical room. Although the employees from the Medical Records area had experienced problems on a more regular basis, other members of the staff including the clinic manager, dentists, and the area sanitarian had experienced some of these symptoms at one time or another. While a few of the employees reported problems on a daily basis, others reported that they occurred only occasionally. No pattern had been noted as to what was different or the same during these episodic incidents.

VI. DISCUSSION AND CONCLUSIONS

Building-related illness episodes have been reported more frequently in recent years as buildings have been made more air-tight to conserve energy and to reduce air conditioning expenses. Modern office buildings are constructed primarily of steel, glass, and concrete, with large windows that cannot be opened, thus making the building totally dependent on mechanical systems for air conditioning. Contaminants may be present in make-up air or may be introduced from indoor activities, furnishings, building materials, surface coatings, air handling systems, and the building occupants. Symptoms often reported are eye, nose, and throat irritation, headache, fatigue, and sinus congestion. Occasionally, upper respiratory irritation and skin rashes are reported. In some cases, the cause of the symptoms has been ascribed to an airborne contaminant, such as formaldehyde, tobacco smoke, or insulation particles, but most commonly a single cause cannot be pinpointed.

During the course of this survey, no environmental agent was identified in the building that would be responsible for the symptoms reported by the employees. Measurements of ventilation system parameters (i.e., CO_2, temperature, and relative humidity) revealed the system to be supplying sufficient quantities of adequately tempered air to the various workspaces examined. However, there were occasions in the past when this may not have been the case. A specific example is when the outside temperature exceeds 70°F, the fresh air damper automatically closes. During this situation, especially when the clinic is operating at maximum capacity, the CO_2 levels could have risen dramatically due to the lack of fresh air. Therefore, while the ventilation parameters were found to be within the NIOSH and ASHRAE "guidelines" during the period of this survey, it is possible that changing environmental factors (i.e., seasonal temperature variations) could alter these conditions. Therefore, ongoing attention to the operation and maintenance of the HVAC system is necessary.

Another problem which may have occurred was the introduction of low levels of pesticides, paints, etc. from the maintenance storeroom into the mechanical equipment room and subsequent distribution into the HVAC system. Smoke tube tests demonstrated that if the door between the maintenance storeroom and the air handling room is open, then air flows rapidly from the storeroom into the ventilation system. Likewise if the plywood cover is left off the entrance to the basement (below the air handling unit), then air flows from this lower room into the ventilation system. The space in the basement is an exhaust for air exiting the HVAC system (including that air from the lab). Therefore it is possible for air that is exhausted from the lab to be reentrained into the ventilation system. One of the first places that is supplied by the ventilation system is the medical records room.

VII. RECOMMENDATIONS

1) The clinic should continue with its program of preventive maintenance and periodic inspection of the HVAC system and related equipment. Complaints regarding air quality or distribution in specific work areas should be promptly investigated.

2) Maintenance personnel should be instructed to keep the door between the maintenance storeroom and the air handling unit closed at all times and to replace the plywood panel over the basement entrance as soon as possible. A better door should be developed for this space as it presents a safety hazard.

3) The HVAC system should be maintained so that the air in the clinic is tempered to ASHRAE conditions all year round.

4) In the event that employee complaints continue, a formal log should be maintained which notes the date, time, and type of complaint noted. Such a log could help isolate specific work areas or times of the year when employee complaints are highest. Additional information should be kept with the log including weather conditions (temperature, wind speed, and % relative humidity), activities in the lab (with special attention paid to the type of material being used), status of the doors mentioned in #2 above, status of boiler (i.e., on or off), and the position of the fresh air damper.

5) Complete the material inventory using the material safety data sheets (MSDSs).

6) Safety glasses should be worn by all personnel in the lab.

7) Pigeons had been roosting around the entrance to the lab air conditioning unit. Efforts should be made to encourage the pigeons not to roost in this area.

VIII. REFERENCES

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Table 1
ENVIRONMENTAL CRITERIA FOR SELECTED SUBSTANCES

SUBSTANCE	OSHA PEL	NIOSH REL	ACGIH TLV	ASHRAE*
Carbon Dioxide	10,000 ppm 8-hr TWA 30,000 ppm STEL	10,000 ppm 8-hr TWA 30,000 ceiling (10 min)	5,000 ppm 8-hr TWA 30,000 ppm STEL	2,500 ppm Continuous TWA
Carbon Monoxide	35 ppm 8-hr TWA 200 ppm ceiling (no minimum time)	35 ppm 8-hr TWA 200 ppm ceiling (no minimum time)	50 ppm 8-hr TWA 400 ppm STEL	45 ppm 1-hr TWA
Formaldehyde	1 ppm 8-hr TWA 2 ppm STEL	LFL	1 ppm 8-hr TWA 2 ppm STEL	0.01 ppm Continuous TWA
	STEL		STEL	24-hr TWA

Abbreviations and Key
*ASHRAE guidelines apply only to indoor situations
TWA - Time-weighted average concentration
LFL - Lowest Feasible Level
NA - No applicable evaluation criteria
ppm - Parts of contaminant per million parts of air
STEL - Short-term exposure limit; 15-minute TWA exposure

TABLE 2
ENVIRONMENTAL MEASUREMENTS OF INDOOR AIR QUALITY PARAMETERS
SOUTHWEST INDIAN POLYTECHNIC INSTITUTE DENTAL CLINIC
ALBUQUERQUE, NEW MEXICO
SEPTEMBER 13, 1989

Sample Time	Sample Location	Dry Bulb Temperature °F	Relative Humidity Reading(%)	CO_2 (ppm)
8:10	Records room	72	36	350
8:27	Store room	71	42	375
8:40	Lab	72	41	500
8:42	Outside	56	71	300
8:50	Library	74	36	375
9:50	Store room	72	42	375
11:50	Records room	73	45	400
14:30	Records room	73	41	400
15:20	Records room	73	41	400
15:25	Outside	74	37	300

Evaluation Criteria - Refer to Section IV of Report

Abbreviations and Key
ppm - parts of contaminant per million parts of air
CO_2 - Carbon dioxide

FIGURE 1

Physical Layout and Personnel Distribution for SIPI Clinic

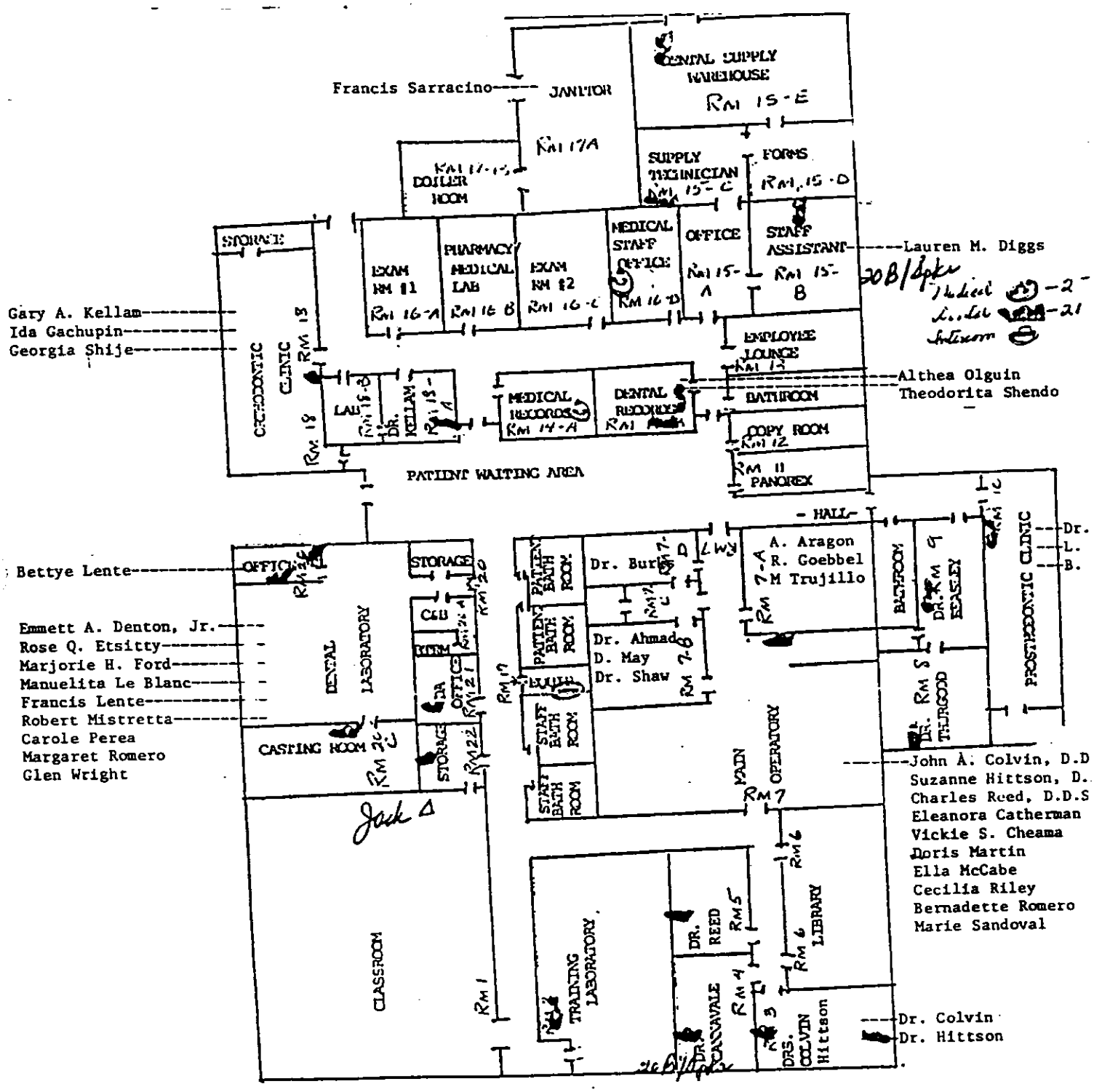

FIGURE 2

Volatile Organic Compounds Identified in Bulk Air Sample of SIPI Clinic