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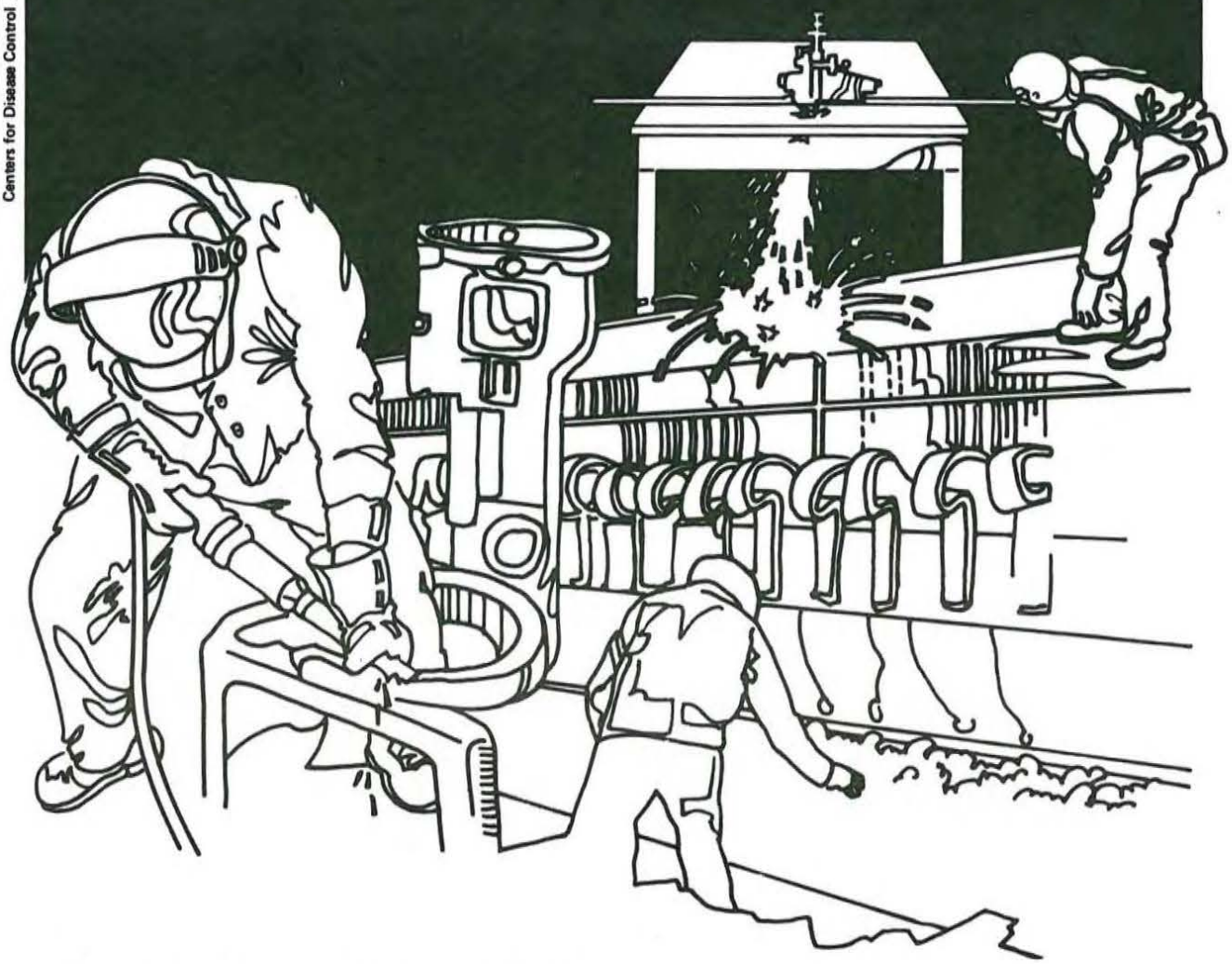

Health Hazard Evaluation Report

HETA 82-045-1108
UNIVERSITY OF COLORADO MEDICAL SCHOOL
DENVER, COLORADO

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.

HETA 82-045-1108
MAY 1982
UNIVERSITY OF COLORADO MEDICAL SCHOOL
DENVER, COLORADO

NIOSH INVESTIGATORS:
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I. SUMMARY

In November 1981 the National Institute for Occupational Safety and Health (NIOSH) received a request from medical and dental students at the University of Colorado Medical School, Denver, Colorado, to evaluate a potential health hazard from exposures to formaldehyde and phenol during the dissection of cadavers in the gross anatomy laboratory.

On December 2 and 15, 1981, NIOSH investigators conducted an environmental evaluation. Twenty-five formaldehyde and 30 phenol breathing zone air samples were collected on students dissecting cadavers. The sampling times averaged approximately one and one-half hours per sample. Values for the formaldehyde samples ranged from less than 0.02 mg/M^3 to 3.3 mg/M^3. Eight of 25 (32%) formaldehyde air samples exceeded the former NIOSH recommended criteria of 1.2 mg/M^3 for any 30 minute sampling period. The 1.2 mg/M^3 NIOSH recommended level is based on formaldehyde's irritant properties and not on its carcinogenic potential. The carcinogenic potential of formaldehyde is outlined in the NIOSH Current Intelligence Bulletin No. 34. All of the 30 phenol air samples were within the most recent evaluation criteria of 19 mg/M^3. Values for the phenol samples ranged from less than 0.01 mg/M^3 to 12.2 mg/M^3.

On December 6, 1981, pre-exposure pulmonary function tests were performed. Post-exposure pulmonary function tests were performed and medical questionnaires were administered on December 15, 1981. The pulmonary function tests included measurements of forced vital capacity (FVC), one-second forced expiratory volume (FEV_1), and calculation of the ratio of FEV_1/FVC.

Twenty-three students participated in the pulmonary function testing, 12 men and 11 women. The average age was 26.0 years with a range of 22 to 37 years. All of the best values for pulmonary function tests were normal with the FVCs averaging 107.8% of predicted, the FEV_1s 109.7% of predicted, and the FEV_1/FVCs 84.8%.

Twelve students also had post-exposure tests, 6 men and 6 women. Their FVCs averaged a drop of 2.1% (standard deviation 3.8), FEV_1s a drop of 2.2% (standard deviation 3.9), and FEV_1/FVCs a rise of 0.03% (standard deviation 2.7). Only one student showed a clinically significant drop--13.0% in FVC and 10.7% in FEV_1.

There is sufficient exposure to formaldehyde to cause discomfort in a majority of the students, but not sufficient to cause any short-term changes in pulmonary function. One student has a considerably greater adverse reaction to formaldehyde, both by history and as demonstrated by a drop in pulmonary function post-exposure. An allergic basis for this problem is likely.

On the basis of these environmental data, pulmonary function test results, and medical questionnaires, NIOSH concluded that a health hazard to formaldehyde did exist at the time of this survey. Recommendations on preventing and correcting the formaldehyde exposure are included in this report.

KEYWORDS: SIC 8221 (Colleges, Universities, and Professional Schools), phenol, formaldehyde, gross anatomy.

II. INTRODUCTION

In November 1981 the National Institute for Occupational Safety and Health (NIOSH) received a request from medical and dental students at the University of Colorado Medical School, Denver, Colorado, to evaluate a potential health hazard from formaldehyde and phenol during the dissection of cadavers in the gross anatomy laboratory.

On December 2 and 15, 1981, NIOSH conducted an environmental evaluation. On December 6, 1981, pre-exposure pulmonary function tests were performed. Post-exposure pulmonary function tests were performed and medical questionnaires were administered on December 15, 1981. Results of the environmental sampling and pulmonary function testing were discussed with the requestor and with the Health Sciences Center industrial hygienists in January 1982.

III. BACKGROUND

The gross anatomy laboratory at the University of Colorado Medical School is divided into seven cubicles (A, B, C, D, E, F, and the dental gross anatomy lab; see Figure 1). Several of the medical students are also industrial hygienists and were concerned about the apparent exposures to both formaldehyde and phenol and asked for NIOSH to perform a health hazard evaluation.

Most of the cubicles are approximately the same size, approximately 500 square feet for each cubicle. There is no local ventilation in any of the cubicles. The only ventilation is general comfort ventilation which serves as air conditioning in the summer and heat in the winter.

Students rarely spend over one and one-half to two hours in the laboratory per day.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Students in each of the seven cubicles were monitored for formaldehyde and phenol. Twenty-five (25) formaldehyde samples were collected on sorbent tubes containing Chromosorb 102 coated with N-benzylethanolamine using vacuum pumps operating at 50 cubic centimeters per minute and analyzed according to NIOSH P&CAM Method No. 354.

Thirty (30) phenol samples were collected on Chromosorb tubes using vacuum pumps operating at 50 cubic centimeters and analyzed by NIOSH Method S-157.

B. Medical

Medical effects of exposures were evaluated utilizing pulmonary function testing and a brief questionnaire administered by the industrial hygienist. Due to scheduling difficulties, the unexposed tests were done on Sunday, December 6, 1981. The post-exposure tests and questionnaires were done on Tuesday, December 15, 1981. Only one-half the study group took part in the post-exposure tests. The one student with a clinically significant decrease in function "over shift" was interviewed by telephone by the physician.

Pulmonary function tests--forced vital capacity (FVC), one-second forced expiratory volume (FEV_1)--were obtained by the industrial hygienist (certified in pulmonary function testing) using an Ohio Medical Products Model 822 Spirometer. Predicted values based on sex, race, age, and height were calculated utilizing the formulae of Knudson, et al.[1]

V. EVALUATION CRITERIA

A. Environmental

Three sources of criteria used to assess the workroom concentrations of the chemicals were (1) recommended Threshold Limit Values (TLVs) and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), 1981, (2) the NIOSH criteria for a recommended standards, and (3) the Occupational Safety and Health Administration (OSHA) standards (29 CFR 1910.1000), July 1980.

	Permissible Exposure Limits 8-Hour Time-Weighted Exposure Basis
Formaldehyde	* (NIOSH) (ACGIH) 4.5 mg/M^3 (OSHA)
Phenol	19.0 mg/M^3 (NIOSH) (ACGIH) (OSHA)

mg/M^3 = milligrams of substance per cubic meter of air.
* = suspect carcinogen--no safe exposure level given.

Occupational health standards are established at levels designed to protect individuals occupationally exposed to toxic substances on an 8-hour per day, 40-hour per week basis over a normal working lifetime.

B. Medical

The pulmonary function tests included measurements of forced vital capacity (FVC), one-second forced expiratory volume (FEV_1), and calculation of the ratio of FEV_1/FVC. FVC measures the total amount of air one can force out of his lungs after breathing in as deeply as possible. FEV_1 measures the amount of air one can breathe out in the first second. The FVC can be impaired by restrictive lung disease, such as pulmonary fibrosis. FEV_1 can be impaired by cigarette-related lung damage or some other conditions causing obstruction to air flow. Any condition that impairs FVC usually impairs FEV_1, but the reverse is not true. Conditions that impair FEV_1 do not necessarily impair FVC. The FEV_1/FVC ratio is also used to help evaluate obstructive lung disease.

In interpreting the results, the best test results are used. They are compared to "predicted values" which take into account age, height, sex, and race.[1] Pulmonary function is considered "normal" if the best FEV_1 and the best FVC are each 80 percent or more of their respective predicted values and the FEV_1/FVC ratio using the best values is 70 percent or more.

Some exposures to substances that irritate the lungs and bronchi will cause a temporary decrease in pulmonary function over the work shift. A drop in results over shift of less than 10 percent in FVC or FEV_1 and of less than six percent for FEV_1/FVC is considered within normal variation. A drop greater than this may indicate a problem with exposures to noxious substances in the work place. Where the "pre-" and "post-shift" tests were done on different days, these criteria will be applied a little less strictly in this study.

C. Toxicological

Formaldehyde[2] -- Formaldehyde is a colorless, flammable gas with a strong, pungent odor. It can form explosive mixtures with air and oxygen. Formaldehyde is usually manufactured by reacting methanol vapor and air over a catalyst. Formaldehyde usually will contain small amounts of methanol and formic acid. Formaldehyde is sold mainly as an aqueous (water-based) solution called formalin, which is about 50% formaldehyde by weight.

The first signs or symptoms from exposure to formaldehyde at concentrations ranging from 0.1 to 5.0 parts per million (ppm) are burning of the eyes, tearing, and general irritation of the upper respiratory passages. Exposures of 10-20 ppm produces coughing, tightening in the chest, a sense of pressure in head, and palpitation of the heart. Exposures at 50-100 ppm and above can cause pulmonary edema, pneumonitis, or death.

Formaldehyde is often used to sterilize hemodialysis machines. There have been cases of pulmonary distress associated with this procedure. Dermatitis from formaldehyde exposure is a well recognized problem. After several days of exposure a worker may develop a sudden inflammatory reaction of the skin of the eyelids, face, neck, scrotum, and arms. Dermatitis may occur on fingers, back of hands, wrist, and forearms. Formaldehyde can also cause both dermal and respiratory allergic sensitization.

NIOSH recommends that formaldehyde be handled as a potential occupational carcinogen. These recommendations are based on a Chemical Industry Institute of Toxicology (CIIT) study in which laboratory rats and mice that were exposed to formaldehyde vapor developed nasal cancers. This is supported by a New York University study where rats exposed to a mixture of formaldehyde and hydrochloric acid vapors developed nasal cancers. Formaldehyde has also been shown to be a mutagen in several short-term laboratory studies.

Since formaldehyde has induced a rare form of nasal cancer in both rats and mice, NIOSH recommends that it be handled in the workplace as a possible occupational carcinogen. Exposure levels should be maintained as low as possible. The OSHA standard of 3 ppm was established based on the irritant effects of formaldehyde and not on the carcinogenic potential.

Phenol[3] -- Phenol may be toxic either by inhalation, ingestion, or percutaneous. Excessive exposures to phenol may produce cellular necrosis, cerebral edema, damage to the liver and kidney and pulmonary edema. The central nervous system (CNS) is first stimulated then depressed. Acute

signs and symptoms of exposure include conjunctival burns, corneal necrosis, and severe skin burns. The effect of ingestion include burns of mouth, pharynx, gastrointestinal tract, perforation of intestinal tract, nausea, vomiting, abdominal pain, and jaundice. Acute symptoms of inhalation include dyspnea, cough, cyanosis, and pulmonary edema.

Workers that are chronically exposed to phenol should receive annual physicals including liver and kidney function. Individuals with serious disease of the CNS, liver, kidney, and lung should be precluded from exposure. Maintaining a worker's exposure below a time weighted average (TWA) of 19 mg/M^3 should be adequate protection.

VI. RESULTS

A. Environmental

Twenty-five formaldehyde and 30 phenol breathing zone air sample were collected on students dissecting cadavers. The sampling times averaged approximately one and one-half hours per sample. Values for the formaldehyde samples ranged from less than 0.02 mg/M^3 to 3.3 mg/M^3. Eight of 25 (32%) formaldehyde air samples exceeded the former NIOSH recommended criteria of 1.2 mg/M^3 for any 30 minute sampling period. (Refer to Tables 1 and 2.) The 1.2 mg/M^3 NIOSH recommended level is based on formaldehyde's irritant properties and not on its carcinogenic potential. All of the 30 phenol air samples were within the most recent evaluation criteria of 19 mg/M^3. (Refer to Tables 3 and 4.) Values for the phenol samples ranged from less than 0.01 mg/M^3 to 12.2 mg/M^3.

B. Medical

Twenty-three students participated in the pulmonary function testing, 12 men and 11 women. The average age was 26.0 years with a range of 22 to 37 years. All of the best values for pulmonary function tests were normal with the FVCs averaging 107.8% of predicted, the FEV_1s 109.7% of predicted, and the FEV_1/FVCs 84.8%.

Twelve students also had post-exposure tests, 6 men and 6 women. Their FVCs averaged a drop of 2.1% (standard deviation 3.8), FEV_1s a drop of 2.2% (standard deviation 3.9) and FEV_1/FVCs a rise of 0.03% (standard deviation 2.7). Only one student showed a clinically significant drop--13.0% in FVC and 10.7% in FEV_1.

At the time of the post-exposure testing the following symptoms were noted:

Symptom	Number Reporting It
Eye irritation	8
Dry or irritated throat	6
Headache	6*
Nasal irritation or congestion	5*
Dizziness	4
Cough	3*
Skin irritation	2
Shortness of breath	1

* In each case one said it was the same as the beginning of the session.

Two students reported skin problems, not on the test day. Four students said they got excessively tired, were more moody or had other vague discomfort during the quarter in which they had their gross anatomy course.

The one student showing significant decreases in pulmonary function after exposure gave a history of eye irritation from formaldehyde first noted in Comparative Anatomy in undergraduate years. Symptoms during the gross anatomy quarter included increased thirst, dry throat and lips, burning eyes, congested nose, and extreme fatigue. The eye irritation and nasal congestion would begin to clear by the morning after exposure. All symptoms cleared in a few days after completion of gross anatomy, but return to a more limited extent when a formalin fixed brain was dissected. There were no symptomatic breathing problems.

VII. DISCUSSIONS AND CONCLUSIONS

Based on the environmental sampling, pulmonary function test results, and medical questionnaires, a hazardous situation existed during this evaluation to all students that were being exposed to formaldehyde. This conclusion is based on the allergenic and carcinogenic potential of formaldehyde.

There is sufficient exposure to formaldehyde to cause discomfort in a majority of the students, but not sufficient to cause any short-term changes in pulmonary function. One student has a considerably greater adverse reaction to formaldehyde, both by history and as demonstrated by a drop in pulmonary function post-exposure. An allergic basis for the problems is likely.

VIII. RECOMMENDATIONS

1. Workers should be informed of the potential health effects from exposure to formaldehyde.

2. Ventilation should be installed that would prevent exposure to formaldehyde and phenol. A minimum of five air changes per hour in these laboratories would probably lower concentrations to an acceptable level.

3. Students should continue to wear rubber gloves when dissecting to prevent skin absorption of phenol and formaldehyde (which may also prevent formaldehyde dermatitis on hands and forearms).

IX. REFERENCES

1. Knudson, R.J., Slatin, R.C., Lebowitz, M.D., Burrows, B. "The Maximal Expiratory Flow-Volume Curve", American Review of Respiratory Disease, Volume 113, pp. 587-600 (1976).

2. Current Intelligence Bulletin 34: Formaldehyde: Evidence of Carcinogenicity. NIOSH Publication No. 81-111, April 15, 1981.

3. Proctor, N.H. and Hughes, J.P. Chemical Hazards of the Workplace. J.B. Lippincott Company, Philadelphia, 1978, pp. 409-410.

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. University of Colorado Medical School.
2. U.S. Department of Labor/OSHA - Region VIII.
3. NIOSH - Region VIII.
4. Colorado Department of Health.
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 1

Breathing Zone Air Concentrations of Formaldehyde
on Dental Students

University of Colorado Medical School
Denver, Colorado

December 2, 1981

Sample Number	Sampling Time	mg/M^3 Formaldehyde
100	10:04 AM - 10:45 AM	1.6
101	10:00 AM - 10:50 AM	3.3
102	10:05 AM - 10:49 AM	1.6
103	10:06 AM - 10:48 AM	1.9
104	9:58 AM - 10:46 AM	*
105	10:01 AM - 10:40 AM	1.4
EVALUATION CRITERIA		1.2**
LABORATORY LIMIT OF DETECTION mg/sample		0.02

* = below laboratory limit of detection

** = This level is based on formaldehyde's irritant effect (1976 NIOSH Criteria for Recommended Standard). Subsequently it has been shown to cause cancer in animals. Exposures should be controlled at lowest feasible level.

TABLE 2

Breathing Zone Air Concentrations of Formaldehyde
on Medical Students in the Anatomy Lab

University of Colorado Medical School
Denver, Colorado

December 15, 1981

Sample Number	Sampling Time	mg/M^3 Formaldehyde
400	9:29 AM - 11:57 AM	2.1
401	9:45 AM - 11:00 AM	*
402	9:57 AM - 11:53 AM	0.5
403	9:59 AM - 11:50 AM	0.7
404	10:01 AM - 11:47 AM	*
405	10:02 AM - 11:48 AM	1.4
406	10:07 AM - 11:58 AM	1.1
407	10:08 AM - 11:00 AM	*
408	10:13 AM - 11:49 AM	0.4
409	10:12 AM - 11:58 AM	0.9
410	10:08 AM - 11:48 AM	1.1
411	10:16 AM - 11:56 AM	1.2
412	10:14 AM - 11:55 AM	0.4
413	10:15 AM - 11:56 AM	0.5
414	10:16 AM - 11:54 AM	0.5
F1	9:59 AM - 11:56 AM	*
F2	10:23 AM - 12:14 PM	0.7
F3	2:25 PM - 4:11 PM	0.5
F4	2:14 PM - 4:06 PM	0.8
EVALUATION CRITERIA		1.2**
LABORATORY LIMIT OF DETECTION mg/sample		0.02

* = below laboratory limit of detection

** = This level is based on formaldehyde's irritant effect (1976 NIOSH Criteria for Recommended Standard). Subsequently it has been shown to cause cancer in animals. Exposures should be controlled at lowest feasible level.

TABLE 3

Breathing Zone Air Concentrations of Phenol
on Dental Students

University of Colorado Medical School
Denver, Colorado

December 2, 1981

Sample Number	Sampling Time	mg/M^3 Phenol
200	10:08 AM - 10:45 AM	*
201	9:59 AM - 10:49 AM	2.9
202	10:06 AM - 10:48 AM	*
203	10:06 AM - 10:46 AM	*
204	10:02 AM - 10:46 AM	*
205	10:04 AM - 10:46 AM	*
EVALUATION CRITERIA		19.0
LABORATORY LIMIT OF DETECTION mg/tube		0.01

* = below laboratory limit of detection

TABLE 4

Breathing Zone Air Concentrations of Phenol
on Medical Students in the Anatomy Lab

University of Colorado Medical School
Denver, Colorado

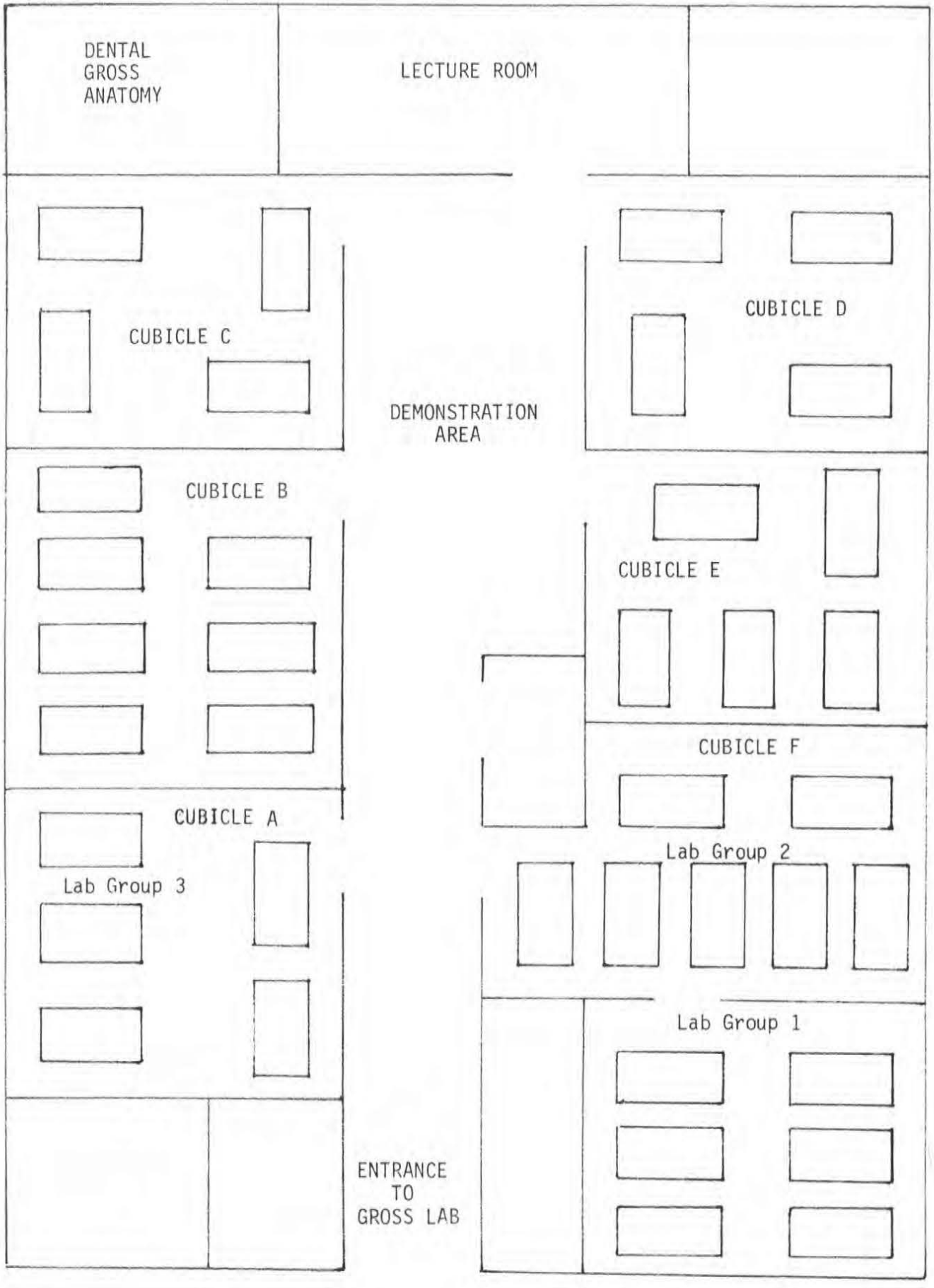
December 15, 1981

Sample Number	Sampling Time	mg/M^3 Phenol
300	10:16 AM - 11:59 AM	*
301	10:21 AM - 12:45 PM	5.0
302	10:16 AM - 11:54 AM	2.1
303	10:18 AM - 11:56 AM	3.2
304	10:19 AM - 11:46 AM	3.9
305	10:12 AM - 11:56 AM	2.7
306	10:15 AM - 11:55 AM	7.9
307	10:14 AM - 11:55 AM	1.9
308	10:09 AM - 11:48 AM	5.8
309	10:15 AM - 11:56 AM	4.5
310	10:13 AM - 11:50 AM	*
311	10:08 AM - 11:53 AM	3.3
312	10:07 AM - 11:58 AM	2.5
313	10:06 AM - 11:56 AM	1.8
314	9:45 AM - 11:00 AM	*
315	10:02 AM - 11:50 AM	*
316	10:01 AM - 11:48 AM	1.5
317	9:58 AM - 11:53 AM	4.5
318	10:00 AM - 11:52 AM	4.4
319	9:29 AM - 11:56 AM	12.2
P1	10:23 AM - 12:16 PM	6.7
P2	10:14 AM - 11:45 AM	2.2
P3	2:16 PM - 4:52 PM	3.8
P4	2:26 PM - 4:14 PM	3.5
EVALUATION CRITERIA		19.0
LABORATORY LIMIT OF DETECTION mg/tube		0.01

* = below laboratory limit of detection

FIGURE 1

University of Colorado Medical School
Gross Anatomy Laboratory



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