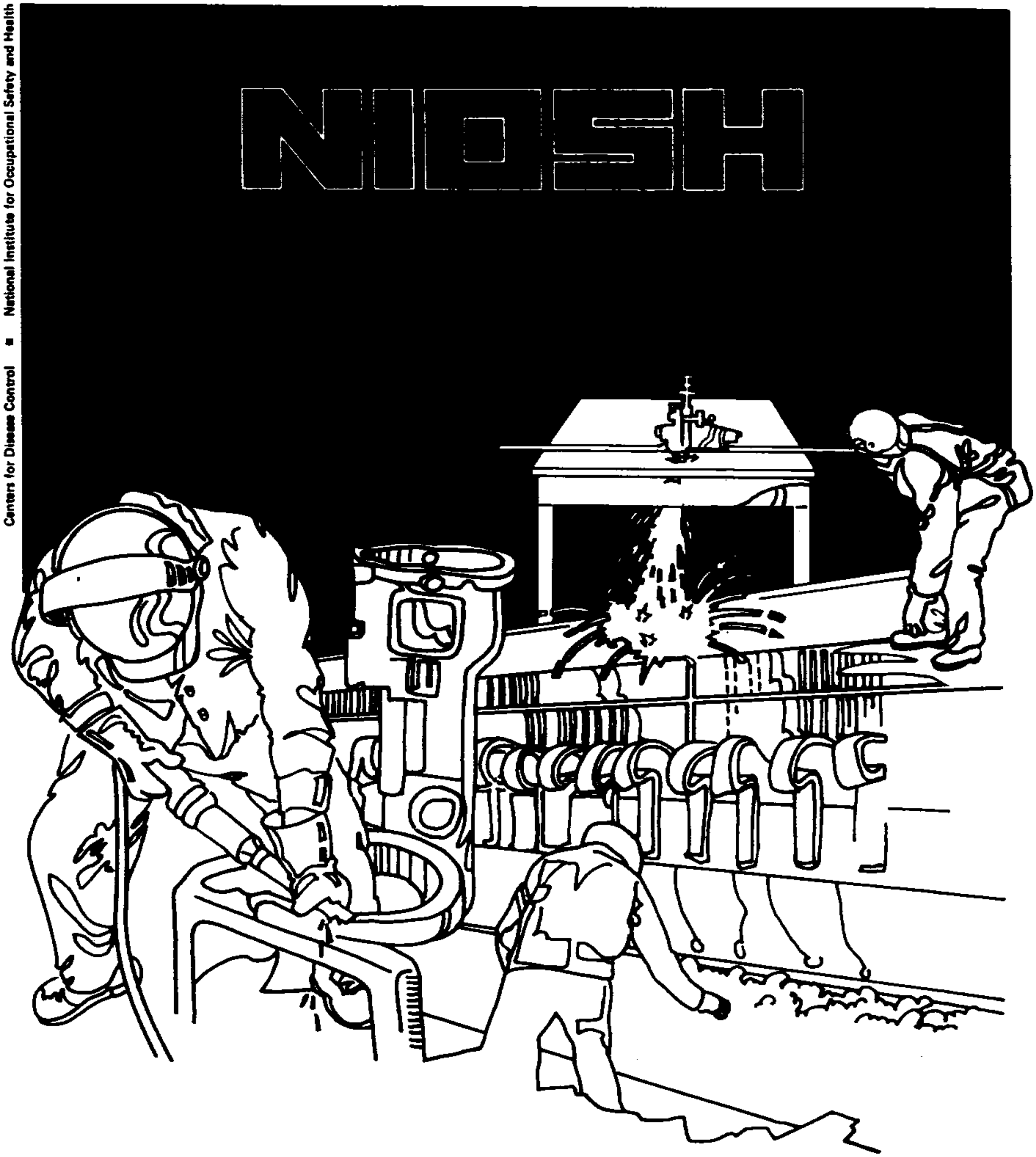
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 88-364-2104 - VOL. III
LIBRARY OF CONGRESS
MADISON BUILDING
WASHINGTON, D.C.

WORK ENVIRONMENT STUDY

Library of Congress
Madison Building

Volume III:

Association Between Health and Comfort Concerns and Environmental Conditions

National Institute for Occupational Safety and Health

U.S. Environmental Protection Agency

John B. Pierce Laboratory at Yale University

National Institute of Standards and Technology

HETA 88-364-2104
March 1991

PREFACE

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 and 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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

TECHNICAL TEAMS

This study of indoor air quality and work environment was conducted by three

Overall project coordination was provided by two technical team leaders: Lawrence Fine at NIOSH and Kevin Teichman at EPA.

SURVEY DESIGN TEAM

NIOSH

Anne Fidler, Epidemiologist
Thomas Wilcox, Physician
Joseph Hurrell, Psychologist
Richard Hornung, Statistician

Westat

Robert Clickner, Statistician
Stephen Dietz, Statistician

EPA

Mel Kollander, Survey Statistician
Lance Wallace, Environmental Scientist
F. Cecil Brenner, Statistician

J.B. Pierce Found. at Yale University

Brian Leaderer, Environmental Scientist
O. John Selfridge, Environmental Scientist

MONITORING TEAM

NIOSH

Richard Gorman, Industrial Hygienist
Michael Crandall, Industrial Hygienist
Rebecca Stanevich, Industrial Hygienist
G.E. Burroughs, Industrial Hygienist
Gregory Burr, Industrial Hygienist
Teresa Seitz, Industrial Hygienist
Matthew Klein, Mechanical Engineer

NIST

Andrew Persily, Mechanical Engineer

EPA

Lance Wallace, Environmental Scientist
Ross Highsmith, Chemist
Larry Purdue, Chemist

J.B. Pierce Found. at Yale University

Brian Leaderer, Environmental Scientist
O. John Selfridge, Environmental Scientist
H. Irene Hall, Environmental Scientist

REPORTING AND ANALYSIS TEAM

NIOSH

Anne Fidler, Epidemiologist
Deanna Wild, Statistician
Thomas Wilcox, Physician
Joseph Hurrell, Psychologist
Richard Hornung, Statistician

Research Triangle Institute

Andy Clayton, Statistician
George Dunteman, Statistician

EPA

C.J. Nelson, Statistician
Mel Kollander, Survey Statistician
Lance Wallace, Environmental Scientist

J. B. Pierce Found. at Yale University

Brian Leaderer, Environmental Scientist
O. J. Selfridge, Environmental Scientist

FOREWORD

Washington, D.C. have expressed their concerns about indoor air quality and discomfort related to their work environment. A systematic study was undertaken to assess the nature and spatial distribution of employee health and comfort concerns and to attempt to identify associations between employee responses and workplace conditions. This evaluation of the Madison Building has been performed by a team of researchers from the National Institute for Occupational Safety and Health (NIOSH), the Environmental Protection Agency (EPA), the John B. Pierce Laboratory, Inc. at Yale University, the National Institute of Science and Technology (NIST), and Westat, Inc., a health consulting firm.

The primary objectives of the study were:

1. To survey the nature, magnitude, and spatial distribution of acute health symptoms and comfort concerns;

2. To characterize selected physical, chemical and biological aspects of the building in selected locations during the survey period; and

3. To generate hypotheses from any associations observed between acute health and comfort effects and environmental factors while taking into account factors that would confound or modify such associations.

To address these three objectives, the following study design was implemented. Phase I consisted of the administration of a questionnaire to the entire federal workforce of the LOC Madison Building. This questionnaire, administered in February of 1989, sought information about health symptoms and comfort concerns experienced during the previous year and the previous week, data on background health and demographic characteristics, and other potential risk factors for the development of health problems. Findings from the employee survey were then used to rank all the rooms in the building using a health symptom index and a comfort index, and then to select approximately 100 locations within the building for environmental monitoring and physical measurements. Phase II of the study consisted of environmental monitoring conducted three weeks after the employee survey. At the same time, a supplemental questionnaire was administered to all employees whose workstations were near the environmental monitoring station.

The results of this study are provided in three volumes. Volume I addresses the first objective listed above, by documenting the study design and the results of the survey conducted in February 1990 of all Madison Building employees. Volume II, which addresses the second objective, summarizes the environmental measurements taken in the building. Volume III addresses the third objective and presents the results of a statistical investigation of the interrelationships among employees' responses regarding health and comfort concerns, the environmental monitoring data, and other potential work-related and non-work-related risk factors.

This report (HETA Number: 88-364-2104) includes Volume III, as well as the Executive Summaries from Volumes I and II. The complete versions of Volumes I and II are available through the National Technical Information Service. The reference numbers are HETA 88-364-2102 (Volume I) and 88-364-2103 (Volume III).

TABLE OF CONTENTS

VOLUME I: EMPLOYEE SURVEY

1. Purpose

In recent years, employees in the Madison Building of the Library of Congress (LOC) in Washington, D.C. have expressed their concerns about air quality and work environment discomforts. Because of the difficulties usually encountered in determining the exact causes of such concerns about the building environment, a systematic study was undertaken to assess the nature and spatial distribution of employee health symptom and comfort concerns in an attempt to determine if associations exist between employee responses and specific workplace conditions. This evaluation of the Madison Building has been performed by a team of researchers from the National Institute for Occupational Safety and Health (NIOSH), the Environmental Protection Agency (EPA), the John B. Pierce Foundation at Yale University, and the National Institute of Science and Technology (NIST), and Westat, Inc., a health consulting firm.

This is the first of three reports that investigate the perceived and actual quality of indoor air and work environment at the Madison Building of the LOC. This report documents the design of the study and the results of a survey conducted in February 1989 of all Madison Building employees. This report presents only a descriptive summary of the survey data. Results of the environmental monitoring will be presented in Volume II; multivariate analyses of all the study results will be presented in Volume III.

The research effort at the Library of Congress was integrated with a parallel study of three headquarters buildings at the Environmental Protection Agency (EPA) in Washington, D.C. Both the LOC and EPA surveys made use of similar study designs and survey instruments, although separate reports are being prepared for each agency. While certain details are specific to the particular buildings involved, the survey design is applicable to a study of any building suspected of environmental problems.

2. Study Design

Because of the lack of systematic information on employee health that could be used in this study, and because of the spatial variability of ventilation, thermal factors, and other conditions that influence health and comfort, it was decided to conduct a complete survey of all Madison Building employees. A self-administered questionnaire was distributed in February 1989, asking for information about health symptoms and comfort concerns, along with data on background health and demographic

monitoring data);

- Description of workstation; both current and changes over the last year;

- Amount of time spent at workstation;

- Symptoms experienced while in building, both in the previous week and last year;

- Other health effects and risk factors: contact lenses and eyeglasses wear, smoking, allergies, asthma, etc.;

- Eye, nose, throat, or respiratory irritation from tobacco smoke or chemicals during last year;

- Comfort issues: temperature, humidity, air movement, noise, dust, light, odors, and furniture during last year;

- Job characteristics, including job satisfaction and job stresses;

- Education, job pay plan and grade, and job classification.

To increase participation in the survey, both management and unions were given the opportunity to review the draft questionnaire and their endorsements were communicated to all employees prior to the survey. Stringent measures were taken to ensure the confidentiality of all responses.

Findings from the employee survey were used to rank all rooms in the building using a health symptom index and a comfort index, and then to select approximately 100 locations within the building for environmental monitoring and physical measurements. Environmental monitoring was conducted three weeks after the employee survey. All locations were monitored for temperature, relative humidity, carbon dioxide, and carbon monoxide, and biological contaminants. A subset of locations was also sampled for nicotine, particles, formaldehyde and other aldehydes, other volatile organic compounds (VOC's), and pesticides In addition, ventilation parameters were measured.

While the monitoring was in process, a supplemental questionnaire was administered to all employees near the environmental equipment. This provided a

3. Results of the Employee Survey

The overall response rate for the survey questionnaire was 90 percent, with 2,145 of 3,176 Madison Building employees completing the survey. More than 1200 employees also took the opportunity to make additional comments in the "essay" portion provided at the end of the survey.

Key results are reported below, first for health symptoms, then for comfort issues. It is important to note that the health symptoms and comfort issues reported in this survey are self-reported by the respondents, and have not been verified by a physician's diagnosis as part of this study. No attempt is made in this report to associate health or comfort outcomes with possible risk factors in the building. These analyses will be the focus of Volume III.

Health Symptoms

Employees were asked to report whether each of 32 health symptoms occurred during the past year "never," "rarely," "sometimes," "often," or "always." To focus the findings of this report, a "positive " symptom is defined here as one that was reported to have occurred "often" or "always" and usually gets better when away from work in the Madison Building. This allows the focus to be on symptoms that are recurring rather than unusual and that appear to be connected in some way to the building.

The proportion of Madison Building employees reporting positive work-related symptoms, as defined above, is presented in Exhibit I-1. The most commonly reported work-related symptoms among Madison Building employees were:

- contact lens problems (31% of contact lens wearers)
- sleepiness or drowsiness (24%)
- sore eyes (23%)
- fatigue (21%)
- dry eyes (21%)
- stuffy nose (21%)
- headache (16%)
- burning eyes (13%)
- sneezing (13%)
- tension or nervousness (12%)

It is noted that most of these symptoms, most notably headache, fatigue, and symptoms associated with mucous membrane irritation, have often been reported in

in past year and gets better when away from work) can be viewed another way, as in Exhibit I-2, which groups the symptoms into three categories and presents the results by floor:

1. Indoor Air Quality Symptoms, typically associated with acute discomfort, such as headache, runny nose, stuffy nose/sinus congestion, dry, itching, or tearing eyes, burning eyes, dry throat, fatigue, sleepiness;

2. Respiratory or Flu-like Symptoms, which may be manifested in clinically defined illnesses that may require prolonged recovery times after leaving the building. Such symptoms include cough, wheezing, shortness of breath, chest tightness, fever, and aching muscles or joints; and

3. Ergonomic Symptoms, which include back pain or stiffness, and pain or numbness in the shoulder, neck, hands, or wrists.

The predominant type of symptoms which occurred among employees in the Madison Building are those that may be associated with poor indoor air quality. As this exhibit shows, and as is borne out by other findings, the highest proportions of employees reporting positive indoor air-related symptoms are those on the 4th floor. Respiratory and flu-like symptoms occurred among relatively few persons and did not vary across floors. Although the 4th and 5th floors report the highest symptom rates for these symptoms, the differences are small. Similarly, the differences across floors for ergonomic symptoms of the upper body were relatively small.

For each of these symptom groups, the floor-specific prevalence of each symptom was compared with the overall building prevalence and the differences were averaged. For example, if a floor reported a positive two percent variation for headaches, that would mean that respondents on that floor experienced a rate of headaches 2 percent greater than the building as a whole, namely 16 percent plus 2 percent, equaling 18 percent. Negative percents indicate a lower than building average percent of persons reporting work-related symptom (occurring "often" or "always"), while positive percentages indicate a higher than average level. (Note that the rows do not sum to zero because of different numbers of respondents on each floor.)

Defining a "positive" symptom as one that is reported to have occurred often or always may represent a conservative estimate of symptoms experienced by respondents. Employees may experience symptoms only "sometimes" that are nevertheless related to the building. (For example, persons may be sensitive to paint employees reporting symptoms "sometimes," "often," or "always" last year that usually got better when away from work. In addition, it is recognized that certain symptoms that may be building-related do not improve upon leaving work (e.g., muscle pains, delayed hypersensitivity reactions). The main body of the report includes exhibits that eliminate the "got better upon leaving work" criterion.

Almost half (44%) of the respondents in the building reported that the symptom or symptoms reduced their ability to work at least some of the time. Approximately one third (35%) of workers reported that in the past year their symptoms had caused them to stay home from work or leave work early sometimes or often.

Seventy percent of workers associated one or more of their symptoms with their work in the Madison Building, ranging from 78% on the 4th floor to 64% on both the 1st and ground floors. Of those employees reporting that they "often" or "always" experienced symptoms, the percentage who reported that their symptoms improved when they left the building generally ranged between 60 and 85 percent. Most respondents (67%) stated that in the past year their symptoms had stayed the same.

Almost half (41%) of Madison Building employees reported more frequent infections since beginning work in the building, with the highest proportion on the 4th floor (49%). More than one third (37%) of building respondents reported that their infections tend to last longer, again with the highest proportion being among employees on the 4th floor (44%).

Of nine possible sources of eye, nose, throat, or respiratory irritation mentioned, those reported most often were tobacco, paint, cleaning fumes (from carpets, drapes, etc.), miscellaneous chemicals, and glues and adhesives. One-third (33%) of respondents throughout the Madison Building reported that they consider themselves especially sensitive to the irritants mentioned.

Comfort Issues

Approximately two thirds (65%) of respondents reported that they were generally satisfied with their physical workstations (chair comfort, lighting), although this may be because respondents have some ability to adjust these factors. For example, desk lamps are used regularly by 33% of respondents. Dissatisfaction with other building-related variables, however, ran high. Overall, 43% of respondents wanted to adjust air movement, 26% wanted to adjust the humidity, and 39% wanted to adiust the temperature in their immediate environment. Second floor employees

Throughout the Madison Building, respondents reported the air to be often or always too dry, rather than too humid, with too little as opposed to too much air movement. Overall, these reported percentages were 25% as opposed to eight percent, and 40% as opposed to 12%, respectively. The desire to adjust temperature was seasonally dependent, with respondents wanting to adjust temperature more during winter and summer. Almost two-thirds of respondents wanted to adjust the temperature during the winter months.

Almost half of the respondents (46%) reported that, during the past year, the environment at their workstation was often or always too stuffy, and almost one quarter (23%) of the respondents reported it being too dusty, often or always in the past year.

This report also outlines the findings of the survey regarding respondents background characteristics, including demographic characteristics, health factors not related to the building, job satisfaction and sources of stress, and the physical work environments in which employees work. These factors will be used in the Volume III analyses as background variables to help explain patterns of health symptoms and comfort problems. These analyses will provide a more detailed context in which to understand the differential health and comfort problems experienced by different types of employees, and employees in different areas of the building. The analyses will thus help to determine to what extent the health symptoms and comfort concerns described in this report can be attributed to building conditions and to what extent they can be attributed to other independent factors.

Exhibit I-1

Percent of Respondents[1] Reporting Symptoms "Often" or "Always" in the Past Year

	and Got Better Upon Leaving Work
Headache	16%
Nausea	1%
Runny nose	10%
Stuffy nose	21%
Sneezing	13%
Cough	5%
Wheezing	2%
Shortness of breath	2%
Chest tightness	2%
Dry, itchy eyes	21%
Sore, strained eyes	23%
Blurry vision	6%
Burning eyes	13%
Sore throat	3%
Hoarseness	3%
Dry throat	10%
Fatigue/tiredness	21%
Sleepiness	25%
Chills	9%
Fever	1%
Aching muscles/joints	7%
Problems with contacts [2]	31%
Difficulty remembering	2%
Dizziness/lightheadedness	4%
Feeling depressed	7%
Tension/nervousness	12%
Difficulty concentrating	7%
Dry skin	8%
Pain-upper back	10%
Pain-lower back	9%
Pain-shoulder/neck	8%
Pain-hand/wrist	3%

[1] Total number of respondents equals 2,750 (excluding persons for whom "floor" was missing).

[2] These percentages are based upon only the people who wear contact lenses at work "sometimes, often, or always" (Part II, Question 1a), as opposed to all respondents in the building.

Exhibit I-2

SYMPTOMS	TOTAL (n=2750)	FLOOR							
		6th (n=267)	5th (n=712)	4th (n=457)	3rd (n=284)	2nd (n=386)	1st (n=115)	G (n=409)	SG (n=120)
Indoor Air Quality Symptoms									
Headache	16%	18%	16%	20%	14%	19%	12%	14%	13%
Runny nose	10%	11%	11%	14%	6%	9%	11%	8%	9%
Stuffy nose	21%	23%	20%	25%	14%	22%	25%	18%	19%
Dry eyes	21%	19%	24%	24%	18%	20%	14%	18%	14%
Burning eyes	13%	9%	16%	14%	10%	11%	13%	11%	7%
Dry throat	10%	10%	11%	13%	5%	9%	14%	10%	10%
Fatigue	21%	17%	23%	27%	13%	24%	13%	21%	14%
Sleepiness	25%	20%	27%	32%	25%	25%	20%	20%	21%
Respiratory or Flu-like Symptoms									
	5%	3%	7%	7%	3%	5%	4%	6%	6%
Cough	2%	2%	1%	3%	1%	1%	4%	2%	3%
Wheezing	2%	1%	2%	2%	1%	2%	4%	2%	3%
Short of breath	2%	3%	3%	2%	0%	1%	2%	1%	2%
Chest tightness	1%	0%	1%	1%	1%	0%	1%	1%	1%
Fever	7%	5%	7%	8%	5%	7%	6%	6%	7%
Aching muscles									
Ergonomic Symptoms									
Pain-upper back	10%	7%	12%	10%	10%	11%	9%	9%	4%
Pain-lower back	9%	7%	10%	10%	10%	8%	5%	9%	6%
Pain-shoulders	8%	6%	10%	8%	9%	8%	7%	6%	4%
Pain-hands/wrist	3%	3%	5%	4%	3%	3%	2%	2%	3%

[1] Excluding persons for whom "floor" was missing.

Exhibit I-3

Percent of Respondents[1] Reporting Symptoms "Sometimes," "Often," or "Always"

	and Got Better Upon Leaving Work
Headache	44%
Nausea	11%
Runny nose	24%
Stuffy nose	36%
Sneezing	31%
Cough	18%
Wheezing	7%
Shortness of breath	10%
Chest tightness	9%
Dry, itchy eyes	43%
Sore, strained eyes	47%
Blurry vision	18%
Burning eyes	30%
Sore throat	14%
Hoarseness	10%
Dry throat	26%
Fatigue/tiredness	43%
Sleepiness	52%
Chills	23%
Fever	4%
Aching muscles/joints	16%
Problems with contacts [2]	53%
Difficulty remembering	9%
Dizziness/lightheadedness	17%
Feeling depressed	22%
Tension/nervousness	34%
Difficulty concentrating	27%
Dry skin	15%
Pain-upper back	22%
Pain-lower back	22%
Pain-shoulder/neck	20%
Pain-hand/wrist	9%

[1] Total number of respondents equals 2,750 (excluding persons for whom "floor" was missing).

[2] These percentages are based upon only the people who wear contact lenses at work "sometimes, often, or always" (Part II, Question 1a), as opposed to all respondents in the building.

Exhibit I-4

Percent of Respondents Reporting Symptoms "Often" or "Always" Wanting to Adjust

	TOTAL (n=2750)	FLOOR							
		6th (n=267)	5th (n=712)	4th (n=457)	3rd (n=284)	2nd (n=386)	1st (n=115)	G (n=409)	SG (n=120)
Adjust Air Movement	43%	47%	43%	47%	39%	49%	38%	40%	31%
Adjust Temperature	39%	44%	39%	45%	33%	41%	37%	36%	33%
Adjust Humidity	265	27%	28%	28%	23%	30%	25%	22%	13%

[1] Excluding persons for whom "floor" was missing.

VOLUME II: ENVIRONMENTAL MONITORING

1. Background

In recent years, employees in the James Madison Memorial Building of the Library of Congress (LOC) in Washington, DC, have reported health symptoms and discomfort concerns which they have attributed to the building indoor environment. As a result, a systematic study was undertaken to determine if associations exist between these symptoms and concerns and workplace conditions. This evaluation of the Madison Building has been performed by the National Institute for Occupational Safety and Health (NIOSH), the Environmental Protection Agency (EPA), the John B. Pierce Foundation at Yale University, the National Institute of Standards and Technology (NIST), and Westat, Inc., a health consulting firm.

The research effort at the LOC was integrated with a parallel study of three headquarters buildings at the EPA in Washington, D.C. Both the LOC and EPA surveys made use of similar study designs and survey instruments. While certain features of the study are specific to the particular buildings involved, the survey was designed to be applicable to any building suspected of environmental problems.

The objectives of the study were to survey health symptoms and comfort concerns of employees; characterize the indoor air environment in selected building locations; and analyze possible associations between health or comfort symptoms and conditions in the building environment. The study results are being presented in three successive reports. Volume I, released in December 1989, summarized the employees' health symptoms and comfort concerns. This report, Volume II, summarizes the environmental measurements in the Madison Building. Volume III, to be published in the second half of 1990, will analyze any associations between health or comfort and the building environment.

The Hazard Evaluations and Technical Assistance Branch (HETAB) of NIOSH's Division of Surveillance, Hazard Evaluations, and Field Studies (DSHEFS) and the Atmospheric Research and Exposure Assessment Laboratory (AREAL) of EPA's Office of Research and Development (ORD) planned, directed, and carried out most of the environmental monitoring performed at the LOC. The Environmental Investigations Branch (EIB) of the Division of Respiratory Disease Studies (DRDS), NIOSH, conducted the biological sampling and analysis. NIST conducted a study of the LOC ventilation systems and air quality.

as their job characteristics and workstation environment. This questionnaire was analyzed to select locations for environmental monitoring. An equal proportion (1:1) of high-complaint level and low-complaint level locations was selected. Information regarding which category the monitoring site was in was not revealed to any LOC employee or member of the monitoring team, in order to avoid possible bias. A supplementary questionnaire was administered to the employees in the vicinity of the sampling site on the day of monitoring that included the same questions on health, comfort and odors.

The basic concept of the monitoring study was to measure a series of comfort and environmental variables in selected locations for a single day. About 20 locations were sampled in a day, allowing the total monitoring effort to be completed in one week (February 27 through March 3, 1989).

Available resources allowed for a complete set of environmental samples to be collected in 51 locations inside the Madison Building and one outdoor location. These "primary sites" were supplemented by an additional set of 40 "secondary sites" and ten "special sites", where a less complete set of environmental samples were collected.

Environmental parameters monitored at all sites included the "comfort variables" (temperature and relative humidity), an indicator for the amount of fresh air in a space (carbon dioxide [CO_2]), and a measure of dust levels (respirable suspended particulates [RSP]). Each was instantaneously monitored during four separate site visits (morning, late-morning, early afternoon, and late-afternoon) on the day monitoring was conducted. Additional variables measured at the 51 primary sites included indicators of potential chemical contamination (formaldehyde and 27 other volatile organic compounds, or VOCs), an indicator of smoking activity (nicotine), and an integrated (time-weighted average) measurement of RSP. The formaldehyde, VOCs, and RSP measurements were integrated over a 9-h period; the nicotine measurement was integrated over the entire five-day workweek. Microbiological aerosols (bacteria and fungi) were also sampled at the primary sites and some of the secondary sites. At a few sites (about three per day), integrated air samples were collected and analyzed for 15 aldehydes and 33 pesticides. One fixed indoor site and one fixed outdoor site were established and evaluated over all five days, to obtain an idea of the daily variability of the environmental parameters.

Whole-building air exchange rates were measured using the tracer gas decay technique (sulfur hexafluoride). Qualitative measurements of local air exchange effectiveness were performed at 56 locations. Other qualitative evaluations of were collected for the VOCs. All monitoring instruments were calibrated periodically according to the study protocol.

3. Results

Table II-1 summarizes the total number of sites sampled at the LOC for each environmental parameter. Results are presented as overall mean values for the building for the week (Tables II-2 and II-3).

Comfort Parameters

The mean temperature for the building was 73.1 °F (Table II-2). There was a general trend for the temperature to increase from morning to afternoon throughout the building, on all days. A majority (>75%) of the measured temperatures were between 70 and 75 °F. The minimum measured indoor temperature was 61.5 °F (recorded in the morning on the subground level), and the maximum was 77.5 °F.

The mean relative humidity was 49.2%. More than 80% of the individual measurements fell between 40 and 60%. Variability between time periods, days, and sample sites was not great. The maximum indoor value was 72% and the minimum was 34%.

Ventilation Parameters

Mean carbon dioxide concentrations increased at all sampling locations throughout the morning, with the maximum mean values observed near midday, and decreased somewhat toward the end of the day. The mean CO_2 concentration overall was 491 parts per million (ppm). The range of values was 300-675 ppm (Table A.32). All values were below the guideline value of 1000 ppm.

Whole-building air exchange rates were relatively constant, with day- and night-time averages being 0.85 and 0.79 air changes per hour (ACH) respectively. The minimum ventilation recommendation by ASHRAE (20 CFM/person) corresponds to an air exchange rate of roughly 0.72 ACH. Local measurements indicated good distribution of the outdoor air at measurement locations. All outdoor air dampers inspected were believed to be in the maximum open position. Some minor problems were noted with operation of individual air handler filter systems and control gages, as well as with individual variable air volume distribution systems and room thermostats.

real-time device employs optical scattering, which depends on the aerodynamic diameter of the particles, whereas the integrating monitor measures the mass of the particles. An instantaneous value of 50 $\mu g/m^3$ was observed on one occasion. The highest 9-h integrated average was 37.3 $\mu g/m^3$.

Nicotine

Nicotine was measured in the smoking area of the ground floor snack bar (18.5 $\mu g/m^3$), as well as in several lounges (range 0.6-11.7 $\mu g/m^3$). Nicotine was also measured in 4 of the 51 primary sampling locations (range 0.4-0.7 $\mu g/m^3$).

Formaldehyde and other aldehydes

The mean formaldehyde concentration in this building (Table II-3), 9.2 $\mu g/m^3$ (<0.01 ppm), was very low. The mean acetaldehyde concentration, 16.1 $\mu g/m^3$ (<0.01 ppm), was similarly low, and the mean acetone concentration was 32.5 $\mu g/m^3$ (0.01 ppm). Other aldehyde concentrations ranged from 0.1 to 2.1 $\mu g/m^3$.

Volatile Organic Compounds

Tetrachloroethylene (31 $\mu g/m^3$, 5 parts per billion [ppb]), 1,1,1-trichloroethane (23 $\mu g/m^3$, 4 ppb), toluene (15.9 $\mu g/m^3$, 4 ppb), and the xylene isomers (o-xylene, 3.2 $\mu g/m^3$ [<1 ppb], and p-xylene, 7.2 $\mu g/m^3$ [2 ppb]) were the predominant VOC species measured (Table II-3). The highest values were measured on the ground floor. Most of the targeted chlorinated compounds were found in all of the indoor samples. The mean indoor benzene concentration (6.8 $\mu g/m^3$, 2 ppb) was minimally greater than the measured outdoor concentration (6.0 $\mu g/m^3$). With the exception of benzene, indoor sources appear to be the principal contributors the VOCs.

Total VOCs, measured using gas chromatography and flame ionization detection (GC-FID), averaged 1.1 ppm carbon (Table D.16). The mean of the sum of the 27 VOCs, measured using GC and mass spectrometry (GC-MS), was 95.8 $\mu g/m^3$. Outdoor concentrations for the 27 VOCs added up to 16.7 $\mu g/m^3$.

There was no 4-PC (4-phenylcyclohexene) measured above the analytical limit of quantitation.

Pesticides

Carbon Monoxide

Whole-building average CO concentrations, measured by NIST in the building air return system, averaged between one and two ppm.

Biological Aerosols

Overall mean counts of airborne fungi inside the Madison Building, 35 colony forming units per cubic meter (CFU/m^3), were lower than mean counts in the outdoor samples, 102 CFU/m^3. The most commonly seen organisms indoors were Penicillium, Aspergillus, Sporobolomyces, and Cladosporium. Only indoor Penicillium concentrations exceeded ambient concentrations. Fungal spore counts were low and consisted of common airborne spores.

Generally, human source bacterial counts (HSB) were low (44 CFU/m^3 indoors, 80 CFU/m^3 outdoors) with Staphylococcus sp. being seen most frequently both indoors and outdoors. Micropolyspora sp. and Proteus sp. counts were higher at some locations indoors than outdoors.

Thermophylic actinomycetes colonies (Micropolyspora sp.) averaged 7 CFU/m^3 outdoors and 13 CFU/m^3 indoors.

Concentrations of microorganisms found in water-spray humidification system water samples were orders of magnitude greater than those found in the steam humidification system water samples. No thermophylic organisms were identified in any of the water samples.

Parameter	Total Sites	
	Inside	Outside
Temperature	101	1
Relative Humidity	101	1
CO_2	101	1
RSP (real-time)	101	1
RSP (integrated)	51	1
VOCs	51	1
Aldehydes	11	0
Nicotine	64	0
Pesticides	11	0
Microbiological	92	1

and Respirable Particles

Environmental Parameter	Results
Temperature (°F)	
Mean	73.1
Standard Error	0.2
Minimum	61.5
Median	73.1
Maximum	77.5
Relative Humidity (%)	
Mean	49.2
Standard Error	0.9
Minimum	34.0
Median	49.5
Maximum	72.0
CO_2 (ppm)	
Mean	491
Standard Error	15
Minimum	300
Median	501
Maximum	675
RSP: Real-time ($\mu g/m^3$)	
Mean	5.5
Standard Error	0.8
Minimum	0.0
Median	5.4
Maximum	50.0
RSP: Real-time ($\mu g/m^3$)	
Mean	19.5
Standard Error	1.3
Minimum	10.1
Median	18.0
Maximum	37.3

Chemical	Indoors	Outdoors
Aldehydes (total)	32.1	NM [1]
Formaldehyde	9.2	NM
Acetaldehyde	16.1	NM
Acetone	32.5	NM
VOCs (total of 27 targets)	95.8	16.7
Toluene	15.9	8.0
p-Xylene	7.2	3.2
o-Xylene	3.2	1.2
Benzene	6.8	6.0
Methylene chloride	4.4	1.3
Tetrachloroethylene	31.0	3.9
1,1,1-Trichloroethane	23.0	1.7
Trichloroethylene	1.0	ND [2]

[1] Not measured
[2] Not detected

1 INTRODUCTION

The quality of the air and the work environment in office buildings has become an increasingly important issue. Workers in numerous modern, apparently well-designed office buildings have voiced concern about health problems that appear to be related to working in the buildings, whether from unacceptable indoor air quality, job characteristics, or other factors. Health concerns of workers in office buildings fall into several categories, including symptoms associated with indoor air quality, comfort concerns, and ergonomic symptoms. Indoor air quality symptoms refer to a complex mix of occupant reported symptoms associated with acute discomfort (e.g., headache, fatigue, stuffy nose, sinus congestion, eye irritation, sore throat) that improve while away from work. Comfort issues include concerns about air movement, temperature, humidity, odors, and physical comfort considerations (e.g., lighting, noise). Back pain/stiffness or pain/numbness in shoulders or hands are examples of symptoms associated with ergonomic stresses (repetitive motion or awkward postures).

Building-related illnesses, another important potential health problem among office workers, are diseases that are caused by specific building-related etiologic factors. For example, hypersensitivity pneumonitis can be caused by bioaerosols produced by microbial contamination of ventilation systems, water-damaged rugs, furniture, or ceilings. This respiratory illness is characterized by infiltrates seen on chest x-rays and non-specific symptoms (fever, muscles aches, cough, and shortness of breath). Other building related illnesses include toxic effects of overexposure to chemical agents such as carbon monoxide (initial symptoms of headache and nausea) and dermatitis caused by fibrous glass which wears from ventilation duct linings. These symptoms can, of course, often occur for reasons unrelated to working in the building. Essential to the proper diagnosis of individuals with building related illnesses are physician evaluation and the measurement of environmental contaminants.

In recent years, employees in the Madison Building of the Library of Congress (LOC) in Washington, D.C. have expressed their concerns about indoor air quality and discomfort related to their work environment. In response to these concerns, the Library of Congress requested that the National Institute for Occupational Safety and Health (NIOSH) and the Environmental Protection Agency (EPA) undertake a systematic study of the nature and geographic distribution of the employees' health symptoms and comfort concerns, and to attempt to determine if associations exist between employee responses and specific workplace conditions. This study has been done in cooperation with investigators from the John B. Pierce Foundation at Yale University. At the time of this evaluation, the National Institute of Science and Technology (NIST, formerly NBS) was in the process of conducting a long-term study of ventilation and air quality at the Madison Building, under contract to the Department of Energy. Westat, Inc., a health statistics consulting firm, was brought into the study

The overall goal of this study was to characterize the extent of building-related health, comfort, and environmental problems at the Library of Congress Madison Building and to suggest remedies, where advisable.

The four specific objectives of the study were:

1. Survey the nature, magnitude, and spatial distribution of acute health symptoms and comfort concerns;

2. Characterize selected physical, chemical and biological aspects of the building in selected locations during the survey period;

3. Generate hypotheses from any associations observed between acute health and comfort effects and environmental factors while taking into account factors that would confound or modify such associations;

4. Identify areas not in compliance with standards or guidelines and make recommendations.

This is the third in a series of three reports documenting the study, and addresses Objective 3. It presents the results of a statistical investigation of the interrelationships among employees' responses regarding health and comfort concerns, the environmental monitoring data, and other potential work-related and non-work-related risk factors. Two prior reports, Volumes I and II, addressed Objectives 1 and 2, respectively. Objective 4 was addressed by bringing to the attention of the LOC Safety Office the one site with an elevated level of fungi for further attention. (Upon re-sampling at this site, a level of fungi was measured that was well within the range found throughout the rest of the bulding. It is likely that the original measurement was a spurious finding, not representative of the usual conditions in the area.)

This research effort was integrated with a parallel study at the U.S. Environmental Protection Agency headquarters where employees were also reporting physical symptoms and discomforts that they attributed to the buildings in which they worked. Both the Library of Congress and EPA surveys made use of similar study designs and survey instruments, although separate reports are being prepared for each agency. While certain details are specific to the particular buildings involved, the survey was designed to be applicable to a comprehensive study of any building suspected of environmental problems.

questionnaire administered at the time of the monitoring. Detailed descriptions of these are provided in Volume I. In addition, a description of the dependent and independent variables used in the analysis is provided in this section.

2.1 Overall Study Design

An extensive self-administered questionnaire was distributed to all federal employees at the LOC Madison Building in February 1989. The questionnaire asked about the occurrence of a variety of health symptoms within the past year and the past week, and their relationship to time at work. The questionnaire also ascertained information about demographic and personal factors, as well as descriptions of an individual's work environment. The first report (Volume I) summarized the design, conduct, and descriptive statistics of this initial cross-sectional study. A copy of the questionnaire is provided in Appendix A.

Based on the results of this questionnaire, approximately 100 sites within the Madison Building were chosen for environmental monitoring, which was performed during the week of February 27 - March 3, 1989. The monitoring results were presented in Volume II. In conjunction with the monitoring, a second survey was administered to workers in proximity (within 25 feet) to each monitoring station. This supplemental questionnaire asked about health symptoms and comfort levels experienced on the day of environmental testing. The intent of this questionnaire was to provide a point-prevalence of work-related health symptoms in areas where environmental monitoring was being done.

2.2 Selection of Environmental Monitoring Sites

A health symptom index was computed for each employee from responses to the first questionnaire (Appendix A), and a standardized mean score was computed for each room in the building. Similarly, a comfort index was computed for each employee and a standardized mean comfort score was computed for each room. Rooms were independently ranked according to the standardized health and comfort indices. Rooms selected for inclusion in this phase of the study were those with the highest and those with the lowest health scores. (Health and comfort scores were highly correlated, but only health scores were considered.) (Details of this selection procedure are provided in Volume I of this report.) Results of these rankings were not revealed to the monitoring team in order to avoid any possible observation bias.

Some additional ("special") sites were identified as being of concern by

the results obtained at those sites were reported separately in Volume II, and are not included in the analyses in this volume.

2.3 Environmental Monitoring Research Design

The basic design was to monitor approximately one hundred sites within the building and all employees who worked in the immediate area of each sampling site. The rationale for this was that environmental conditions might differ throughout the building. This variation in the environmental conditions might be related to differences in the level of complaints of employees. At all sites, information was collected about the four parameters routinely used to describe the office environment: temperature, relative humidity, respirable particulates, and carbon dioxide. At some of the sites, other measurements were also taken, including volatile organic compounds, bioaerosols, and aldehydes. Details of this sampling protocol are provided below.

Comfort and environmental parameters were monitored at the selected sites during routine employee working hours (7:00 am to 5:00 pm) during the week of February 27 - March 3, 1989. Four categories of monitoring locations were identified: primary, secondary, fixed, and special. On a typical day, samples were collected at the fixed indoor, fixed outdoor, up to 10 primary indoor, and up to 20 secondary indoor monitoring locations. Samples were collected on all five days at the fixed indoor and outdoor monitoring locations. A total of about 50 primary and 50 secondary sampling sites were identified. Sampling results from all of these locations were presented in Volume II.

2.3.1 Primary Sites

Extensive monitoring was done at each primary site to characterize the magnitude and spatial differences of the comfort and environmental parameters, and included the following:

- real-time temperature (T), relative humidity (RH), carbon dioxide (CO_2), and respirable suspended particulate (RSP) measurements were made four times daily (early morning, late morning, early afternoon, late afternoon);
- viable (fungi, thermophylic actinomycetes, and other bacteria) and non-viable (fungal spores) microbiological samples;

- integrated 9-hour RSP, volatile organic compounds (VOCs), and passive

- integrated 9-hour aldehyde and pesticide samples at 11 selected sites.

2.3.2 Secondary Sites

Real-time T, RH, CO_2, and RSP measurements were collected four times (early morning, late morning, early afternoon, late afternoon) at each secondary site.

2.3.3 Fixed Indoor and Outdoor Sites

At the single fixed indoor and outdoor sites, samples were collected daily during the survey week in order to determine the relationship between the outdoor air and the indoor air. Protocols and types of samples were identical to those described above for the primary sites. Only the results collected on the first day of sampling are included in the analyses presented in this volume.

2.3.4 Special Sites

Viable and non-viable microbiological parameters were monitored in various components of the Madison Building heating, ventilation, and air conditioning (HVAC) system. As mentioned above, when possible, environmental monitoring was performed in selected areas to support management, union, and concerned individual worker requests. Because these sites were not chosen in conformance to the overall sampling strategy (see Section 2.2), data collected at these sites are not included in the analyses presented in this report.

2.4 Supplemental Questionnaire

A short follow-up questionnaire (Appendix B) was designed to be administered to individuals near the environmental monitoring stations on the day of testing. The purpose of the questionnaire was to assess health and comfort status during the same period the environmental parameters were measured. Information was ascertained about descriptive aspects of the workstation, workstation conditions (including perception of thermal comfort and odors), health concerns, and mood.

One or two interviewers were assigned to each environmental monitoring cart.

At each of the sites sampled by the cart, the interviewer identified all workers eligible

or other ceiling to floor barrier.

Information used in this study regarding study respondents is derived from two primary sources. Information about workstation characteristics and other potential risk factors has been obtained from the comprehensive questionnaire administered to all employees. This questionnaire is referred to in this report as Q1. Information regarding work-related activities on the day of environmental monitoring are obtained from the supplemental questionnaire (referred to as Q2). Health symptoms, comfort concerns, and mood states on the day of testing are also obtained from Q2.

2.5 Dependent (Outcome) Variables

This section describes the various types of outcome measures used in the statistical models and indicates how they were developed from the specific questionnaire items. The outcome measures include health symptoms, thermal comfort, perception of odors, air quality ratings, and mood states. (Comfort and odor variables are also used as predictor (independent) variables.) A list of the dependent variables used in the data analysis is in Table 2-1.

2.5.1 Self-Reported Health Symptoms

Information was ascertained on the occurrence of each of 33 symptoms on the day of environmental monitoring from the Supplemental Questionnaire (Q2: Part III). These symptoms are the same as those in Q1, although in Q1, the time frame is different (last week and last year). A "positive work-related symptom" was considered to be one which was reported to have occurred on the day of testing, and which began after arriving at work. (Symptoms defined as beginning in the morning at work and symptoms defined as beginning either in the morning or in the afternoon at work were highly correlated. Therefore, only symptoms beginning at work either in the morning or in the afternoon were considered further.)

One option for analysis of these symptoms would have been to analyze each of the symptoms separately. However, for many of the individual symptoms, the prevalence was relatively low, which hinders the development of meaningful models. In addition, this approach would have greatly increased the probability of finding false positive results. Symptoms were therefore clustered into biologically meaningful groups, as follows. (The letters in parentheses refer to the specific symptoms in Q2, Part III). A person was considered to have a positive response to a cluster if he or she reported any of the symptoms in the cluster

H4) flu-like symptoms (f,g,h,i,u,v)
H5) ergonomic symptoms (dd,ee,ff,gg)
H6) headache, nausea (a,b)
H7) nasal and cough symptoms (c,d,e,f)
H8) chest-related symptoms (g,h,i)
H9) eye-related symptoms (k,l,m,n)
H10) throat-related symptoms (o,p,q)
H11) fatigue, tiredness (r,s)
H12) ergonomic symptoms and aching muscles (v, dd,ee,ff,gg)
H13) nervous system symptoms (x,y,aa,bb)
H14) dizziness/lightheadedness (y)
H15) dry skin (cc)
H16) nasal symptoms (c,d,e)
H17) eye irritation symptoms (k,l,n)
H18) eye strain symptoms (m,n)

Clusters H3, H4, and H5 are consistent with those reported in Volume I, generated with responses to Q1. Principal components analysis (PCA) was performed on the Q1 symptom data for the corresponding indoor air quality study at the EPA Headquarters Buildings. From the results of this analysis, clusters H6 through H16. Specifically, the PCA, using a Varimax rotation, was performed on the 5-point scales (from Part II, question 7), through which respondents reported the occurrence of symptoms during the past year. (The symptom "problem with contact lenses" was not included, since it only applied to lens wearers.) The principal component analysis was also performed on the data from the LOC Madison Building; similar results were obtained. Clusters H16, H17, and H18 have been included in the LOC analysis in an effort to improve the specificity of the more general nasal (H7) and eye (H9) symptom clusters.

2.5.2 Perceived Thermal Comfort

Employees were asked about their perception of thermal comfort (air movement, temperature, humidity) on the day of testing (Q2: Part II). Based on principal components analysis of the EPA study data and chamber studies of occupant-reported assessments of thermal comfort under a range of thermal comfort conditions found in buildings,[1] the comfort variables were collapsed into the following four clusters.

C1) too little air movement, too hot, and/or too stuffy

2.5.3 Self-Reported Odors

Information on odors perceived by employees at their workstations on the day of testing was obtained through responses to Questionnaire 2, Part II, Question 8. Principal component analysis of the EPA study data and knowledge of ventilation conditions yielded the following odor variables:

O1) chemicals, pesticides, carpet cleaning, paint (l,m,n,o)
O2) body odor, cosmetics, other food smells (a,b,e)
O3) photocopying, printing processes (j,k)
O4) fishy smells, musty/damp smells (d,f)
O5) tobacco smoke (c)
O6) diesel exhaust (i)

2.5.4 Perceived Overall Air Quality

Respondents were asked to rate their perception of the overall air quality in the building on the day of testing (Q2, Part II, Question 9) as excellent, good, fair, or poor. Two variables were created from responses to this question:

A1) 1 = poor or fair; 0 = excellent or good
A2) 1 = poor; 0 = excellent, good, or fair

2.5.5 Self-Reported Mood States

Items from the Profile of Mood States[2] that are used to form factors related to tension, fatigue, and vigor were contained in Questionnaire 2, Part IV. These factors are calculated as follows:

M1) tension (sum of items f,h,j,k,m,p,r] - item i)
M2) fatigue (sum of items a,b,l,o,q,s,x)
M3) vigor (sum of items c,d,g,n,t,u,v,w)

In contrast with the other outcome variables that have been defined in Sections 2.5.1 through 2.5.4, the three mood states variables are continuous, rather than binary, in nature. The tension score has a possible range of 3 to 39 (higher score =

more tension); the fatigue scale has a can range from 7 to 35 (higher score = more

The primary goal of this report is to assess the relationship between the health and comfort outcomes described above and environmental parameters measured. To assess this relationship in a valid manner, it is necessary to control for other factors that may also be associated with these outcomes. These other risk factors are referred to as confounders or effect modifiers. The independent variables, including both environmental measurements and potential confounders, used in these analyses, are presented in Tables 2-2, 2-3, and 2-4.

2.6.1 Environmental Measurements

2.6.1.1 Temporal Data

The temporal data (measured four times throughout the day) consisted of measurements of temperature (dry bulb), relative humidity, carbon dioxide, and respirable particulates. The following 5 variables were created and used in the regression models:

T1) dry bulb temperature (°F)
T2) relative humidity (%)
T3) natural logarithm of carbon dioxide level (ppm)
T4) natural logarithm of respirable particulate level (ug/m^3)
T5) temperature range: maximum - minimum

The mean of the four values observed (or its natural logarithm) was used as a summary variable for each of the first four temporal variables (T1 through T4). (Logarithmically-transformed values were used to normalize the distributions of these variables.) Analogous sets of variables were computed using the mean of the two morning values and the maximum value for each parameter. These were highly correlated with the daily average and were therefore not considered in further analyses. (Correlations of mean of morning values with daily mean for the four variables ranged from 0.89 to 0.97. Similarly, correlations of maximum value with the daily mean ranged from 0.89 to 0.94.)

2.6.1.2 Volatile Organic Compound (VOC) Data

At a subset of the monitoring sites (e.g., 51 primary sites), concentrations of chemicals. At each of the primary sites, a single integrated air measurement was made (over a nine-hour time frame). Many of the concentrations for the individually measured VOCs fell below the detection limits for all or most of the sample sites. Nine VOCS had a sufficient number of measurable values to warrant further consideration: 1,1,1-trichloroethane, benzene, trichloroethylene, toluene, tetrachloroethylene, ethylbenzene, o- and p-xylene (combined), methylene chloride, and n-octane (all measured in ug/m^3). In addition, total VOCs (in ppmc) and respirable particulate (RSP) concentrations (ug/m^3) were measured at the same sites. (These RSP measurements differ from the temporal RSP measurements in two ways: 1) measured over the course of 9-hours, versus four instantaneous measurements; and 2) the particle size captured is different. For the VOCs, "not detected" values were set equal to 0.5 times the limit of detection (LOD), "trace" values wet set at the midpoint between the limit of quantification (LOQ) and the LOD [0.5*(LOQ+LOD)], and "not calculated" values were treated as missing.

Principal components analysis of the nine VOCs performed with the parallel EPA indoor air quality study data yielded two major factors: (1) total of concentrations of 1,1,1-trichloroethane and tetrachloroethylene, and (2) total of remaining seven VOCs. Because of the unique features of methylene chloride relative to the other six compounds in the group and because this variate was only weakly associated with the group, methylene chloride was treated as a separate variable. The VOC-related variables used in statistical modeling consisted of the following variables:

V1) ln [total of concentrations (ug/m^3) for 1,1,1-trichloroethane and tetrachloroethylene]
V2) ln [total of concentrations (ug/m^3) for benzene, toluene, trichloroethylene, ethylbenzene, o- and p-xylene, n-octane]
V3) ln [methylene chloride concentration (ug/m^3)]
V4) ln [total VOCs (ppmc)]
V5) ln [integrated RSP concentration (ug/m^3)]

2.6.1.3 Biological Data

Microbiological data were obtained at each of the primary sites. The data consisted of counts of colony forming units (CFUs) for various fungi, human source bacteria, and thermophiles. Fungi may be associated with allergic reactions (sneezing, runny nose) or respiratory symptoms. Bacteria of certain types (e.g., Legionella) have been associated with building-related illness. Thermophilic bacteria, which thrive in warm, moist areas, may be associated with certain respiratory symptoms, including

Aspergillus	Alcaligenes
Cladosporium	Klebsiella
Mucor	Micrococcus
Penicillium	Micropolyspora
Phoma	Proteus
Rhizopus	Serratia
Sporobolmyces	Staphylococcus
Verticillum	Streptococcus
Yeast	Un-identified
Un-identified	

Because the number of any specific species of fungi or bacteria was very small, they were not included in further regression analyses. The three variables derived from the bioaerosol data were:

B1) $\log_{10}$ [total fungi (CFU/m^3)]
B2) $\log_{10}$ [total bacteria (CFU/m^3)]
B3) $\log_{10}$ [total thermophilic bacteria (CFU/m^3)]

There were no organisms found at a substantial number of sites and, therefore, a large number of persons had values of zero for counts of fungi (N=133; 20% of study population), bacteria (N=77; 11%), and thermophilic bacteria (N=341; 51%). Since the logarithm of zero is undefined, and would therefore be considered as missing values in analyses using the transformed data, the values of zeros were reassigned the value of "1" prior to logarithmic transformation. These values are considered as zero in the transformed data, since the log of 1 is zero.

2.6.1.4 Aldehydes and Pesticides

These measurements were made at only 11 sites within the Madison Building. Because of the relatively small number of individuals represented by these 11 sites (87 of the 674), complete multivariable analyses were not performed for these data. However, descriptive data are presented in Section 3.2.2 of formaldehyde, acetaldehyde, acetone, and carbonyls.

primary sampling locations, with a range of only 0.4 to 0.7 ug/m^3. All other nicotine samples were below the limit of quantification. Therefore, no further analysis was performed with these data.

2.6.2 Other Potential Risk Factors (Workplace, Personal, Medical Confounders/Effect Modifiers)

The models for relating the reported health systems and comfort concerns to the exposure measurements can be influenced by a variety of confounding factors -- that is, workplace, personal, or medical characteristics that are associated with both the health and comfort outcomes and the environmental measurements, and can cause spurious or false associations between them. Among these factors are type of workspace, years spent at one's workstation, employee age, gender, smoking status, pay grade, and history of medical conditions such as asthma. A complete list of the variables considered in the regression models is found in Tables 2-3 and 2-4.

These risk factors are chosen based on results of prior study and biological plausibility. For example, it may be hypothesized that older individuals may have a higher frequency of certain health symptoms, or that lower pay grade employees may experience more health problems due to several factors (e.g., poorer medical care).[5,6] Persons wearing glasses or contact lenses may be more subject to eye irritation, headaches, and fatigue. With regard to type of workspace (e.g., open area vs. enclosed office), it might be that those with less privacy may more frequently incur stress-related symptoms such as headaches,[5,6] or that the presence of partitions may serve to modify the airflow to an individual's workspace.

Also considered as potential risk factors for reporting health symptoms are seven scales dealing with work-related and non-work-related stresses. These scales, derived from responses to Questionnaire 1 (Part IV), are described in Appendix C. The scales assess overall job satisfaction, role conflict, job control, workload, utilization of abilities, role clarity, and external stress. These psychosocial factors, which are partly personal and partly job-related, have been linked to a variety of health symptoms.[7,8]

2.7 Statistical Analyses

The statistical analyses presented in this report are of two major types:

1) descriptive statistics of the dependent and independent variables evaluated

2) statistical modeling results that relate the questionnaire responses data to the environmental data. Linear regression techniques were employed for outcomes that are relatively continuous in nature (mood states); logistic regression techniques were used in the evaluation of the dichotomous symptom outcomes.

The second item is the main focus of this report, since it addresses the primary objective of the study: to determine the association between the environmental factors measured at the LOC Madison Building and the self-reported health symptoms, perceived air quality, comfort concerns, mood states, and odors noticed.

3 RESULTS

During Phase I of the study, 3176 questionnaires (Q1) were delivered to federal employees at the Madison Building. Of these, 2845 were completed and returned, for a response rate of 90%. The supplemental questionnaire (Q2) was made available to the 811 persons who were at their desks on the day of the survey. Of these, 785 (97%) were completed and returned. Of these 785, 111 persons did not complete Q1 and were therefore eliminated from further analysis since data regarding workplace, demographic and other confounding risk factors were not available about them. The final data set consists of 674 individuals who completed both questionnaires. Further description of the participation rates in Phase II is provided in Table 3-1.

3.2 Descriptive Analyses of Dependent and Independent Variables

3.2.1 Dependent Variables

Health Symptoms

Table 3-2 summarizes the prevalences of positive responses to each of the symptom clusters. The percentages of positive responses are shown separately for the high complaint and low complaint areas (as defined using Q1), and for males and females. For all symptom clusters, the percentage of female employees reporting work-related health symptoms is greater than the percentage of male employees reporting the same symptom cluster. Because gender may be associated with other potential risk factors for the occurrence of symptoms, further analysis was not performed separately for each gender, but used gender as one of the variables in multivariable analyses. A consistently higher percentage of health symptoms was reported by workers in the areas designated as "high complaint" than in the "low complaint" areas. This is not surprising, given that the areas were thus designated based on symptom reporting on the first questionnaire.

The prevalence of each of the symptoms used to generate the symptom complexes is presented in Appendix D. The prevalences of symptoms reported to have occurred on the day of monitoring (and which began after arriving at work) ranged from 0.6% (fever) to 32% (sleepiness). Also presented in this table are the prevalences of the same symptoms as reported on the first questionnaire (Q1) among the 674 persons who completed both questionnaires. A "positive" symptom for Q1 was defined in two ways: 1) a symptom that occurred "often" or "always" in past year and got better away from work ("Q1: O/A"), and 2) one that occurred "sometimes," "often," or "always" in past year and got better away from work ("Q1: S/O/A"). The associations between the symptom reports from Q2 (day of monitoring) and symptom

or "always" in the past year. (The difference between the prevalence of Q2 symptoms and the prevalence of Q1: O/A symptoms was statistically significant in 13 of 31 symptoms ($p<0.05$ by McNemar's test) and the prevalence of Q2 symptoms was lower than Q1: S/O/A symptoms in 30 of 31 symptoms ($p<0.03$ by McNemar's test)).

Comfort Concerns

The percentages of respondents with positive responses for the thermal comfort clusters are presented in Table 3-3. These percentages are presented by gender and for high and low symptom complaint areas (as defined by responses to Q1). The most prevalent concerns were those describing conditions as too hot and stuffy (60%, overall). There was a higher reporting of C1 (too hot, stuffy) and C2 (too dry) among those in the high symptom complaint area than in the low symptom complaint areas. There was no significant difference in the prevalence of positive reports for C3 (too humid) and C4 (too cold) between the high and low symptom complaint areas. Overall, there was a higher reporting of comfort concerns among females; however, this difference was statistically significant only for reports of being too cold (χ^2: $p=0.001$) and was seen primarily among respondents in the low symptom areas.

Perception of Odors

The percentages of respondents reporting positive odors are shown in Table 3-4. Only O2 (body odor, cosmetics, food smells) had an appreciable number of positive responses (37%, overall); therefore, only the O2 cluster is included in the multivariable analyses. There were no significant differences in reported prevalences of odors between males and females. Furthermore, although for each odor cluster there was a higher prevalence among employees in high symptom complaint areas, none of these differences was statistically significant.

Air Quality Acceptability

The air quality was rated fair or poor by 60% of respondents (Table 3-5) and was rated poor by 12%. Significantly more females rated the air quality as fair or poor than did males (67% vs. 52%; χ^2, $p=0.0002$). In addition, significantly more persons in the high symptom complaint areas reported the air quality to be fair or poor (65% vs 55%; χ^2, $p=0.04$) or poor (15% vs 9%; χ^2, $p=0.01$) than those in low symptom complaint areas

Table 3-6 summarizes the mood factor scores. Males reported a statistically significant higher mean vigor score than females, though the magnitude of the difference was not great (20.0 vs 19.0; t-test, $p=0.05$). Persons in the high symptom complaint areas reported higher mean tension scores (9.0 vs. 7.7; t-test, $p<0.001$), higher fatigue scores (13.2 vs. 11.3; t-test, $p<0.001$), and lower vigor scores (18.7 vs. 20.4; t-test, $p=0.002$) than those in low complaint areas.

3.2.2 Independent Variables

3.2.2.1 Environmental Measurements

Table 3-7 presents summaries of the distributions of the environmental variables, by gender and symptom complaint level. Several of these variables, including CO_2, respirable particulates, VOCs, and bioaerosols, are expressed as logarithmic transformations. To aid in interpretation of the levels observed among the study population, the distributions of the non-transformed variables are provided in Table 3-7a.

There are several statistically significant differences between the high and low symptom complaint areas (by student's t-test). The mean temperature was higher in the high than the low symptom areas ($p<0.0001$); however, the difference was less than one half a degree Fahrenheit (73.5 vs 73.1). The mean relative humidity measured at the high symptom areas was lower than at the low symptom areas ($p=0.03$); again, however, the magnitude of the difference was small (49.5% vs 50.3%). There was a higher level of respirable particulates as measured temporally in the high symptom areas [1.64 vs 1.54 (natural logs); $p=0.005$)]; however, the difference in respirable particulates taken in an integrated sample was not significant [2.80 vs. 2.71 (natural logs)].

There were slightly higher levels of three of the four parameters used in assessing volatile organic compounds in the high symptom areas (t-test, $p<0.05$ for V2 (natural log of combination of 7 VOCs) and V3 (natural log of methylene chloride). However, the total VOC level was slightly higher in the low symptom areas [-0.01 vs 0.07 (natural logs); $p=0.07$)].

The logarithm of level of total fungi was higher in the high symptom levels; however, there was no difference in fungi level when the results of one location which measured above 1500 colony forming units was excluded. This location was clearly an outlier among the measurements. The mean level of total bacteria was lower in the

pneumonitis, were not detected in the Madison Building.

The aldehyde levels were measured for only 11 locations, representing 87 individuals. Because this included only one location in the low symptom areas, tests of statistical significance are not appropriate. However, there are no remarkable differences between the high and low symptom areas. The levels of formaldehyde, acetone, and carbonyl were slightly lower in the high symptom areas than in the low symptom area. Only for acetone was the level higher in the high symptom areas. It is noted, however, that for all of these substances, the levels were low and the differences small.

3.2.2.2 Potential Confounders/Risk Factors

Tables 3-8 and 3-9 shows the distribution, by gender and symptom complaint level, of the variables considered as potential risk factors and confounders. There were several statistically significant differences among these variables between high and low symptom complaint areas, as well as between males and females (by χ^2 test). There were significant associations between working in office spaces with mid-height partitions (vs. all other office types) and being in a high symptom area ($p=0.004$), and working in open areas (vs. all others) and being in a low symptom area ($p=0.006$). Although there was approximately the same percentage of workstations with mid-height partitions among males and females, there were fewer females with enclosed offices (14% vs. 21%) and more with open areas or stacks (25% vs. 18%; $p=0.05$).

There were more males than females reporting that they went outside on the day of monitoring (57% vs. 49%; $p=0.03$). However, more females than males reported that they were near a source of VOCs (copier or laser printer) (39% vs. 25%; $p<0.0001$), used a printer (56% vs. 45%; $p=0.005$), or used a copier (29% vs 22%; $p=0.06$).

Among those in the high symptom areas, there were more individuals reporting the use of glues and chemicals (13% vs. 7%; $p=0.008$) and fewer who could see a window from their workstation (14% vs. 29%; $p<0.0001$).

Compared with the low symptom areas, there were fewer persons in the high symptom areas who reported to be in the high pay category (11% vs. 22%; $p<0.0001$) and more in the lowest pay category (44% vs. 35%). Similarly, there were more females reporting to be in the lowest pay category (48% vs 31%) and more men in the highest pay category (21% vs. 12%; p=0.005). Additionally, there were more males

actual difference was relatively small (45.5 vs. 40.5). Women reported a statistically higher mean number of external stresses than men (2.0 vs. 1.7; t-test, p=0.006).

Interpretation of the individual factors listed in Tables 3-8 and 3-9 as potential risk factors for the occurrence of symptoms should be done with caution. Some of these factors are correlated with one another, and therefore individual associations with symptoms may be spurious. To account for this problem, further regression analyses were performed that control for the effect of these factors simultaneously.

3.3 Multivariable Regression Analyses

3.3.1 Analytic Approach

To determine if the various environmental measures are associated with the outcome (dependent) variables requires the development of statistical models. These models allow the measurement of the association between outcome variables (symptoms, comfort, mood) and workplace exposures (environmental measurements), while controlling for a variety of other potentially confounding risk factors (gender, age, medical conditions, etc.). Two types of models were used:

1) Linear multiple regression models were used to relate continuous outcome variables to the independent variables. These models were used in assessing the risk factors associated with the self-reported mood states, which consist of a score for each individual from a range of possible scores. The linear regression parameter of interest is the "beta" coefficient, which represents the estimated change that occurs in the outcome measure due to a change of one unit in the independent (exposure) variable. For those independent variables that have only a 0 or 1 value (e.g., gender), the associated beta estimate represents the change in the outcome variable between the 0 and the 1 categories.

   The question arises as to whether the beta coefficient is "statistically significant," i.e. is it different from zero? Statistical significance of the beta coefficients can be represented in two manners: 1) p value; i.e. the percent chance that the association occurred by chance. A p value of less than 0.05 is often considered "statistically significant." 2) Confidence Interval, which is derived using the standard error of the beta. A 95% confidence interval, e.g., covers, with 95% confidence, the true coefficient. If the confidence interval does not include 1, the beta is considered "statistically significant."

logistic regression is also referred to as the beta coefficient, and represents the estimated change in the log odds due to a change of one unit in the independent (exposure) variable. The parameter is expressed in this report as the odds ratio (OR), which is the exponential of the beta. For example, in the analysis of the occurrence of a symptom and exposure to Substance X, the odds ratio represents, for those with the symptom, the odds of being exposed to Substance X divided by the odds of not being exposed to Substance X. In the case of a continuous variable, the odds ratio reported here represents the odds, for those with symptoms, of being exposed to Substance X at a level of 1 (logarithm of Substance X) divided by the odds of having no exposure to Substance X. An odds ratio (OR) of "1" means that there is no association between exposure and outcome. An OR greater than "1" represents a positive association between exposure and outcome, and an OR less than 1 represents a negative association. Care should be taken when interpreting the OR when the exposure measure is expressed as logarithms of the substance. This represents the change in odds ratio per *logarithmic* unit of the substance, and the magnitude of the association will therefore appear at first glance to be much higher than it really is. Tests of statistical significance are analogous to those described above for linear regression parameters.

Choice of Dependent Variables

The initial candidate set of outcome variables, as described previously, consisted of 18 health symptom measures, four comfort concern measures, three mood state measures, seven odor measures, and two air quality ratings. Based upon the preliminary descriptive analysis presented in Section 3-2, several of these were dropped. One of the comfort variables and most of the odor variables were dropped because of the low prevalence of positive responses observed. The set of dependent variables used in these analyses is found in Table 2-1.

Modeling Strategy

As described in previous sections of this report, information was gathered about a large number of health and comfort outcomes, exposure levels, workplace characteristics, and other potential confounding factors. A strategy was developed to analyze this information in a meaningful way, with the goal of understanding the relationships between health and comfort outcomes and environmental exposures, while controlling for other potential risk factors. The first step was to identify all potential workplace, personal, and medical risk factors and to choose a set of these

study it. (For example, even it was considered quite plausible that persons with asthma would experience more health symptoms than those without asthma, if only two individuals had reported asthma, it could not have been evaluated in this population.) The resulting list of 20-25 variables was considered in a series of logistic regression models to determine a subset of that list that appeared to be consistently significantly associated with a variety of symptoms. From these analyses, a small subset of variables was chosen to be included in all further models that included the environmental exposure variables.

The environmental variables were grouped into 6 categories, relating to different types of environmental exposures. Associations between these exposure variables and health and comfort outcomes were then determined. A more detailed description of this analytic process is provided below.

Health Symptom Outcomes

The health symptom clusters were considered in two groups - those consisting of symptoms often observed in investigations of indoor office environments (respiratory symptoms, fatigue, headaches, etc.) (referred to here as building-related symptoms) and those related to ergonomic concerns (pain in hands, back, eye strain, etc.). Based upon preliminary univariate analyses and consideration of biologic plausibility, a subset of independent variables (workplace, personal, and medical risk factors) was chosen for each of the two types of symptoms. These variables (listed below) were entered into a logistic model for each symptom complex in a stepwise fashion. (A variable was allowed to enter the model if its beta coefficient was significant at the $p \leq 0.10$ level.)

Building-Related Symptoms	Ergonomic Symptoms
work space	hours at VDT
source of VOCs	lighting
used computer	glare
wood furniture	chair comfort
hours at workstation	table comfort
chemicals/glues	work space
used printer	hours at workstation
used copier	years at workstation
years at workstation	

asthma	external stress
6 job stresses	contact lenses
external stress	contacts/glasses
contact lenses	financial situation
contacts/glasses	education level
financial situation	
education level	

A summary of these regression models is contained in Appendix E. This table presents, for each symptom variable, the list of workplace, personal, or medical variables that entered the regression model. Based on the results of these logistic regression analyses, a smaller group of independent variables was selected, based on consistency and magnitude of effect. These final sets of workplace, personal, and medical confounders were forced into subsequent models testing for the effects of the environmental parameters. The final variable subsets were as follows:

Building-Related Symptoms	Ergonomic Symptoms
gender	gender
age	chair comfort
role conflict	lighting
external stress	glare
contact lenses	role conflict
used copier	financial situation
chemicals/glue	

It should be noted that, although gender is included in these analyses, there is evidence from these preliminary analyses that its effect may be inconsequential, once the effects of confounding variables are accounted for. While it is true that for each symptom cluster there is a higher reporting of symptoms among females than males when looking at gender alone, when the other workplace, personal, and medical (W/P/M) factors were included in the models, the effect of gender became inconsequential in most of the models. It was decided to include gender in all models, since it may act as a proxy or surrogate for the combined effect of other risk factors, such as pay category, education level, and stresses, most notably, external stress, workload, and role clarity. When W/P/M variables, including gender, were forced into the regression models, gender contributed no statistically significant predictive power above and beyond the W/P/M variables (by a Wald χ^2 approach) in 12 of the 18 models. However, if gender was allowed to enter, as were the other W/P/M variables, in a stepwise fashion, it entered the model (at $p \leq 0.10$) for 12 of the 18 symptom

other independent variables listed above, the joint significance of all possible interactions was tested, using a likelihood ratio test. None of the interaction terms was significant for any of the models.

A series of logistic regression models was then constructed to assess the added significance of the environmental parameters. These were added in 6 separate "chunks," as listed in Table 2-2. The six groups of environmental parameters were as follows:

1. **Temperature/Humidity:**
   Measured parameters: temp, RH, max-min temp
   Perceived parameters: too hot, too dry, too cold
2. **Carbon dioxide:** natural log of CO_2 concentration
3. **Respirable particulates:** natural log of RSP concentrations: temporal and integrated measures
4. **Perceived Odor:** body odor, cosmetics, food (Y/N)
5. **VOCs:** 4 VOC parameters: natural logs of 2 VOC groupings, natural log of methylene chloride concentration, and natural log of total VOCs
6: **Bioaerosols:** log(total fungus count), log(total bacteria count), log (total thermophilic bacteria count)

For each of the 6 sets of environmental parameters, all variables in the set ("chunk") were forced into the regression model and the contribution of the entire set was assessed for statistical significance.

In order to determine the effect of using the "standard" set of variables listed above, rather than using the set that best fit the model for each specific symptom cluster (listed in Appendix E), regressions using the temperature and humidity variables were run with both the standard set and the individual set identified for each symptom cluster. There were no notable differences in the resulting models. The coefficients of the temperature and humidity variables were essentially the same, resulting in the same interpretations. Therefore, for ease of comparison of the models, only the results using the standard set of independent variables are presented.

3.3.2 Logistic Regression Results: Health Symptoms

The complete listings of the logistic regression results for each symptom cluster are contained in Appendix F. A summary of these findings is presented in Table 3-10. Almost all of the symptom complexes were significantly associated with the

the association between comfort and symptoms, ranged from 2 to 4. That is, controlling for confounding factors, persons who reported the occurrence of symptoms had 2 to 4 times the odds of reporting being uncomfortable as those without symptoms. It is of note that, although the magnitude of the odds ratios was slightly lower, symptoms associated with ergonomic stresses were also associated with perception of thermal comfort.

Only non-specific indoor air quality symptoms (headache, fatigue) were associated with the carbon dioxide level (OR = 8.0; 95% CI =1.4, 16.8). However, this translates to a mean CO_2 level for those with this symptom complex of 503 ppm and 493 ppm for those without the symptom complex. Although this difference may be "statistically significant," it is quite small, and in fact, less than the degree of accuracy of the measuring apparatus, which measures CO_2 levels in increments of 25 ppm.

No statistically significant associations were detected for the occurrence of symptoms and measured respirable particulates, using either the temporal or the integrated measurement. Nor were any statistically significant associations seen for symptoms and measured levels of volatile organic compounds (VOCs).

In assessing the association between symptom occurrence and the perception of odors (body odor, cosmetics, food smells), the odds ratios ranged from approximately 1.5 to 2.3. That is, persons with symptoms had 1.5 to 2.3 times the odds of reporting odors than those who did not report symptoms. Again, this occurred for ergonomic symptoms as well.

The only statistically significant association between symptoms and bioaerosol levels (logarithm_{10} of fungi, bacteria, and thermophilic bacteria counts) was that between level of fungi and reporting of dizziness. All other symptom complexes were not associated with bioaerosol levels.

3.3.3 Logistic Regression Results: Comfort Concerns

Analyses were performed to identify risk factors for reporting the perception of being thermally uncomfortable (being too hot, too cold, or air too dry). Persons who reported being too hot experienced air temperatures that were higher than persons not reporting being too hot (Odds Ratio=1.23; 95% CI=1.00, 1.46). That is, for each degree increased, the odds of reporting being too hot increase by 23 percent. The actual magnitude of this difference is small, i.e. persons reporting it being too hot experienced a mean temperature of 73.5°F, while all others experienced a mean

(OR=0.78; 95% CI=0.65, 0.93). For each degree decreased, the odds of reporting being too cold increase by 22 percent. Again, the magnitude of the difference is relatively small; the environment of persons reporting it was too cold had a mean temperature of 73.0°F, and all others had a mean temperature of 73.5°F.

The perception that the air is too dry was negatively associated with relative humidity (OR=0.93, 95% CI=0.89, 0.97); i.e. persons reporting that the air was too dry on the day of testing did experience a lower relative humidity than other respondents, though the actual magnitude of this difference was small (48.7% vs. 50.2%).

The parameters reflecting thermal discomfort were not related to the level of carbon dioxide. Most of the thermal comfort parameters were also not unrelated to levels of respirable particulates, though persons reporting that it was too cold had a lower level of respirable particulates, measured temporally (OR=0.33, 95% CI=0.15, 0.74).

Reporting that the environment was too hot or too dry was associated with the perception of odors. (Too hot: OR=1.7, 95% CI:1.1, 2.4; Too dry: OR=1.5, 95% CI: 1.00, 2.2).

There were no positive associations between being thermally uncomfortable and the level of volatile organic compounds (VOCs), though the perception of being too dry was negatively associated with the level of one of the VOC combinations (V2) (OR=0.2, 95% CI: 0.1, 0.6). Though this was statistically significant, there is no apparent reason why this should have occurred. It is most likely a spurious finding, occurring as an artifact of the multiple comparisons being made in this analysis.

No consistent association was seen between bioaerosol levels and perception of comfort, with the only statistically significant ($p=0.04$) association between reporting it to be too hot and stuffy with an increase in total bacteria count.

3.3.4 Logistic Regression Results: Odors

There were no associations between the perception of odors and parameters of measured or perceived temperature or humidity, with odds ratios ranging between 0.95 and 1.5. None of these odds ratios was statistically significant.

There were also no significant associations between perception of odors and levels of carbon dioxide, respirable particulates, volatile organic compounds, or

Persons who reported that the overall air quality was fair or poor (vs. good or excellent) had an increased odds of reporting that their work environment was too hot (OR=7.9; 95% CI=4.9, 13.0), too cold (OR=2.6; 95% CI=1.6, 4.5), and too dry (OR=2.7; 95% CI=1.5, 4.6). There was no relationship, however, between overall perception of air quality and actual measured temperature and relative humidity, when the parameters pertaining to perception of thermal comfort were included in the model. Similar findings were noted in the analysis of persons reporting the perception that the overall air quality was poor (vs. fair, good, or excellent), though the odds ratios were smaller.

There was a statistically significant association between reporting that the air quality was fair or poor and the CO_2 level (OR=8.6; 95% CI=1.5, 48.2). Again, though this is statistically significant, the difference translates to a level of 503 ppm for those reporting the air quality to be fair or poor, while those reporting it to be good or excellent had a mean CO_2 level of 493 ppm. Similar results were found comparing those who reported the air quality to be poor and those who reported it to be fair, good, or excellent, though, because of the relatively small number of persons reporting the air quality to be poor, the association was not statistically significant (OR=17.4; 95% CI=0.8, 397.8). In this case, as well, the difference translates to an actual difference of 513 ppm for those who reported the air quality to be poor and 498 ppm for all others. These differences, though statistically significant, are less than the accuracy of the measurement apparatus, and therefore are should be interpreted with caution.

There were no significant associations between the perception of air quality and the levels of respirable particulates and bioaerosols. There was a statistically significant association between reporting that the air quality was fair or poor and level of methylene chloride (V3). However, no other significant relationships were found between perception of air quality and VOC levels.

As with health symptoms and perception of thermal comfort, the perception of the overall air quality was associated with the perception of odors (OR=1.7; 95% CI=1.2, 2.4). That is, those who reported that the air quality was fair or poor had 1.7 times the odds of reporting perceiving body odors, cosmetic odors, or food smells.

3.3.6 Linear Regression Results: Mood State Scales

Tension scores were positively related to the measured temperature (beta=0.46, p=0.01). That is, for every increase in temperature of one degree, the

CO_2, respirable particulates, bioaerosols, or the perception of odors.

There were no consistent relationships between mood scales and volatile organic compounds, although the scale related to vigor was significantly associated with higher levels of one group of VOCs (benzene, toluene, trichloroethylene, ethylbenzene, o- and p-xylene, n-octane) (beta = 3.28, p=0.02) and lower levels of methylene chloride (beta = -1.25, p=0.04).

DISCUSSION

The study design used in this evaluation of the Library of Congress Madison Building has a number of strengths and weaknesses in assessing the risk factors of health effects experienced by the employees. It is a study of a relatively large population in a single building. The study design afforded the opportunity to observe workers' health and comfort experience on the same day as a host of environmental conditions were measured. The first phase of the study consisted of a questionnaire administered to the entire building population; during the second phase of the study, environmental measurements were made at approximately 100 locations within the building and a second questionnaire was administered to employees in proximity to the sampling locations. A high response rate was obtained in both phases of the study (Phase I: 90%; Phase II: 97% of available workers), minimizing the potential for a selection bias. This type of bias may be present with a low participation rate, often because the persons with more health problems tend to volunteer for participation in the study, whereas people without problems may not.

This is a cross-sectional study, i.e., the health outcomes and exposures were measured at a single point in time. Although there was little potential for selection bias occurring among the current workforce because of the high response rates in both phases of the study, inherent in this type of study design is the potential for a "survivor" bias; i.e. people who left the workforce because of work-related illness are not in the study population. Although there were several accounts of persons who may have experienced health effects serious enough for them to leave the workforce, the number of these persons was small, and was not considered to be a major problem in this study.

With the exception of the results of the first questionnaire, which were obtained from the entire population of the building, inferences should not be made to the building as a whole or to other buildings, particularly with regard to the prevalence of symptom and comfort concerns and overall environmental monitoring results, because of the purposeful (non-random) process by which the monitoring sites were selected. That is, information from the first questionnaire was used to identify those areas with higher than average health and thermal comfort complaints and lower than average health and comfort complaints. However, it is noted that the 674 individuals who were selected for Phase II of the study and who completed both questionnaires were similar to the 2171 individuals who completed only the first questionnaire with regard to age (42.1 vs. 42.6; t-test: $p=0.23$), gender (46.0% male vs. 47.2%; χ^2: $p=0.59$) and years at their workstation (4.8 vs. 4.9; t-test: $p=0.68$).

In addition, monitoring was not carried out in the breathing zone of individuals;

rather, for economy, stationary area sites were used. The supplemental

workers who spent much time away from their workstation may have been misclassified with respect to their exposure levels, or air drafts or other conditions may have existed that might have lead to differences in environmental conditions experienced by workers within the same monitoring location.

Another limitation of the study design is the fact that measurements were taken at only one point in time, providing a "snapshot" of the environmental conditions and health concerns experienced at the given point that the monitoring took place. Concern was voiced to study investigators by a number of employees during the week of environmental monitoring that conditions were much better than usual and that they felt that some deliberate improvements were made by building engineers because of the study. There is some evidence that speaks against this possibility. The year-long evaluation of the ventilation system of the Madison Building performed by NIST showed no remarkable differences during the week of the survey.[9] In addition, temperature and humidity logs routinely maintained by building maintenance personnel showed some small differences during the survey week compared with the week prior to the survey (many locations were slightly cooler with slightly lower relative humidity). However, there was no evidence to support the concern that the HVAC system had been manipulated during the survey week. Brief summaries of the NIST and temperature log data are provided in Appendix G.

4.2 Principal Findings and How They Relate to Other Studies

The primary objective of this study was to assess the relationship between self-reported responses (health symptoms, comfort concerns, odors noticed, perceived indoor air quality, and mood states) and objective environmental measurements (temperature, humidity, carbon dioxide, respirable suspended particulates, several volatile organic compounds, and bioaerosols). No consistent relationships between symptoms and environmental measurements were noted. The few associations that were observed to be statistically significant were sporadic and inconsistent for symptoms of a similar nature.

Several experimental studies have demonstrated an association between symptoms and volatile organic compounds (VOCs).[10,11] In addition, Morey and Jenkins[12] reported total VOC concentrations in the range of 1 ug/m^3 to over 2000 ug/m^3 with a mean of 660 ug/m^3 from 109 indoor samples of 15 office buildings with occupant complaints. However, the rates of occupant complaints among these workers were not reported. Hodgson, et al.[13] reported that total VOC levels were related to "complaint" rates. The mean levels found were 0.14 ppm to 3.59 ppm in different areas of the building; however 4 of 5 samples were below the

of epidemiologic studies often fail to find any differences in VOC levels between persons with symptoms and those without symptoms.[14-17] The total VOC concentration in the Madison Building was low compared to many other studies. In fact, it is possible that the negative findings with regard to an association between symptoms and VOC levels at the Madison Building may be due to the generally low levels of VOCs and the small variation noted across areas in the building.

Perceived comfort levels were significantly associated with objective thermal measurements. That is, persons who complained of being too hot did experience a slightly higher mean temperature than other respondents, and persons reporting it to be too cold experienced a slightly lower mean temperature than other respondents. In addition, the mean relative humidity (RH) of those reporting it to be too dry was slightly, but significantly, lower than the mean RH for other respondents. It should be noted, however, that the measured ranges of temperature and relative humidity were small and within accepted standards for indoor office environments.

Another objective of this study was to assess the relationship between health symptom reports and comfort concerns. Almost all of the symptom complexes studies were significantly associated with the variables related to perception of comfort (too hot, too cold, and too dry). The odds ratios, adjusted for potential confounding factors, estimating the relationship between symptoms and comfort concerns ranged from 2 to 4., that is, persons who reported the occurrence of symptoms had 2 to 4 times the odds of reporting being uncomfortable as those without symptoms.

A number of other studies of the indoor office environment have observed associations between comfort parameters, such as air freshness, temperature, and humidity, and symptom prevalence. Some of these studies support the findings at the Madison Building; i.e., occupants' perception of air freshness or humidity related to symptom reporting, but no relationship was found to actual measurements.[18,19] Other recent studies observed associations between symptoms and objective measurements. In general, negative associations were seen between mucous membrane symptoms and humidity and positive associations between symptoms and temperature.[20-23] However, the temperature range observed in most of these studies was larger than that observed at the Madison Building, and the relative humidity was considerably lower than at the Madison Building. Most studies demonstrating an association between symptoms and temperature and relative humidity[21,22,24-26] evaluated buildings with areas experiencing much lower relative humidity than were seen at the Madison Building. Relative humidities in these studies ranged down to 10-15%; whereas the mean RH at the Madison Building was 49.5%, with a range of 36.7% to 61.5%.

Ambient Air Quality Standard for particulates is 75 ug/m^3. The mean respirable particulate levels measured at the Madison Building for the two measurement techniques were 5 and 18 ug/m^3, with peak measurements of 20.5 and 37 ug/m^3, respectively.

These levels were low in comparison to studies which documented an association with symptoms. In a study reported by Hodgson, et al,[13] particulate levels ranged from non-detectable to 90 ug/m^3, with a mean of 36 ug/m^3. Armstrong[28] reported RSP levels ranging from "negligible" to 1.07 mg/m^3, with a mean of 0.13 mg/m^3. The high RSP levels in that building were most likely due to the adjacent highway, smoking, and construction within the building.

In summary, this evaluation of the Madison Building demonstrated no consistent relationships between health symptoms and measured environmental contaminants, including volatile organic compounds, respirable particulates, and bioaerosols. Although there have been a number of studies in the literature which do document a positive association between symptoms and these substances, the levels of contaminants measured in those studies were, by and large, much higher and more variable than those observed at the Madison Building. In addition, this evaluation documented a positive association between health symptoms and perceived comfort. This supports the findings of several other studies. No association, however, was seen in this study, between symptoms and measured parameters of thermal comfort (temperature and relative humidity). Again, the range of temperature was relatively small and within normally acceptable limits, and the range of relative humidity readings measured at the Madison Building was substantially better than that of positive studies.

4.3 Association of Health/Comfort Concerns and Workplace, Personal, and Medical Risk Factors

Gender

As seen in many other studies of the office environment, it was noted in this study that females tend to report more symptoms than males. The reason for this is unclear. There are three possibilities: 1) that, for physiologic reasons, women do indeed have more symptoms than men, 2) that, for cultural reasons, women tend to report more symptoms than men, and 3) that women have more risk factors for the development of symptoms than do men. Some evidence in this study points to the last reason. For example, there are more women in the low pay category than men, stress. These risk factors appear to account for much of the overall difference in symptom reporting seen between men and women. Although gender, when considered by itself, was significantly associated with reports of almost all symptoms, when a variety of workplace, personal, and medical (W/P/M) variables were controlled for, gender did not add any significance to the model for most of the symptoms.

Workstation Risk Factors

A number of workstation factors were found to be associated with a variety of health complaints (at $p<0.10$). The most predominant of these was use of a photocopier on the day of the study, which was significantly associated with eight of the 14 symptom complexes (not including ergonomic symptoms), with odds ratios ranging from approximately 1.5 to 2.5. These included a variety of types of symptoms, including non-specific symptoms (headache, fatigue, mucous membrane irritation), as well as flu-like and respiratory symptoms, and tension and nervousness. Some photocopiers are a significant source of volatile organic compounds, which have been shown experimentally to be associated with such symptoms.[3] However, it is also possible that factors such as intense light exposure, noise, and postures assumed while photocopying may influence the development of symptoms.

Also associated with a variety of symptoms was the reported use of chemicals or glues, such as white-out or other strong smelling chemicals. Six symptom complexes were significantly associated with the use of such chemicals, with odds ratios ranging from 1.9 to 3.2. Other workplace factors associated with several symptoms included pay category (with high pay grades reporting fewer symptoms) and hours at the workstation on the day of the study (with higher symptom rates with increasing hours at work).

A variety of work and non-work stresses are considered to be potential risk factors for reporting health symptoms. Seven such types of stress were assessed in this study, most of which were significantly associated with at least one symptom complex. The most common of these was role conflict, which was a significant predictor of 9 of the fourteen building-related symptoms and 2 of the four ergonomic symptom complexes. These results suggest that role conflict is a potent job stress for Library of Congress employees. Specifically, role conflict refers to the presence of two or more conflicting demands from superiors, peers, and/or subordinates. The conflicting demands may come from the same person or from more than one person. The conflict may involve time, i.e., the employee is unable to perform two tasks at the same time, or they may involve competing legitimate requests, one of which might negate the other (Superior A requests one thing while Superior B requests the

group.

Non-work-related (external) stress was also found to be significantly associated with several symptoms (primarily relating to headache, fatigue, mucous membrane irritation, and dizziness). The external stress measure assessed a variety of domestic and other non-work-related demands experienced by modern workers. These include such things as having major responsibility for childcare, housecleaning, care of an elderly person, and outside activities, including courses for credit, volunteer work, second job, etc. Such demands may by themselves affect symptoms or add to or interact with existing job stresses to exacerbate health problems. The establishment of more flexible work schedules, part-time and job sharing opportunities, and parental leave programs have been shown to help ameliorate health and organizational consequences associated with these non-work demands. Further evaluation of the potential for role conflict and other job stresses should be performed to assess the potential utility of some of these interventions.

4.4 Risk Factors for Ergonomic Symptoms

Although the principal focus of this investigation was health concerns possibly related to indoor air quality, in order to address other problems often encountered in the modern office environment, a number of questions were asked regarding ergonomic stressors, such as chair comfort, work station design, and quality of lighting. Two types of health complaints possibly related to ergonomic stressors were assessed: muscle and joint pains (pain or stiffness in upper or lower back, pain or numbness in shoulder, neck, hands, or wrists), and eye strain symptoms (dry, sore, strained eyes, blurry vision, burning eyes). The analysis of these symptom complexes (H5, H12, H9 and H18) identified several risk factors. In addition to a few personal (education, financial situation) and job stress (role conflict, role clarity) factors, a number of risk factors were identified pertaining to the work station itself. For example, the odds of reporting symptoms relating to muscle and joint pain among persons who reported that their chairs were uncomfortable were approximately three times the odds of reporting no such symptoms. Of the 2845 individuals who completed Questionnaire 1, 1013 (37%) reported their chair was uncomfortable. Significantly associated with the comfort of one's chair was whether the chair was easily adjustable. Over half (58%) of the respondents reported that their chair was either not easily adjustable or not adjustable at all. Of those who reported their chairs to be comfortable, 71% said the chair was adjustable. On the other hand, of those with uncomfortable chairs, only 44% were adjustable.

1.97), too much lighting (OR = 1.66), and uncomfortable chair (OR = 1.46).

5. CONCLUSIONS AND RECOMMENDATIONS

The primary objective of this study was to assess the relationship between self-reported responses (health symptoms, comfort concerns, odors noticed, perceived indoor air quality, and mood states) and objective environmental measurements (temperature, humidity, carbon dioxide, respirable suspended particulates, several volatile organic compounds, and bioaerosols). With these objectives in mind, the major findings are:

1. The primary associations, both in consistency and magnitude, were observed between health symptoms and both the perception of thermal comfort and the perception of odors.

2. Few associations were demonstrated between symptom occurrence and objective environmental measurements. Those that were seen were both sporadic and small in magnitude.

3. No environmental contaminants were identified at levels above any relevant criteria or standards, with the exception of one location at which an elevated level of fungi was detected. (No elevation in fungi level was detected upon re-sampling at this site.) Variability of these parameters was low (e.g., the standard deviation for temperature was 1.3°F, and for relative humidity 4.7%).

4. This study assessed conditions for one week and provides measures at only a single point in time. The values cannot be extrapolated to other points in time.

5. A variety of work station risk factors were identified for symptoms associated with ergonomic stresses (hand, wrist, shoulder, neck, and back pain, as well as eye strain). These included uncomfortable chairs, hours working at video display terminals, and inadequate lighting (level of brightness and glare).

5.2 Recommendations

Although no measured environmental conditions were identified as risk factors in the development or reporting of health symptoms, some areas of concern were noted by the industrial hygienists during their evaluation of the building environment. The following recommendations are provided in an effort to address these areas of concern.

Building Maintenance and Ventilation

that monitors the operations of the air handlers for these trends should be incorporated in the system's current software. In this way, control system problems, such as searching, could be monitored.

2. Filters of the maximum efficiency possible should be used in the air handlers. Efficiency should be rated according to the ASHRAE dust spot test and should be determined by an independent laboratory. Use of newer design filters that are self-supporting should be investigated. Such filters would be of a pleated or wire frame type. In any case, the filters should be prevented from getting wet during cleaning of the HVAC heat exchange coils.

3. The feasibility of repairing or replacing the current roll mechanisms on the roll filters should be investigated.

4. All building thermostats should be cleaned and checked for calibration, condition, and location. Cleaning, maintenance, and calibration should be performed according to the instructions of the manufacturer. If a thermostat is obstructed so that free movement of air cannot take place around it, it should be relocated. In addition, thermostats located away from areas served by its designated VAV (variable air volume) box should be relocated to within the area served by the VAV box. Each thermostat should be checked to assure that the environment sensed at its location is reflective of the entire area served by the VAV box. Pressure lines to thermostats and from thermostats to actuators should be checked for any obstruction.

5. All exhaust systems in the building should be checked to assure that they are operating according to design. Problems of lack of exhaust flow from areas such as lounges and bathrooms should be corrected.

6. Drawings of the buildings mechanical systems should be updated and kept up-to-date. During this process, all ducts should be inspected for problems, such as leaks and attachment to luminaires.

7. Because of the widespread changes in the building from design, a mechanical design firm should perform an audit of the building's mechanical systems. This audit should investigate design air volumes for all spaces, the air balance of the current system, diffuser placement for adequate air distribution to all locations, VAV box design parameters,

operating temperatures of the supply air, current control systems, and other

problems with control of contaminant generation areas such as the print shop, and the reason for the building being under negative pressure. A remediation plan should also be developed and implemented to resolve the thermal comfort problems in the building, the negative pressure problem of the building, and air balance problems between the buildings. The remediation plan should include a new theory of design for the mechanical systems and controls.

8. Optimally, exhaust stacks on the roof should be extended. However, if this is not possible because of building codes, the current fans should be replaced with fans designed to exhaust contaminants far enough above the building to prevent them from being recirculated. Problems with standing water on the roof should be corrected.

9. Because smoke from burning coal was smelled in one outdoor air chase during the survey, the potential for and magnitude of outdoor air contaminants entering the building through the air handlers should be investigated. Outdoor air contaminants of interest are SO_2, NOX, and ozone.

Job Stress

10. A consistent relationship was observed between symptom reporting and the job stress related to role conflict. Only limited research evidence exists which suggests means for reducing role conflict in organizations. However, several organizational-level stress management approaches seem promising. Goal Setting[30] is one such approach, in which management helps workers establish goals that are challenging, but not overly difficult, that are meaningful, and can be used to provide employees with feedback on their performance. If an employee knows what is expected on the job and the time period in which the goals are to be achieved, the goal-setting experience can reduce uncertainty and help reduce role conflict. Similarly, programs designed to increase employee participation in decision making may help reduce uncertainty and thereby role conflict.[31]

Ergonomics

office seating and other workstation equipment. There are several references which may provide guidance in determining the adequacy of existing equipment and purchasing new equipment, if necessary.[32-34] Ergonomically-designed equipment is only effective if those using it know how to adjust it to their advantage. Appropriate training should therefore be provided, addressing ergonomic principles and health concerns related to office work and VDT use. A joint labor-management committee is often the best mechanism for addressing ergonomic problems. The mechanism for reporting symptoms and referral for medical evaluation should be reviewed to ensure that early reporting is encouraged. Early identification of symptoms and intervention can prevent more serious cases of musculoskeletal and other cumulative trauma disorders that have been associated with VDT work in other studies.

REFERENCES

The Human Equation: Health and Comfort, pp. 95-99. American Society of Heating Refrigerating, and Air Conditioning Engineers, Atlanta, 1989.

2. McNair DM, Lorr M, Droppleman LF: Profile of mood states (POMS). Educational and Industrial Listing Service, San Diego, California, 1971.

3. Molhave l: Volatile organic compounds as indoor air pollutants. Proceedings of the Seventh Life Sciences Symposium, Knoxville, Tennessee, pp. 403-414, 1984.

4. Otto D, Molhave L, Rose G, Hudnell HK, House D: Neurobehavioral and sensory irritant effects of controlled exposure to a complex mixture of volatile organic compounds. Neurotoxicol Teratol 12: 649-652, 1990.

5. Skov P, Valbjorn O: The 'sick' building syndrome in the office environment: The Danish Town Hall study. Indoor Air '87: Proceedings of the 4th International Conference on Air Quality and Climate (Seifert, et al, eds.). Institute of Water, Soil and Air Hygiene, Berlin, 1987.

6. Wilson S, Hedge A: The Office Environmental Survey: A Study of Building Sickness. Building Use Studies, Ltd., London, England, 1987.

7. Caplan RD, Cobb S, French JRP Jr, Van Harrison R, Pinneau SR: Job Demands and Worker Health. HEW Publication No. (NIOSH) 75-160, 1975.

8. Murphy LR; Hurrell JJ Jr: Stress measurement and management. In: AW Riley, SJ Zaccaro, eds: Occupational Stress and Organizational Development, Prager, New York, 1987.

9. Persily AK; Dols WS: Ventilation and air quality investigation of the Madison Building, Phase I report. U.S. Dept. of Commerce, National Institute of Standards and Technology, NISTIR 89-4219.

10. Molhave L, Bach B, Pedersen OF: Human reactions to low concentrations of volatile organic compounds. Environment International 12: 167-175, 1986.

11. Molhave L, Jensen JG, Larsen S: Acute and subacute subjective reactions to volatile organic pollutants. Institute of Environmental and Occupational Medicine, University of Aarhus, Universitetsparken, bygn. 180, Aarhus C, 1988.

13. Hodgson M, Traven ND, Permar E, Karpf M, Froniger J, Olenschock SA: Symptoms and the microenvironment in non-problem buildings. Proceedings of Indoor Air '90, Canada Mortgage and Housing Corporation: Vol. 1: 549-554, 1990.

14. Harrison J, Pickering AC, Finnegan MJ, Austwick PKC: The sick building syndrome: further prevalence studies and investigation of possible causes. In: Indoor Air, Vol 2 (Seifert, et al (eds.), pp. 487-491. Institute for Water, Soil and Air Hygiene, Berlin, 1987.

15. Robertson AS, Burge PS, Hedge A, Sims J, Gill FS, Finnegan M, Pickering CAC, Dalton G: Comparison of health problems related to work and environmental measurements in two office buildings with different ventilation systems. Brit Med J 291: 373-291, 1985.

16. Sterling DA, Moschandreas DJ, Relwani SM: Office building investigation. In: Indoor Air, Vol 2 (Seifert, et al (eds.), pp. 444-448. Institute for Water, Soil and Air Hygiene, Berlin, 1987.

17. Hedge A, Sterling TD, Sterling EM, Collett CW, Sterling DA, Nie V: Indoor air quality and health in two office buildings with different ventilation systems. Environmental International 15: 115-128, 1989.

18. Arundel A, Collett C, Sterling E, Steeves J: Low relative humidity and eye, nose, throat, and skin irritation. In: Indoor Air, Vol 2 (Seifert, et al (eds.), pp. 650-654. Institute for Water, Soil and Air Hygiene, Berlin, 1987.

19. Broder I, Pilger C, Corey P: Building related discomfort is associated with perceived rather than measured levels of indoor environmental variables. Proceedings of Indoor Air '90, Canada Mortgage and Housing Corporation: Vol. 1: 221-226, 1990.

20. Jaakkola JJK, Heinonen OP, Seppanen O: Sick building syndrome, sensation of dryness and thermal comfort in relation to room temperature in an office building: Need for individual control of temperature. Environment International 15: 163-168, 1989.

21. Menzies RI, Tamblyn RM, Tamblyn RT, Farant JP, Hanley J, Spitzer WO: Sick

1: 519-524, 1990.

22. Reinikainen LM, Jaakkola JJK, Helenius T, Seppanen O: The effect of air humidification on symptoms and environmental complaints in office workers. A six period cross-over study. Proceedings of Indoor Air '90, Canada Mortgage and Housing Corporation: Vol. 1: 775-780, 1990.

23. Skov P, Valbjorn O, Pedersen BV, Danish Indoor Climate Study Group: Influence of indoor climate on the sick building syndrome in an office environment. Scand J Work Environ Health 16: 363-371, 1990.

24. Seppanen O; Jaakkola J: Factors that may affect the result of indoor air quality studies in large office buildings. In: NL Nagda and JP Harper, eds: Design and Protocol for Monitoring Indoor Air Quality, ASTM STP 1002, pp. 51-62. American Society for Testing and Materials, Philadelphia, 1989.

25. Reinikainen LM; Jaakkola JJK; Heinonen OP: The effect of air humidification on different symptoms in an office building. An epidemiological study. Proceedings Healthy Buildings '88: 207-215, 1988.

26. Breunis K; de Groot JP: Relative humidity of the air and ocular discomfort in a group of susceptible office workers. In: B. Seifert, H Esdorn, M Fischer, H Ruden, J Wegner (eds): Indoor Air, pp. 625-629. Institute of Water, Soil and Air Hygiene, Berlin, 1987.

27. ASHRAE. Ventilation for Acceptable Indoor Air Quality. ASHRAE 62-1981, 1981.

28. Armstrong CW; Sheretz PC; Llewellyn GC: Sick building syndrome traced to excessive total suspended particulates (TSP). Proceedings ASHRAE IAQ '89: 3-7, 1989.

29. Van Sell M, Brief AP, Schuler RS: Role conflict and role ambiguity: integration of the literature and directions for future research. Human Relations 34: 43-71, 1981.

30. Locke EA, Latham GP: Goal Setting: A Motivational Approach Technique That Works. Prentice-Hall, Englewood Cliffs, NJ, 1984.

WHO Publication No. 99, WHO: Geneva, Switzerland. ISBN 92-4-1700998, 1987.

33. Human Factors Society (HFS)/American National Standards Institute (ANSI): American national standard for human factors engineering of visual display workstations. Human Factors Society, Santa Monica, California, ANSI/HFS Standard 100-1988, 1988.

34. Sauter, SL: Improving VDT work: causes and control of health concerns in VDT use. Prepared for the Department of Administration, State of Wisconsin, reprinted and distributed by the Report Store, Lawrence, Kansas (913-842-7348), 1986.

35. Quinn RP, Staines GL: The 1977 Quality of Employment Survey. Institute for Social Research, University of Michigan, Ann Arbor, 1979.

36. Quinn RP, Shepard LJ: The 1972-73 Quality of Employment Survey: Descriptive Statistics with Comparison Data From the 1969-70 Survey of Working Conditions. Survey Research Center, Ann Arbor, Michigan, 1974.

Table 2-1

Variables Used in Data Analysis

I. Dependent (Outcome) Variables

Health Symptom Clusters	
Indoor Air Quality/Respiratory:	
H1) non-specific IAQ symptoms	Q2. III. a,r,s
H2) mucous membrane irritation	c,d,k,n,q
H3) H1 + H2	a,c,d,k,n,q,r,s
H4) flu-like symptoms	f,g,h,i,u,v
H6) headache and nausea	a,b
H7) nasal symptoms and cough	c,d,e,f
H8) chest symptoms	g,h,i
H10) throat symptoms	o,p,q
H11) tired/fatigue	r,s
H13) nervous system symptoms	x,y,aa,bb
H14) dizziness	y
H15) dry skin	cc
H16) nasal symptoms	c,d,e
H17) eye irritation	k,l,n
Ergonomic/Strain:	
H5) ergonomic symptoms	Q2. III. dd,ee,ff,gg
H12) ergonomic sx & muscle aches	v,dd,ee,ff,gg
H9) eye symptoms	k,l,m,n
H18) eye strain symptoms	m,n
Perceived Thermal Comfort	
C1) too little air, too hot/stuffy	Q2. II. 1(2),2(1),5(2)
C2) too dry	3(2)
C4) too much air, too cold	1(1),2(2)
Self-Reported Odors	
O2) body odor, cosmetics, foods	Q2. II. 8 a,b,e
Perceived Overall Air Quality	
A1) 0=excellent/good; 1=fair/poor	Q2. II. 9
A2) 0=excellent,good,fair; 1=poor	
Self-Reported Mood States	
M1) tension	Q2.IV. f,h,i,j,k,m,p,r
M2) fatigue	a,b,l,o,q,s,x
M3) vigor	c,d,g,n,t,u,v,w

[1] Q2 = supplemental questionnaire

Table 2-2

Variables Used in Data Analysis

A. ENVIRONMENTAL PARAMETERS

VARIABLES
1. Temperature/Humidity: T1) mean temperature T2) mean relative humidity T6) maximum - minimum temperature C1) too hot, stuffy, too little air C2) too dry C4) too cold, too much air
2. Carbon dioxide: T3) ln (carbon dioxide)
3. Respirable Suspended Particulates (RSP): T4) ln (RSP): mean of 4 temporal measurements V5) ln (RSP): integrated sample
4. Perceived Odor: O2) body odor, cosmetics, food smells
5. Volatile Organic Compounds: V1) ln (1,1,1-trichloroethane + tetrachloroethylene) V2) ln (benzene + toluene + TCE + ethylbenzene + o- and p-xylene + n-octane) V3) ln (methylene chloride) V4) ln (total VOCs)
6. Bioaerosols: B1) $\log_{10}$ (total fungi) B2) $\log_{10}$ (total bacteria) B3) $\log_{10}$ (total thermophilic bacteria)

Table 2-3

Variables Used in Data Analysis

II. Independent (Predictor) Variables

VARIABLE	SOURCE OF INFORMATION[1]
Type of workspace (enclosed, mid-height partitions, other)	Q1: I. 1a.
Years at workstation	Q1: I. 4a.
Near source of VOCs (copier, laser printer)	Q1. I. 7j,k.
Wood furniture	Q1. I. 7b,d,g.
Perception of lighting (too little, just right, too much)	Q1. III. 4.
Presence of glare (never/sometimes vs. often/always)	Q1. III. 5a.
Ability to see window	Q1. III. 6.
Comfort of chair	Q1. III. 7a.
Comfort of work table	Q1. III. 8.
On day of monitoring:	
hours at workstation	Q2. I. 3.
went outside	Q2. I. 4.
used a copier (Y/N)	Q2. I. 5.
hours at VDT	Q2. I. 6.
smoker or near a smoker	Q2. I. 7a.
used or near humidifier	Q2. I. 7b.
used chemicals/glues	Q2. I. 7c.
used or near computer	Q2. I. 7d.
used or near printer	Q2. I. 7e

[1] Q1 = comprehensive questionnaire
Q2 = supplemental questionnaire

Table 2-4

Variables Used in Data Analysis

VARIABLE	SOURCE OF INFORMATION[1]
Gender	Q1: II. 22.
Age	Q1: II. 21.
Pay category [(GS 1-8; GS 9-12; GS 13-18 (or equiv.)] A) 0=low+high; 1=middle B) 0=low+middle; 1=high	Q1. V. 4a.
Lifestyle/financial situation (lives alone; lives with others + sole support; lives with others + shares financial support)	Q1. V. 2.
Education level 1 = grades 9-12 2 = 2 yrs college 3 = college/some graduate work 4 = graduate school/professional	Q1. V. 3.
Cigarette smoking A) 0=non+heavy smokers; 1=light C) 0=non+light smokers; 1=heavy	Q1. II. 6. (none=0; light=1-10; heavy=>10/day)
Wears contact lenses at work	Q1. II. 1b.
Wears contacts or glasses at work	Q1. II. 2.
Asthma	Q1. II. 16.
Stress-Related Factors:	
Job satisfaction	Q1. IV. 1 a-d.
Role conflict	Q1. IV. 4 a-c.
Job control	Q1. IV. 5 a-c.
Quantitative Workload	Q1. IV. 6 a-d.
Utilization of abilities	Q1. IV. 6 e-g.
Role clarity	Q1. IV. 6 h-k.
External stresses	Q1. IV. 7 a-f.

[1] Q1 = comprehensive questionnaire
Q2 = supplemental questionnaire

Table 3-1

Number of Eligible and Actual Participants in Follow-Up Survey (February 27-March 3, 1989), by Workstation Location[1]

Work in Area	530	409	939
Available on Day of Monitoring	456 (86%)[2]	355 (87%)	811 (86%)
Participated in Study (Completed Q2)	437 (96%)[3]	348 (98%)	785 (97%)
In Final Data Set (Completed Q1 & Q2)	375 (86%)[4]	299 (86%)	674 (86%)

1 Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.
2 Percent of those who work in the area
3 Percent of those who were available on day of monitoring
4 Percent of those who completed Q2

Table 3-2

Distribution of Dependent Variables by Gender and Workstation Location[1]

H1: non-spec. IAQ sx	All	53.5	38.8	46.8
	M	49.0	36.0	41.9
	F	56.6	42.0	51.1
H2: mucous membrane irritation	All	60.8	45.8	54.0
	M	54.5	36.0	44.5
	F	65.1	57.2	62.4
H3: H1 & H2	All	71.7	57.9	65.4
	M	74.5	50.3	58.4
	F	67.6	66.7	72.0
H4: flu-like symptoms	All	27.7	18.4	23.5
	M	24.1	14.9	19.4
	F	30.2	22.5	27.2
H6: headache & nausea	All	31.9	22.1	27.4
	M	26.2	16.8	21.0
	F	35.8	28.3	33.0
H7: nasal symptoms & cough	All	51.3	38.8	45.6
	M	46.9	32.9	39.7
	F	54.2	45.7	51.4
H8: chest symptoms	All	11.8	7.0	9.6
	M	6.9	5.0	5.8
	F	15.1	9.4	12.6
H10: throat symptoms	All	27.5	20.7	24.4
	M	24.1	14.9	19.4
	F	29.7	27.5	29.9
H11: tired/fatigue	All	40.6	30.4	36.0
	M	37.2	29.2	32.9
	F	42.9	31.9	39.0
H13: nervous system symptoms	All	25.2	20.4	22.1
	M	24.8	18.0	19.4
	F	25.5	23.2	25.3
# of Respondents	All	375	299	674
	M	149	161	310
	F	226	138	364

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-2 (continued)

Distribution of Dependent Variables by Gender and Workstation Location[1]

(building-related)		Areas	Areas	TOTAL
H14: dizziness	All	8.7	5.7	7.3
	M	6.9	5.0	5.8
	F	9.9	6.5	9.3
H15: dry skin	All	14.0	6.7	10.7
	M	9.7	5.0	7.1
	F	17.0	8.7	13.7
H16: nasal symptoms	All	49.6	36.1	43.4
	M	44.8	29.8	37.1
	F	52.8	43.5	49.5
H17: eye irritation	All	45.9	32.1	39.6
	M	39.3	26.1	31.9
	F	50.5	39.1	46.2

Symptom Cluster (ergonomic)		High Sx Areas	Low Sx Areas	TOTAL
H5: ergonomic symptoms	All	22.1	19.1	20.7
	M	19.3	16.8	18.1
	F	24.1	21.7	23.9
H12: ergonomic sx & muscle aches	All	23.5	20.4	22.1
	M	20.7	18.0	19.4
	F	25.5	23.2	25.3
H9: eye symptoms	All	48.7	34.4	42.2
	M	42.1	28.6	34.5
	F	53.3	41.3	48.6
H18: eye strain symptoms	All	31.9	24.7	28.7
	M	28.3	23.0	25.2
	F	34.4	26.8	31.9

# of Respondents	All	375	299	674
	M	149	161	310
	F	226	138	364

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-3

Distribution of Dependent Variables by Gender and Workstation Location[1]

C1: too hot, stuffy, too little air	All	65.2	54.8	60.5
	M	67.2	51.4	58.4
	F	63.7	59.1	61.9
C2: too dry	All	36.6	25.0	31.3
	M	35.8	20.5	27.6
	F	37.1	30.5	34.4
C3: too humid	All	15.3	12.1	13.9
	M	15.7	9.6	12.4
	F	15.1	15.3	14.8
C4: too cool, too much air	All	32.1	29.6	31.0
	M	24.8	23.6	24.3
	F	37.4	37.0	36.7

# of Respondents	All	375	299	674
	M	149	161	310
	F	226	138	364

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-4

Distribution of Dependent Variables
by Gender and Workstation Location[1]

		Areas	Areas	
O1: chemicals, pesticides, paint	All	12.3	9.4	11.0
	M	12.3	8.1	10.0
	F	12.4	10.9	12.1
O2: body odor, cosmetics, food	All	38.9	33.8	36.6
	M	38.6	28.6	33.5
	F	39.2	39.9	40.4
O3: photocopying, printing process	All	10.1	8.4	9.2
	M	8.3	8.7	8.4
	F	11.3	8.0	9.9
O4: fishy, moist/damp smells	All	10.9	11.0	11.0
	M	10.3	10.6	10.3
	F	11.3	11.6	11.8
O5: tobacco smoke	All	7.6	8.0	7.8
	M	6.2	8.1	7.4
	F	8.5	8.0	9.1
O6: diesel exhaust	All	0.3	1.0	0.6
	M	0.0	0.6	0.3
	F	0.5	1.4	0.8

# of Respondents	All	375	299	674
	M	149	161	310
	F	226	138	364

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-5

Distribution of Dependent Variables by Gender and Workstation Location[1]

air quality: fair or poor	All	65.0	55.4	60.6
	M	60.3	47.1	52.5
	F	68.1	65.2	67.0
air quality: poor	All	14.9	9.3	12.3
	M	14.7	6.4	10.1
	F	15.0	12.9	13.9

# of Respondents	All	375	299	674
	M	149	161	310
	F	226	138	364

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-6

Distribution of Dependent Variables by Gender

Tension	All	666	3	34	8.4	7.0	4.6
	M	307	3	31	8.5	7.0	4.8
	F	359	3	34	8.4	7.0	4.4
Fatigue	All	666	7	32	12.4	11.0	5.8
	M	307	7	32	12.2	10.0	5.8
	F	359	7	31	12.6	11.0	5.7
Vigor	All	666	8	40	19.4	20.0	6.6
	M	307	8	40	20.0	21.0	6.7
	F	359	8	39	19.0	20.0	6.6

Distribution by Gender and Workstation Location[1]

E. MOOD STATE SCORES [Mean (Standard Deviation)]

Mood State		High Sx Areas	Low Sx Areas	TOTAL
Tension	All	9.0 (4.9)	7.7 (4.0)	8.4 (4.6)
	M	9.3 (5.3)	7.9 (4.2)	8.5 (4.8)
	F	8.8 (4.5)	7.6 (3.9)	8.4 (4.6)
Fatigue	All	13.2 (6.1)	11.3 (5.1)	12.4 (5.8)
	M	13.0 (6.3)	11.5 (5.3)	12.2 (5.8)
	F	13.3 (6.0)	11.2 (4.9)	12.6 (5.7)
Vigor	All	18.7 (6.6)	20.4 (6.6)	19.4 (6.6)
	M	19.2 (6.7)	20.6 (6.7)	20.0 (6.7)
	F	18.4 (6.5)	20.1 (6.6)	19.0 (6.6)

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-7

Distribution of Independent Variables by Gender and Workstation Location[1]
[Mean (Standard Deviation)]

		Areas	Areas	
T1: mean temp.	All	73.5 (1.3)	73.1 (1.2)	73.3 (1.3)
	M	73.4	73.1	73.2
	F	73.7	73.1	73.4
T2: mean rel. humid.	All	49.5 (5.1)	50.3 (4.1)	49.8 (4.7)
	M	49.3	49.8	49.5
	F	49.7	50.9	50.1
T3: ln (CO_2)	All	6.22 (0.1)	6.21 (0.1)	6.21 (0.1)
	M	6.23	6.20	6.21
	F	6.21	6.21	6.22
T4: ln (resp. part.) (mean: 4 samples)	All	1.64 (0.5)	1.54 (0.4)	1.60 (0.5)
	M	1.60	1.53	1.56
	F	1.67	1.55	1.62
T5: max - min temp	All	1.84 (1.0)	1.76 (1.1)	1.80 (1.0)
	M	1.86	1.74	1.80
	F	1.82	1.78	1.80
V1: ln(1,1,1-TCA + tetraCE)	All	3.44 (0.5)	3.40 (0.5)	3.42 (0.5)
	M	3.51	3.39	3.46
	F	3.38	3.40	3.38
V2: ln(benzene+toluene+TCE +ethylbenz.+o- & p-xylene +n-octane	All	3.58 (0.4)	3.50 (0.2)	3.55 (0.3)
	M	3.61	3.51	3.57
	F	3.55	3.49	3.54
V3: ln (MeCl)	All	1.40 (0.6)	1.27 (0.5)	1.35 (0.6)
	M	1.30	1.31	1.30
	F	1.47	1.22	1.38
V4: ln (total VOCs)	All	-0.01 (0.5)	0.07 (0.3)	0.009 (0.4)
	M	-0.07	0.06	-0.01
	F	0.03	0.08	0.03
# of Persons Represented by Samples (range):				
Temporal (T1 -T5)		347-370	274-299	621-669
VOCs (V1 - V5)		141-252	115-146	256-398
Bioaerosols (B1 - B3)		343	278-299	634-655
Aldehydes (A1 - A4)		76	11	87

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on& responses to symptoms, Questionnaire 1.

Table 3-7 (continued)

Distribution of Independent Variables by Gender and Workstation Location[1] [Mean (Standard Deviation)]

		Areas	Areas	
V5: ln (resp. part.) (integrated sample)	All	2.80 (0.5)	2.71 (0.6)	2.74 (0.6)
	M	2.83	2.58	2.71
	F	2.78	2.85	2.76
B1: $\log_{10}$ (total fungi)	All	0.95 (0.74)	0.84 (0.60)	0.90 (0.68)
	M	0.97	0.78	0.87
	F	0.94	0.91	0.92
B2: $\log_{10}$ (total bacteria)	All	1.24 (0.74)	1.37 (0.62)	1.29 (0.69)
	M	1.30	1.41	1.35
	F	1.19	1.33	1.24
B3: $\log_{10}$ (total thermophilic bacteria)	All	0.46 (0.56)	0.44 (0.68)	0.46 (0.61)
	M	0.50	0.42	0.45
	F	0.44	0.47	0.46
A1: formaldehyde	All	8.5 (1.4)	10.1 (0.0)	8.7 (1.4)
	M	8.3	10.1	8.4
	F	8.8	10.1	9.0
A2: acetaldehyde	All	15.2 (2.9)	19.1 (0.0)	15.7 (3.1)
	M	15.1	19.1	15.5
	F	15.2	19.1	15.8
A3: acetone	All	33.0 (11.9)	28.8 (0.0)	32.4 (11.2)
	M	30.9	28.8	30.7
	F	35.1	28.8	34.1
A4: carbonyls	All	64.0 (10.5)	69.0 (0.0)	64.6 (9.9)
	M	61.9	69.0	62.6
	F	66.2	69.0	66.7

# of Persons Represented by Samples (range):			
Temporal (T1 -T5)	347-370	274-299	621-669
VOCs (V1 - V5)	141-252	115-146	256-398
Bioaerosols (B1 - B3)	343	278-299	634-655
Aldehydes (A1 - A4)	76	11	87

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-7a

			Low	High
CO_2 (ppm)	502	512	331	594
Resp Part (temp.) (ug/m^3)	5.5	5.0	1.3	20.5
Resp Part (integ.) (ug/m^3)	17.8	16.0	3.2	37.3
VOC1[1] (ug/m^3))	52.9	43.3	26.0	210.0
VOC2[2] (ug/m^3)	37.2	32.6	18.2	120.3
VOC3[3] (ug/m^3)	4.8	3.2	1.8	25.7
VOC4[4] (ppm)	1.1	1.0	0.4	3.5
Fungi (cfu/m^3)	55	10	0	1637
Bacteria (cfu/m^3)	49	28	0	370
Thermophilic bact. (cfu/m^3)	12	0	0	223

[1] VOC1 = TCA + tetraCE
[2] VOC2 = benzene + toluene + TCE + ethylbenzene + o- & p-xylene + n-octane
[3] VOC3 = methylene chloride
[4] VOC4 = total VOCs

Table 3-8

Distribution of Independent Variables by Gender and Workstation Location[1]

Workspace: A) % partitions (vs. enclosed/other)	All	66.4	55.1	61.3
	M	69.4	52.5	60.4
	F	64.3	58.2	61.5
Workspace: B) % other spaces (vs. enclosed/part.)	All	17.2	26.2	21.3
	M	13.2	22.5	18.2
	F	20.0	30.6	24.6
Near source of VOCs	All	30.8	34.1	32.3
	M	20.0	29.2	25.2
	F	38.2	39.9	39.3
Wood furniture	All	56.9	57.5	56.2
	M	53.8	60.2	57.4
	F	59.0	54.3	56.0
Lighting: A) % too little (vs. just right/too much)	All	27.6	27.5	27.5
	M	20.8	28.5	24.8
	F	32.2	26.3	29.9
Lighting: B) % too much (vs. just right/too little)	All	25.3	19.9	22.9
	M	27.8	17.1	22.2
	F	23.6	23.3	23.5
Glare: % often/always	All	22.7	21.4	22.1
	M	20.1	21.5	20.9
	F	24.4	21.3	22.6
Window (% can see from workstation)	All	13.9	28.7	20.6
	M	16.7	27.6	22.3
	F	12.0	29.9	19.1
Chair uncomfortable	All	39.4	37.4	38.5
	M	34.7	35.5	35.1
	F	42.6	39.5	41.1
Work table uncomfortable	All	33.8	30.4	32.3
	M	31.9	32.9	32.4
	F	35.1	27.5	32.2
Outside on day of monitoring	All	52.2	53.4	52.8
	M	55.9	58.4	57.3
	F	49.8	47.4	48.6

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-8 (continued)

Distribution of Independent Variables by Gender and Workstation Location[1]

VARIABLE		High Sx Areas	Low Sx Areas	TOTAL
Used a copier	All	27.7	21.7	25.0
	M	26.2	18.6	22.3
	F	28.8	25.4	28.6
Smoked or near smoker	All	4.2	7.4	5.6
	M	4.1	6.8	5.6
	F	4.2	8.0	5.7
Used or near humidifier	All	0.8	0.3	0.6
	M	0.0	0.6	0.3
	F	1.4	0.0	0.8
Used chemicals/glues	All	12.9	6.7	10.1
	M	14.5	5.0	9.4
	F	11.8	8.7	10.2
Used or near computer	All	71.3	65.2	68.5
	M	69.7	61.5	65.5
	F	72.5	69.6	71.6
Used or near printer	All	52.0	49.2	50.7
	M	49.7	41.0	45.2
	F	53.6	58.7	55.9

Distribution of Continuous Variables (Mean)

VARIABLE		High Sx Areas	Low Sx Areas	TOTAL
Years at workstation	All	4.7	4.9	4.8
	M	4.9	5.2	5.1
	F	4.5	4.6	4.6
Hours at workstation (on day of monitoring)	All	4.8	4.6	4.7
	M	4.8	4.7	4.8
	F	4.8	4.6	4.6
Hours using VDT (on day of monitoring)	All	1.4	1.3	1.3
	M	1.4	1.3	1.4
	F	1.4	1.3	1.3

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-9

Distribution of Independent Variables by Gender and Workstation Location[1]

		Areas	Areas	
Gender (% male)		39.7	53.8	46.0
Pay category: A) % middle (vs. low + high)	All	45.0	43.0	44.1
	M	51.9	45.3	48.8
	F	40.4	40.2	39.8
Pay category: B) % high (vs. low + middle)	All	10.8	22.2	15.9
	M	14.1	26.4	20.6
	F	8.6	17.2	12.3
Lifestyle/finances: A) lives w/others-sole vs alone/others-share	All	12.4	11.6	12.1
	M	13.1	11.9	12.5
	F	11.9	11.3	11.7
Lifestyle/finances: B) lives w/others-share vs alone/others-sole	All	58.3	62.0	60.0
	M	54.5	64.8	59.9
	F	61.0	58.6	60.1
Education level: A) % some college (vs. all others)	All	16.6	17.5	17.0
	M	16.7	16.9	16.8
	F	16.5	18.2	17.2
Education level: B) % college/some grad (vs. all others)	All	26.4	25.3	25.9
	M	25.0	24.4	24.7
	F	27.4	26.3	26.9
Education level: C) % grad/prof (vs. all others)	All	33.1	39.4	36.0
	M	45.1	45.6	45.4
	F	25.0	32.1	27.8
Cigarette smoking: A) % light (vs. non + heavy)	All	7.9	6.1	7.1
	M	5.5	6.9	6.1
	F	9.6	5.2	7.5
Cigarette smoking: B) % heavy (vs. non + light)	All	7.2	6.8	7.4
	M	12.4	5.0	8.4
	F	4.8	8.9	6.1
Contact lenses at work	All	16.7	13.4	15.2
	M	12.6	10.8	11.8
	F	19.6	16.4	18.5

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-9 (continued)

Distribution of Independent Variables by Gender and Workstation Location[1]

Contacts or glasses at work	All	77.2	74.3	75.9
	M	77.6	75.5	76.5
	F	77.0	72.9	75.2
Asthma	All	9.8	9.1	9.5
	M	8.3	11.3	9.7
	F	10.9	6.6	9.4

Distribution of Continuous Variables (Mean)

VARIABLE		High Sx Areas	Low Sx Areas	TOTAL
Age	All	41.9	42.3	42.1
	M	42.5	43.9	43.3
	F	41.6	40.3	41.0
Job satisfaction	All	2.6	2.6	2.6
	M	2.5	2.6	2.5
	F	2.6	2.6	2.6
Role conflict	All	1.6	1.5	1.5
	M	1.6	1.5	1.6
	F	1.5	1.5	1.5
Job control	All	2.7	2.8	2.7
	M	2.6	2.9	2.8
	F	2.7	2.8	2.7
Quantitative workload	All	3.4	3.3	3.4
	M	3.3	3.3	3.3
	F	3.5	3.9	3.4
Utilization of abilities	All	3.1	3.2	3.1
	M	3.0	3.2	3.1
	F	3.1	3.2	3.2
Role clarity	All	4.0	4.0	4.0
	M	4.0	4.0	4.0
	F	4.0	3.9	4.0
External stresses	All	1.9	1.8	1.9
	M	1.8	1.7	1.7
	F	2.0	1.9	2.0

[1] Workstation Location: "High Symptom Areas" and "Low Symptom Areas" based on responses to symptoms, Questionnaire 1.

Table 3-10

Summary of Regression Results[1]
(See Appendix E for complete results)

H1) non-spec. IAQ				++	++	++	+		
H2) mucous membrane				++	++	++			
H3) H1 & H2				++	++	++			
H4) flu-like sx				++	+	+			
H6) HA/nausea		+		++	++	+			
H7) nasal/cough					++	++			
H8) chest sx				++					
H10) throat sx					++	++			
H11) tired/fatigue				+		++			
H13) nervous system				+					
H14) dizziness					+				-
H15) dry skin					++	+			
H16) nasal sx					++	++			
H17) eye irritation	+			++	+	++			
H5) ergonomic sx				+	+				
H12) ergo/aches					+				
H9) eye sx	+			++	++	++		+	
H18) eye strain				++					
C1) hot/stuffy	+		++	XXX	XXX	XXX			
C2) too dry		–		XXX	XXX	XXX			
C4) too cold	–	++		XXX	XXX	XXX		–	
O2) odors									
A1) poor or fair				++	++	++	++		
A2) poor air				++		++			
M1) tension	++								
M2) fatigue				+					
M3) vigor									

[1] Adjusting for potential confounders
+/-: $0.01 < p < 0.05$; ++/--: $p \leq 0.01$ (Sign denotes direction of effect)

Table 3-10 (continued)

Summary of Regression Results[1]

H2) mucous membrane								
H3) H1 & H2	++							
H4) flu-like sx	+							
H6) HA/nausea								
H7) nasal/cough	++							
H8) chest sx								
H10) throat sx								
H11) tired/fatigue	+							
H13) nervous system sx	++							
H14) dizziness						++		
H15) dry skin	++							
H16) nasal sx	++							
H17) eye irritation	++							
H5) ergonomic sx	++							
H12) ergo/aches	++							
H9) eye sx	++							
H18) eye strain	++							
C1) hot/stuffy	++						+	
C2) too dry	+		–					
C4) too cold								
O2) odors	XXX							
A1) poor or fair	++			+				
A2) poor air								
M1) tension								
M2) fatigue								
M3) vigor			+	-				

[1] Adjusting for potential confounders
+/-: $0.01<p<0.05$; ++/--: $p\leq 0.01$ (Sign denotes direction of effect)

Congress (Questionnaire 1)

B. Indoor Air Quality and Work Environment Follow-up Survey: Madison Building, Library of Congress (Questionnaire 2)

C. Description of Job and External Stress Scales

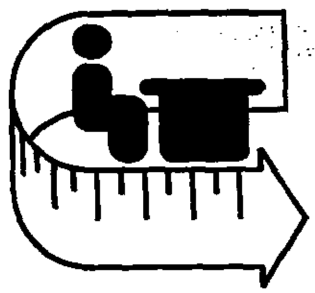
D. Prevalence of Positive Symptoms Defined by Questionnaires 1 and 2 (Among Persons Completing Both Questionnaires)

E. Summary of Stepwise Regression Analyses: Evaluation of Workplace/Personal/Medical Variables

F. Summary of Regression Analyses of Environmental Parameters: Odds Ratios Controlling for Workplace/Personal/Medical Factors

INDOOR AIR QUALITY AND WORK ENVIRONMENT SURVEY

MADISON BUILDING, LIBRARY OF CONGRESS



We are investigating the air quality and work environment in the Madison Building. We need information about your work environment and how it affects you. This information is not available anywhere else. Therefore, we must rely on your answers to this survey, along with monitoring of environmental conditions in the Madison Building, to clearly analyze the situation. We need your participation, regardless of how satisfied you are with the air quality or your work environment.

Attach Label Here

DO NOT PUT YOUR NAME ON YOUR QUESTIONNAIRE OR THE RETURN ENVELOPE PROVIDED. PLEASE PUT YOUR COMPLETED QUESTIONNAIRE IN THE RETURN ENVELOPE. SEAL IT AND TAKE IT TO ONE OF THE RETURN BOXES NEAR THE ELEVATORS AND BUILDING EXITS.

PLEASE READ BEFORE

COMPLETING QUESTIONNAIRE

Many questions in the questionnaire concern either last week or last year. By "LAST YEAR" we mean the 12-month period ending today. If you have worked in the Madison Building for less than one year, answer the "LAST YEAR" questions only for the part of the year that you worked in the Madison Building.

Please report your ACTUAL EXPERIENCES LAST WEEK even if last week was unusual for you. By "LAST WEEK" we mean any or all days worked from last Monday through Friday.

CONFIDENTIALITY

To protect your privacy, the identification for your questionnaire is the bar-code label on the cover. The bar-code cannot be read by Library of Congress computers or staff. Additionally, the survey forms will be gathered by staff from Westat, Inc., an independent survey research firm, and processed away from the Madison Building. Your name and other information necessary for the survey and analysis that might identify you, such as your room and telephone number, will not be disclosed to individuals, unions, or management of the Library of Congress. Reports of the survey will not give your name, nor will data be presented in such a way that you, or anyone else, could be identified.

STUDY SPONSORS AND ORGANIZATION

The study has been developed and is being conducted by the National Institute for Occupational Safety and Health (NIOSH), the Environmental Protection Agency (EPA), the John B. Pierce Foundation Laboratory at Yale University, and Westat, Inc. It is being supported by funds from NIOSH, EPA, the Library of Congress, and the Department of Energy.

PART I. DESCRIPTION OF YOUR WORKSTATION

This section asks you to describe your workstation. Your answers to these questions will help us to construct a picture of your work surroundings.

By WORKSTATION we mean your desk, office, cubicle, or place that is your primary work area. This description is obvious for many people, but more difficult for those whose jobs require them to move about the building. If you do move about the building, your workstation is the specific location where you spend more time than any other single location. If your workstation has been relocated, use the location where you are now.

1. There are many different types of workstations. Please check the categories that best describe the space in which your current workstation is located.

a. Type of space *(Check one)*

1. ☐ Enclosed office with door
2. ☐ Cubicle with floor to ceiling bookcases or partitions and no door
3. ☐ Cubicle surrounded by mid-height bookcases or partitions
4. ☐ Open office area
5. ☐ Stacks
6. ☐ Loading dock, laboratory, copy center, or print shops
7. ☐ Work all around the building
8. ☐ Other (specify) ______________

____

b. Type of space sharing *(Check one)*

1. ☐ Single occupant
2. ☐ Shared with one other person
3. ☐ Shared with two or more other persons
4. ☐ Other *(describe)* ______________

____

2. How many years of service do you have with the Library of Congress? *(Enter number of months if less than one year.)*

_______ years _____ months

3. a. How many years have you been working in the Madison Building? *(Enter number of months if less than one year.)*

_______ years _____ months

b. During a typical week, how many hours do you spend in this building?

_______ hours per week

4. a. How many years have you worked at your current workstation? *(Enter number of months if less than one year.)*

_______ years _____ months

b. During an average workday, how many hours do you spend at your workstation?

_______ hours per day

5. How many days did you work in the Madison Building last week?

_______ days last week

		AM	PM
a.	Arrive at work ____:____	☐	☐
b.	Leave work ____:____	☐	☐
c.	Varies *(describe)* ____________________		

7. Which of the following items are presently located within 15 feet of your workstation? *(Check "no" or "yes" for each item.)*

		No 1	Yes 2
a.	Metal desk	☐	☐
b.	Wood or composition desk	☐	☐
c.	Metal bookshelves or bookcases	☐	☐
d.	Wood or composition bookshelves or bookcases	☐	☐
e.	File cabinet(s)	☐	☐
f.	Other metal furniture	☐	☐
g.	Other wood or composition furniture	☐	☐
h.	Fabric-covered partitions	☐	☐
i.	Portable humidifier	☐	☐
j.	Laser printer	☐	☐
k.	Photocopy machine	☐	☐
l.	Live plants	☐	☐

8. Is there carpeting on most or all of the floor at your workstation?

1. ☐ No
2. ☐ Yes

items? *(If you worked with an item at all, but less than 1 hour, enter 1 hour per day.)*

		Hours per day
a.	Computer or word processor with screen/keyboard	____
b.	Photocopy machine	____
c.	Photographic developing and processing	____
d.	Printing processing (press, binding materials, etc.)	____
e.	Other chemicals such as glues, adhesives, cleansers, white out, rubber cement, pesticides, etc.	____

NOTE: If you have worked in the Madison Building for less than a year, answer the following questions for the part of the year that you worked in the Madison Building.

10. Were any of the following items regularly used at your workstation during the LAST YEAR: *(Check "no" or "yes" for each item.)*

		No 1	Yes 2
a.	Portable fan	☐	☐
b.	Portable air filter, or cleaner, or negative-ion generator	☐	☐
c.	Portable heater	☐	☐
d.	Desk lamp	☐	☐

changes taken place within 15 feet of your current workstation? *(Check "no" or "yes" for each item.)*

	No 1	Yes 2
a. New carpeting	☐	☐
b. New drapes or curtains	☐	☐
c. New furniture	☐	☐
d. New equipment, such as a computer	☐	☐
e. Walls painted	☐	☐
f. Rearranged walls	☐	☐

leaks from the ceiling, floors, walls, or pipes near your workstation?

1. ☐ No
2. ☐ Yes

This section asks questions about the status of your health and well-being. Your answers to these questions will help us construct a profile of the health status of the employees in the Madison Building. Please answer all the questions even if you don't associate these health conditions with your work.

1. a. Do you wear contact lenses?

1. ☐ Never → *Go to Q.2*
2. ☐ Sometimes
3. ☐ Often
4. ☐ Always

b. Do you wear contact lenses at work?

1. ☐ Never
2. ☐ Sometimes → *Go to Q.2*
3. ☐ Often → *Go to Q.2*
4. ☐ Always → *Go to Q.2*

c. If never worn at work, why?

____

____

____

2. During work, how often do you wear eyeglasses (NOT including contacts) for close-up work?

1. ☐ Never
2. ☐ Sometimes
3. ☐ Often
4. ☐ Always

3. Which of the following best describes your history of smoking tobacco products such as cigarettes, cigars or pipes?

1. ☐ Never smoked → *Go to Q.7*
2. ☐ Former smoker → *Go to Q.7*
3. ☐ Current smoker

4. Do you smoke tobacco products at your workstation?

1. ☐ Never
2. ☐ Sometimes
3. ☐ Often

5. Do you smoke tobacco products elsewhere at work?

1. ☐ Never
2. ☐ Sometimes
3. ☐ Often

6. In a typical 24 hour day, how many CIGARETTES do you usually smoke?

1. ☐ None
2. ☐ 1 to 5
3. ☐ 6 to 10
4. ☐ 11 to 20
5. ☐ 21 to 30
6. ☐ 31 or more

7. **Please answer the three questions to the right about each symptom listed below, even if you believe the symptom is not related to the Madison Building.**
(For each symptom, answer the first question. If the response is "never," go down to the next symptom.)

Symptom	you have experienced this symptom while working in the Madison Building.					LAST WEEK you experienced this symptom while working in the Madison Building.	change when not at work?		
	Never	Rarely	Sometimes	Often	Always	*(Fill in No. of days)*	Gets Worse	Stays Same	Gets Better
a. [illegible]	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
b. [illegible]	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
c. runny nose	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
d. stuffy nose/sinus congestion ...	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
e. [illegible]	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
f. [illegible]	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
g. wheezing or whistling in chest ..	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
h. shortness of breath	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
i. chest tightness	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
j. dry, itching, or tearing eyes	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
k. sore/strained eyes	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
l. blurry/double vision	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
m. burning eyes	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
n. sore throat	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
o. hoarseness	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
p. dry throat	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
q. unusual fatigue or tiredness	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
r. sleepiness or drowsiness	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐

7. *(continued)*

(For each symptom, answer the first question. If the response is "never," go down to the next symptom.)

	you have experienced this symptom while working in the Madison Building.					LAST WEEK you experienced this symptom while working in the Madison Building.	change when not at work?		
	Never	Rarely	Some-times	Often	Always	*(Fill in No. of days)*	Gets Worse	Stays Same	Gets Better
[redacted]									
u. aching muscles or joints	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
v. problems with contact lenses ...	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
[redacted]									
y. feeling depressed	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
z. tension or nervousness	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
[redacted]									
cc. pain or stiffness in upper back ..	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
dd. pain or stiffness in lower back ..	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	______	1 ☐	2 ☐	3 ☐
[redacted]									

to your symptoms described in Question 7. If you reported that you never experienced any of these symptoms, go to Question 12.

8. How often during the LAST YEAR have any of your symptoms reduced your ability to work in the Madison Building?

1. ☐ Never
2. ☐ Rarely
3. ☐ Sometimes
4. ☐ Often
5. ☐ Always

9. a. Have any of your symptoms caused you to stay home from work or leave work early during the LAST YEAR?

1. ☐ Never ⟶ *Go to Q.10*
2. ☐ Rarely
3. ☐ Sometimes
4. ☐ Often

b. Which symptoms?

____

____

____

10. In which season(s) are you bothered more by the symptoms you reported in Question 7? *(Check all that apply.)*

1. ☐ Winter
2. ☐ Spring
3. ☐ Summer
4. ☐ Fall
5. ☐ No relation to seasons

reported in Question 7 with your work in the Madison Building?

1. ☐ No ⟶ *Go to Q.12*
2. ☐ Yes

b. Have these symptoms:

1. ☐ improved over the last year
2. ☐ become worse over the last year
3. ☐ stayed the same

12. During the LAST YEAR, have you had an illness in which you had repeated episodes of THREE OR MORE of the following symptoms at the same time: wheezing, cough, shortness of breath, fever, chills, aching joints/muscles?

1. ☐ No
2. ☐ Yes

13. During the LAST YEAR, have you had any chest illnesses, such as bronchitis or pneumonia, that have kept you off work, indoors at home, or in bed?

1. ☐ No
2. ☐ Yes

14. Has a physician ever told you that you have, or had, eczema?

1. ☐ No
2. ☐ Yes

15. During the LAST YEAR, have you had any episodes of wheezing (whistling in the chest) WITHOUT fever, or chills, or sore throat?

1. ☐ No
2. ☐ Yes

1. ☐ No → Go to Q.17

2. ☐ Yes

b. In what year was it first diagnosed?

19 _______

c. Have you had an asthma attack during the LAST YEAR?

1. ☐ No

2. ☐ Yes

17. Comparing your health since working in the Madison Building with your health before you began to work in the Madison Building . . .

a. . . . do you have infections (e.g., colds, flu, bronchitis, etc.) . . .

1. ☐ more frequently?

2. ☐ less frequently?

3. ☐ with the same frequency?

b. . . . do your infections (e.g., colds, flu, bronchitis, etc.) tend to . . .

1. ☐ last longer?

2. ☐ last a shorter amount of time?

3. ☐ last about the same amount of time?

18. Do you believe you are or may be allergic to any of the following? *(Check "no" or "yes" for each item.)*

	No 1	Yes 2
a. pollen or plants	☐	☐
b. animals	☐	☐
c. dust	☐	☐
d. molds	☐	☐
e. Other *(specify)*	☐	☐

____

RESPIRATORY IRRITATION at your workstation from:

	NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS
a. Tobacco smoke . . .	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
b. Fumes from a photocopying machine	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
c. Fumes from printing processing (press, binding materials, etc.)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
d. Fumes from other chemicals such as adhesives, glues, cleansers, white out, rubber cement, etc.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
e. Fumes from pesticides	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
f. Fumes from new carpeting	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
g. Fumes from new drapes, curtains, or furniture	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
h. Fumes from paint	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
i. Fumes from cleaning of carpets, drapes, or other furnishings	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
j. Other *(specify)* . . . . _______________	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

to any of the items in Question 19?

1. ☐ No
2. ☐ Yes

21. **How old are you?**

_______ years

1. ☐ Male
2. ☐ Female

PART III: INFORMATION ABOUT YOUR PRESENT WORK ENVIRONMENT

This section asks you to report specific responses to the physical environment at your present workstation. You or a co-worker may have altered your work environment with a portable fan, heater, humidifier, etc. If so, please tell us how your work environment would have been without this equipment.

1. **At your present workstation, HOW OFTEN . . .** *(Please check one box for last year and one box for last week.)*	**. . . during the LAST YEAR**					**. . . during the LAST WEEK**				
	Never	Rarely	Some-times	Often	Always	Never	Rarely	Some-times	Often	Always
a. was there too much air movement?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
b. was there too little air movement?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
c. did you want to adjust the air movement?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
d. was the temperature too hot?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
e. was the temperature too cold?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
f. did you want to adjust the temperature?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
g. was it too humid? . . .	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
h. was it too dry?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
i. did you want to adjust the humidity?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
j. was the air too stuffy?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
k. was it too noisy?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
l. was it too quiet?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
m. was the work area too dusty?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

you noticed any of these types of ODORS at your present workstation? *(Check one box for each item.)*

	NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS
a. Body odor	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
b. Cosmetics, such as perfume or after-shave	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
c. Tobacco smoke ...	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
d. Fishy smells	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
e. Other food smells ..	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
f. Musty or damp basement smells ..	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
g. Odors from new carpet	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
h. Odors from new drapes or curtains .	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
i. Odors from diesel or other engine exhaust	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
j. Odors from a photocopying machine	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
k. Odors from printing processing (press, binding materials, etc.)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

2. *(continued)*

	NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS
l. Odors from other chemicals such as adhesives, glues, cleansers, white out, rubber cement, etc.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
m. Odors from pesticides	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
n. Odors from cleaning of carpets, drapes, or other furnishings	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
o. Odors from paint	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
p. Other unpleasant odors *(describe)* ... ____________	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

3. **In which seasons would you most like to adjust the physical conditions around your workstation?** *(Check all that apply)*

	None	Winter	Spring	Summer	Fall
a. Air movement ...	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
b. Temperature	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
c. Humidity	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
d. Odors	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

2. ☐ A little too dim
3. ☐ Just right
4. ☐ A little too bright
5. ☐ Much too bright

5. a. Do you experience a reflection or "glare" in your field of vision when at your workstation?

1. ☐ Never → Go to Q.6
2. ☐ Sometimes
3. ☐ Often
4. ☐ Always

b. Where does the reflection or glare come from? *(Check all that apply)*

1. ☐ Window, sunlight, outside reflection
2. ☐ Overhead fluorescent lights
3. ☐ Video display screen and/or reflections when looking at screen
4. ☐ Desk lamp
5. ☐ Other *(specify)* ______________

6. Can you see out an outside window from your workstation?

1. ☐ No
2. ☐ Yes

1. ☐ Reasonably comfortable
2. ☐ Somewhat uncomfortable
3. ☐ Very uncomfortable
4. ☐ Don't have one specific chair → Go to Q.8

b. Is your chair easily adjustable?

1. ☐ No
2. ☐ Yes
3. ☐ Not adjustable

8. How comfortable is the current set-up of your desk or work table (that is, height and general arrangement of the table, chair, and equipment you work with)?

1. ☐ Reasonably comfortable
2. ☐ Somewhat uncomfortable
3. ☐ Very uncomfortable
4. ☐ Don't have one specific desk or work table

9. a. During the LAST YEAR, how many times per week did you go outdoors, weather permitting, during work hours (for lunch, break, or other reasons)?

____ time(s) per week → If zero, go to Q.10

b. How many of these times did you go outdoors primarily to get some fresh air?

____ time(s) per week for fresh air

physical environment at your workstation, that is, the air quality, temperature, light, noise, odor, etc.

10. During the LAST WEEK, how satisfied were you with the physical environment at your workstation?

1. ☐ Very satisfied
2. ☐ Somewhat satisfied
3. ☐ Not too satisfied
4. ☐ Not at all satisfied

11. During the LAST YEAR, how satisfied were you with the overall physical environment at your workstation?

1. ☐ Very satisfied
2. ☐ Somewhat satisfied
3. ☐ Not too satisfied
4. ☐ Not at all satisfied

environment in the vicinity of your workstation:

1. ☐ improved
2. ☐ become worse
3. ☐ stayed the same

13. During a typical work day, does the overall physical environment in the vicinity of your workstation:

1. ☐ improve during the day
2. ☐ become worse during the day
3. ☐ stay the same

This section asks you to describe your job in terms of specific qualities. In order to gain a better understanding of your work environment, we would like to know how you feel about your job situation. As stated before, your responses will be kept confidential.

1. **We would like you to think about the TYPE OF WORK YOU DO IN YOUR JOB.** *(Check one box for each statement)*

   a. **All in all, how satisfied are you with your job?**

      1. ☐ Very satisfied
      2. ☐ Somewhat satisfied
      3. ☐ Not too satisfied
      4. ☐ Not at all satisfied

   b. **Knowing what you know now, if you had to decide again whether to take the job you now have, what would you decide? Would you . . .**

      1. ☐ Decide without hesitation to take the same job
      2. ☐ Have some second thoughts
      3. ☐ Decide definitely not to take the same job

   c. **If you were free right now to go into any type of job you wanted, what would your choice be? Would you . . .**

      1. ☐ Take the same job
      2. ☐ Take a different job
      3. ☐ Not want to work

   d. **If a friend of yours told you he/she was interested in working in a job like yours, what would you tell him/her? Would you . . .**

      1. ☐ Strongly recommend it
      2. ☐ Have doubts about recommending it
      3. ☐ Advise against it

2. **How satisfied are you with your salary?**

   1. ☐ Very satisfied
   2. ☐ Somewhat satisfied
   3. ☐ Not too satisfied
   4. ☐ Not at all satisfied

3. **How satisfied are you with your opportunity for advancement at the Library of Congress?**

   1. ☐ Very satisfied
   2. ☐ Somewhat satisfied
   3. ☐ Not too satisfied
   4. ☐ Not at all satisfied

someone may ask you to do work in a way which is different from what you think is best, or you may find that it is difficult to satisfy everyone. HOW OFTEN do you face problems in your work like the ones listed below? *(Check one box for each statement)*

	RARELY OR NEVER	SOMETIMES	FAIRLY OFTEN	VERY OFTEN
a. Persons equal in rank and authority over you ask you to do things which conflict.	1 ☐	2 ☐	3 ☐	4 ☐
b. People in a good position to see if you do what they ask give you things to do which conflict with one another.	1 ☐	2 ☐	3 ☐	4 ☐
c. People whose requests should be met give you things which conflict with other work you have to do.	1 ☐	2 ☐	3 ☐	4 ☐

influence you now have in each of several areas at work. By influence we mean the degree to which you control what is done by others and have freedom to determine what you do yourself. *(Check one box for each question)*

	VERY LITTLE	LITTLE	A MODERATE AMOUNT	MUCH	VERY MUCH
a. How much influence do you have over the amount of work you do?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
b. How much influence do you have over the availability of materials you need to do your work?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
c. How much do you influence the policies and procedures in your work group?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
d. How much influence do you have over the arrangement of furniture and other work equipment at your workstation?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

box for each question)

	RARELY	OCCASIONALLY	SOMETIMES	FAIRLY OFTEN	VERY OFTEN
a. How often does your job require you to work very fast?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
b. How often does your job require you to work very hard?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
c. How often does your job leave you with little time to get things done?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
d. How often is there a great deal to be done?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
e. How often does your job let you use the skills and knowledge you learned in school?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
f. How often are you given a chance to do the things you do best?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

6. *(Continued)*

	RARELY	OCCASIONALLY	SOMETIMES		
g. How often can you use the skills from your previous experience and training?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
h. How often are you clear on what your job responsibilities are?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
i. How often can you predict what others will expect of you on the job?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
j. How much of the time are your work objectives well defined?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
k. How often are you clear about what others expect of you on the job?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

of questions deals with other significant aspects of your life. *(Check "no" or "yes" for each question)*

	No 1	Yes 2
a. **Do you have children at home?**	☐	☐
b. **Do you have major responsibility for childcare duties?**	☐	☐
c. **Do you have major responsibility for housecleaning duties?**	☐	☐
d. **Do you have major responsibility for the care of an elderly or disabled person on a regular basis?**	☐	☐
e. **Are you taking courses for credit toward a degree or a diploma?**	☐	☐
f. **Do you have a regular commitment of five hours or more per week, paid or unpaid, outside of this job?** *(Include volunteer work, charitable work, second job, etc.)*	☐	☐

This section concludes this survey. Your answers to these questions, like your answers to the previous questions, will be kept confidential. This information is needed for statistical purposes.

1. **What day of the week did you complete this survey?**

   1. ☐ Monday
   2. ☐ Tuesday
   3. ☐ Wednesday
   4. ☐ Thursday
   5. ☐ Friday

2. **Which of the following best describes your current living and financial arrangements?**

   1. ☐ Live alone, sole provider of rent/mortgage, utilities, food, and other living expenses.
   2. ☐ Live alone, but receive assistance from one or more others in paying rent/mortgage, utilities, food, and other living expenses.
   3. ☐ Live with one or more other persons, but sole provider of rent/mortgage, utilities, food, and other living expenses.
   4. ☐ Live with one or more other persons who help to pay rent/mortgage, utilities, food, and other living expenses.

3. **What is the highest grade you completed in school?**

   1. ☐ 8th grade or less
   2. ☐ 9th, 10th, or 11th grade
   3. ☐ High school graduate
   4. ☐ 2 years of college or Associate Degree
   5. ☐ Bachelor's or technical degree
   6. ☐ Some graduate work
   7. ☐ Graduate or professional degree

4. a. **What is your pay plan and grade (e.g., GS-5, GM-14, SES-2, WG-2, etc.)?**

   ____

   b. **Which of the following best describes your job duties and responsibilities?** *(If more than one applies, check the ONE box for the job duties on which you spend the most time.)*

   1. ☐ Managerial (such as administrator, manager, etc.)
   2. ☐ Professional (such as engineer, scientist, lawyer, etc.)
   3. ☐ Technical (such as technician, programmer, etc.)
   4. ☐ Administrative Support (such as clerical, computer operator, etc.)
   5. ☐ Service (such as health services, food preparation, janitorial, etc.)
   6. ☐ Craftsman (such as mechanic, repairer, etc.)
   7. ☐ Operator or laborer
   8. ☐ *Other (specify)*______________________________

The following information is needed so that your workstation can be located within the Madison Building. This is necessary so that we can relate your responses to the air measurements that will be taken in a few weeks. As with the rest of the questions in this survey, this information will be kept confidential. Please tell us:

5. a. **Your room number**

   ____

   b. **Your workstation telephone number (your direct or private number, not your "section" or "division" number.)**

   ____

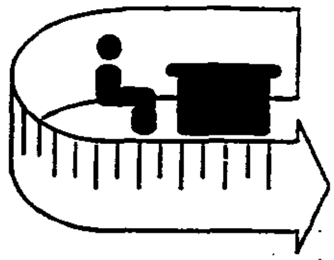
Building? If so, please use this space provided for that purpose.

Please put your completed questionnaire in the return envelope provided. Seal it and take it to one of the return boxes located near the elevators and building exits.

PLEASE READ THE NEXT PAGE

In a few weeks we plan to conduct air measurements in the Madison Building. At that time people whose workstations are close to the air measurement locations will be asked a few additional questions. You may be recontacted at that time.

Thank you very much for your time and patience in filling out this questionnaire.



INDOOR AIR QUALITY AND WORK ENVIRONMENT FOLLOWUP SURVEY

THE MADISON BUILDING STUDY

Measurements of a variety of environmental conditions are being taken in your work area throughout the day TODAY. To help determine how these measurements relate to your comfort and health, please complete the attached questionnaire. Your participation in this part of the evaluation of the Madison Building is, of course, voluntary.

Your completed questionnaire will be collected by and analyzed by NIOSH, Yale and Westat investigators and WILL NOT BE SEEN BY LIBRARY OF CONGRESS MANAGEMENT OR UNION REPRESENTATIVES.

So that we may combine your responses to this questionnaire with the questionnaire distributed three weeks ago, we need you to print your name below. As soon as we have matched your questionnaires, we will remove this cover sheet and save this questionnaire without your name on it. At that time, we will also remove your name from the final combined data file.

YOUR FULL NAME: ______________________________
(please print) FIRST MIDDLE LAST

Please complete this questionnaire even if you did not complete the questionnaire distributed previously.

After you complete this questionnaire, please place it in the attached envelope and seal it. A study investigator will collect it from you.

THANK YOU FOR YOUR PARTICIPATION IN THIS SURVEY.

INDOOR AIR QUALITY AND
WORK ENVIRONMENT STUDY

I. **Your answers to the following questions will allow a better interpretation of the environmental measurements taken TODAY in the area around your workstation.**

1. **Did you complete and return the green-covered Indoor Air Quality and Work Environment questionnaire distributed during the week of February 6, 1989?**

   1. ☐ No
   2. ☐ Yes

2. **Have you been in the Madison Building at least 4 hours yet TODAY?**

   1. ☐ No
   2. ☐ Yes

3. **How many hours (to the nearest 1/2 hour) have you spent <u>at your workstation</u> TODAY?** *(Enter 0 if you have not been at your workstation today.)*

   _____ hours this morning (before 12:00 noon)

   _____ hours this afternoon (between 12:00 noon and time you complete this questionnaire)

4. **Since you arrived at work TODAY, have you gone outside (for lunch, break, or other reason)?**

   1. ☐ No
   2. ☐ Yes

5. **How many hours (to the nearest 1/2 hour) have you spent TODAY working at a photocopy machine?**

   _______ hours

6. **How many hours (to the nearest 1/2 hour) have you spent TODAY working at a video display terminal?**

   _______ hours

7. **During the day TODAY, have you or anyone else performed any of the following activities at or near your workstation?** *(Check "no" or "yes" for each item.)*

	No 1	Yes 2
a. Smoked tobacco	☐	☐
b. Used a humidifier	☐	☐
c. Used a cleanser, glue, white out, or other strong-smelling chemical	☐	☐
d. Used a computer or word processor	☐	☐
e. Used a printer	☐	☐

II. **For the following, please check the response that best describes your work environment TODAY . . .**
(Please check one box for this morning and one box for this afternoon.)

	This MORNING	This AFTERNOON
1. Has the AIR MOVEMENT been:	1. ☐ too much 2. ☐ too little 3. ☐ just right	1. ☐ too much 2. ☐ too little 3. ☐ just right
2. Has the TEMPERATURE been:	1. ☐ too hot 2. ☐ too cold 3. ☐ just right	1. ☐ too hot 2. ☐ too cold 3. ☐ just right
3. Has the HUMIDITY been:	1. ☐ too humid 2. ☐ too dry 3. ☐ just right	1. ☐ too humid 2. ☐ too dry 3. ☐ just right
4. Has the NOISE LEVEL been:	1. ☐ too loud 2. ☐ too quiet 3. ☐ just right	1. ☐ too loud 2. ☐ too quiet 3. ☐ just right
5. Has the air been TOO STUFFY?	1. ☐ No 2. ☐ Yes	1. ☐ No 2. ☐ Yes
6. Has your work area been TOO DUSTY?	1. ☐ No 2. ☐ Yes	1. ☐ No 2. ☐ Yes

7. a. **Would you like to adjust any of the above conditions?**

1. ☐ No ⟶ Go to Q.8
2. ☐ Yes

b. **If yes, which condition(s) would you adjust?**

____

____

____

8. **Have you noticed any of these types of ODORS at your workstation TODAY?** *(Check one box for each item.)*

	No 1	Yes 2
a. Body odor	☐	☐
b. Cosmetics, such as perfume or after-shave	☐	☐
c. Tobacco smoke	☐	☐
d. Fishy smells	☐	☐
e. Other food smells	☐	☐
f. Musty or damp basement smells	☐	☐
g. Odors from new carpet	☐	☐
h. Odors from new drapes or curtains	☐	☐
i. Odors from diesel or other engine exhaust	☐	☐
j. Odors from a photo-copying machine	☐	☐
k. Odors from printing processing (presses, binding materials, etc.)	☐	☐
l. Odors from other chemicals such as adhesives, glues, cleansers, white out, rubber cement, pesticides, etc.	☐	☐
m. Odors from pesticides	☐	☐
n. Odors from cleaning of carpets, drapes, or other furnishings	☐	☐
o. Odors from paint	☐	☐
p. Other unpleasant odors *(describe)* . . . . ____________________	☐	☐

9. **How would you judge the overall air quality in the Madison Building TODAY?**

1. ☐ Excellent
2. ☐ Good
3. ☐ Fair
4. ☐ Poor

III. **Have you experienced any of the following symptoms while at work in the Madison Building TODAY?** *(For each symptom, answer "no" or "yes." If your response is "no," go down to the next symptom.)*

			IF YES, when did this symptom begin?		
	NO	YES	BEFORE ARRIVING AT WORK	THIS MORNING AT WORK	THIS AFTERNOON AT WORK
a. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
b. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
c. runny nose	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
d. stuffy nose/sinus congestion	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
e. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
f. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
g. wheezing or whistling in chest	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
h. shortness of breath	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
i. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
j. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
k. dry, itching, or tearing eyes	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
l. sore/strained eyes	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
m. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
n. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
o. sore throat	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
p. hoarseness	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
q. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
r. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
s. sleepiness or drowsiness	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
t. chills	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
u. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
v. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
w. problems with contact lenses	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
x. difficulty remembering things	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
y. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
z. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
aa. tension or nervousness	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
bb. difficulty concentrating	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
cc. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
dd. [illegible]	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
ee. pain or stiffness in lower back	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
ff. pain or numbness in shoulder/neck	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐
gg. pain or numbness in hands or wrists	1. ☐	2. ☐	1. ☐	2. ☐	3. ☐

IV. The quality of indoor air and other working conditions may influence the way a person feels. For each of the following, please indicate how you have been feeling TODAY. *(Check one box for each item.)*

		Not at all	A little	Moderately	Quite a lot	Extremely
a.	worn out	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
b.	listless	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
c.	lively	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
d.	active	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
e.	on edge	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
f.	shaky	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
g.	energetic	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
h.	tense	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
i.	relaxed	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
j.	uneasy	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
k.	restless	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
l.	fatigued	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
m.	nervous	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
n.	cheerful	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
o.	exhausted	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
p.	anxious	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
q.	sluggish	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
r.	panicky	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
s.	weary	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
t.	alert	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
u.	full of pep	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
v.	carefree	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
w.	vigorous	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐
x.	bushed	1. ☐	2. ☐	3. ☐	4. ☐	5. ☐

V. What time is it now?

____:____ PM

Thank you for your time and patience in filling out this questionnaire. Your answers to this questionnaire, like the previous questionnaire, will be kept confidential.

APPENDIX C

A series of questions was asked in Part IV of Questionnaire 1 to assess aspects of job satisfaction, and sources of work-related and external stressors. The questions used in this questionnaire have been validated in previous job stress studies and were chosen because of their reliability in measuring work and non-work stressors.[7,35,36] These questions were combined to form 7 scales as outlined below. Each scale was constructed so that higher values mean "more" and lower values mean "less" of the stated characteristic (e.g., a high score on "job satisfaction" indicates a high degree of satisfaction; a high score for "workload" indicates a perception of heavy workload.

- <u>Job Satisfaction:</u>

  As perceived job stressors are often found to be highly related to reports of job satisfaction, a measure of global satisfaction was included to provide a rough index of overall job stress level. Items from Question 1 (Q1, Part IV) are combined to form this index:

  Job Satisfaction = ((5-Q1a)+(4-Q1b)+(4-Q1c)+(4-Q1d))/4

  The potential range of scores is 1 to 3.25.

- <u>Role Conflict:</u>

  Role conflict, which occurs when behaviors required of a worker are viewed by the worker as conflicting or incompatible, is a common stressor found in the modern work environment. Items from Question 4 (Q1, Part IV) are combined to form this index:

  Role Conflict = (Q4a + Q4b + Q4c)/3

  The potential range of scores is 1 to 4.

- <u>Job Control:</u>

  Job control has been associated with psychological and physical health complaints. This scale assesses control over workload, resources needed to do the job, policies and procedures at work, and workstation surroundings. This scale is based on responses to Questions 5a-d:

  Job Control = (Q5a + Q5b + Q5c + Q5d)/4.

  The potential range of scores is 1 to 5.

- Workload:

to a variety of health complaints. Items from Question 6 are combined to form this scale:

$$\text{Workload} = (Q6a + Q6b + Q6c + Q6d)/4$$

The potential range of scores is from 1 to 5.

- <u>Utilization of Abilities:</u>

This measure assesses the extent to which workers are required to use their skills and knowledge in completing their work. Underutilization of abilities is a highly prevalent stressor thought to produce a variety of health complaints. Questions 6e-g (Q1, Part IV) are used to form this scale:

$$\text{Utilization of abilities} = (Q6e + Q6f + Q6g)/3.$$

The potential range of scores is from 1 to 5.

- <u>Role Clarity:</u>

Role ambiguity may be caused by a lack of certainty regarding expected role behaviors in the job environment. This scale, referred to as role clarity to correspond to the positive direction of the scale, is derived from Questions 6h-k (Q1, Part IV):

$$\text{Role Clarity} = (Q6h + Q6i + Q6j + Q6k)/4$$

The potential range of scores is from 1 to 5.

- <u>External Stress:</u>

External stressors are important to assess because non-work demands can increase the level and nature of work demands and vice versa. Work and non-work demands may interact to increase symptom reporting. This scale is derived from Questions 7a-f (Q1, Part IV), so that the value is equal to the number of external stressors reported:

$$\text{External Stress} = (Q7a + Q7b + Q7c + Q7d + Q7e + Q7f){-}6$$

The potential range of scores is from 0 to 6.

Appendix D

Prevalence of Positive Symptoms Defined by Questionnaire 1 and Questionnaire 2 (Among Persons Completing Both Questionnaires)

nausea	1.5%	14.2%	5.3%
runny nose	10.4%	24.0%	14.7%
stuffy nose	26.7%	39.3%	28.9%
sneezing	14.6%	36.9%	18.2%
cough	6.2%	20.5%	13.0%
wheezing	2.3%	6.4%	3.5%
short of breath	2.1%	11.7%	4.6%
chest tightness	2.1%	8.8%	5.3%
dry eyes	24.0%	43.5%	28.4%
sore eyes	26.8%	44.4%	24.1%
blurry vision	7.4%	18.1%	7.2%
burning eyes	12.9%	29.2%	15.4%
sore throat	2.9%	13.9%	4.7%
hoarseness	3.0%	9.6%	5.2%
dry throat	12.0%	24.5%	22.0%
fatigue	23.2%	35.2%	14.4%
sleepiness	26.9%	53.1%	32.2%
chills	11.6%	23.1%	11.9%
fever	1.1%	3.1%	0.6%
aching muscles	6.6%	16.0%	6.3%
trouble remembering	2.2%	9.8%	2.8%
dizziness	4.4%	18.0%	7.7%
depressed	7.0%	21.5%	6.6%
tension	11.5%	33.4%	9.4%
trouble concentrating	7.8%	26.7%	11.0%
dry skin	9.0%	13.9%	9.4%
pain - upper back	10.7%	20.6%	10.2%
pain - lower back	8.8%	21.7%	8.7%
pain - shoulders	8.3%	20.0%	9.9%
pain - hand/wrist	4.2%	10.4%	3.5%

[1] Q1: Symptom occurred "often" or "always" in past year; got better away from work
[2] Q1: Symptom occurred "sometimes," "often" or "always"; got better away from work
[3] Q2: Symptom occurred on day of monitoring and began after coming to work

Appendix E

Preliminary Stepwise Regression Analysis
Evaluation of Workplace/Personal/Medical Variables

A. HEALTH SYMPTOMS (building-related symptoms)

H1) nonspec. IAQ	external stress used copier role conflict utilization gender hrs at workstation	1.25 (0.01) 1.95 (0.003) 1.51 (0.01) 0.83 (0.03) 0.68 (0.05) 1.12 (0.06)
H2) mucous membrane	gender role conflict pay (H vs. L/M) contacts at work chemicals/glue external stress	0.51 (0.0007) 1.82 (0.0009) 0.53 (0.02) 1.88 (0.03) 1.88 (0.08) 1.16 (0.08)
H3) H1 & H2	role conflict gender utilization hrs at workstation age used copier	1.82 (0.002) 0.54 (0.003) 0.79 (0.01) 1.15 (0.02) 0.98 (0.05) 1.52 (0.08)
H4) flu-like sx	role conflict gender pay (H vs. L/M) used copier	1.55 (0.01) 0.60 (0.02) 0.46 (0.02) 1.63 (0.05)
H6) HA/nausea	used copier gender job satisfaction chemicals/glue	1.99 (0.004) 0.57 (0.01) 1.65 (0.02) 2.18 (0.02)
H7) nasal/cough	pay (H vs. L/M) pay (M vs. H/L) role conflict gender chemicals/glue contacts at work laser/copier nearby used copier	0.32 (0.0002) 0.67 (0.06) 1.51 (0.02) 0.65 (0.03) 1.92 (0.07) 1.58 (0.09) 0.67 (0.06) 1.46 (0.10)
H8) chest sx	gender used copier asthma pay (M vs. H/L) school (HS vs other)	0.32 (0.001) 2.51 (0.004) 2.34 (0.05) 1.75 (0.08) 1.92 (0.08)

Appendix E (Continued)

Preliminary Stepwise Regression Analysis
Evaluation of Workplace/Personal/Medical Variables

H10) throat sx	school (HS vs other)	1.63 (0.07)
	gender	0.52 (0.004)
	role conflict	1.54 (0.01)
	hrs at workstation	1.15 (0.04)
	age	1.03 (0.01)
	space (part vs other)	1.84 (0.03)
	chemicals/glue	1.88 (0.07)
	yrs at workstation	0.93 (0.10)
H11) tired/fatigue	external stress	1.26 (0.008)
	role conflict	1.60 (0.005)
	used copier	1.68 (0.02)
	age	0.98 (0.03)
	hrs at workstation	1.12 (0.08)
H13) nervous system	role conflict	1.66 (0.008)
	space (open vs other)	2.08 (0.006)
	job satisfaction	0.53 (0.007)
	used copier	1.80 (0.02)
	used computer	1.58 (0.10)
H14) dizziness	wood furniture	2.92 (0.01)
	external stress	1.55 (0.006)
	asthma	2.61 (0.04)
	smoke (light vs other)	3.00 (0.04)
H15) dry skin	school (prof vs other)	0.26 (0.0006)
	chemicals/glue	3.19 (0.003)
	role clarity	0.65 (0.004)
	asthma	2.46 (0.03)
	gender	0.58 (0.08)
H16) nasal sx	gender	0.59 (0.008)
	chemicals/glue	2.16 (0.03)
	pay (H vs. M/L)	0.48 (0.008)
	role conflict	1.49 (0.02)
	contacts at work	1.72 (0.05)
H17) eye irritation	gender	0.54 (0.003)
	contacts at work	1.88 (0.02)
	workload	1.35 (0.007)
	utilization	0.81 (0.02)
	school (prof vs other)	0.67 (0.06)

Preliminary Stepwise Regression Analysis
Evaluation of Workplace/Personal/Medical Variables

H5) ergonomic sx	chair uncomfortable	3.10 (0.0001)
	lighting (too much)	1.97 (0.01)
	hrs at VDT	1.17 (0.03)
	school (coll vs other)	1.62 (0.07)
	finance (others-help)	1.62 (0.06)
	role conflict	1.43 (0.06)
H12) ergonomic sx & muscle aches	chair uncomfortable	3.00 (0.0001)
	lighting (too much)	1.97 (0.01)
	finance (others-help)	1.73 (0.03)
	role clarity	0.76 (0.03)
	hrs at VDT	1.14 (0.06)
	school (HS vs others)	1.63 (0.06)
H9) eye sx	glare	1.97 (0.006)
	gender	0.62 (0.02)
	job satisfaction	0.66 (0.05)
	contacts at work	1.99 (0.01)
	workload	1.32 (0.01)
	lighting (too much)	1.63 (0.05)
	chair uncomfortable	1.46 (0.07)
	pay (H vs. M/L)	0.61 (0.09)
H18) eye strain	glare	1.72 (0.04)
	workload	1.30 (0.04)
	finance (others-help)	1.90 (0.007)
	lighting (too much)	2.41 (0.002)
	lighting (too little)	1.86 (0.02)
	contacts at work	1.72 (0.06)
	hrs at workstation	1.15 (0.04)
	role conflict	1.45 (0.04)

Appendix E (Continued)

Preliminary Stepwise Regression Analysis
Evaluation of Workplace/Personal/Medical Variables

B

C1) hot/stuffy	role conflict yrs at workstation	1.86 (0.001) 0.91 (0.01)
C2) too dry	role clarity chemicals/glue external stress space (open vs others) space (part vs others) contacts at work smoke (light vs other)	0.75 (0.02) 2.51 (0.009) 1.28 (0.01) 2.97 (0.004) 1.80 (0.08) 2.01 (0.04) 2.39 (0.04)
C4) too cold	pay (H vs. M/L) gender smoke (light vs other) chemicals/glue finance (others-sole) space (open vs others)	0.40 (0.01) 0.48 (0.001) 2.69 (0.02) 2.18 (0.02) 1.93 (0.05) 1.68 (0.06)
O2) odors	pay (H vs. M/L) finance (others-help) school (coll vs other) used printer utilization role conflict chemicals/glue asthma age	0.36 (0.005) 2.01 (0.001) 0.56 (0.01) 1.90 (0.003) 0.83 (0.05) 1.36 (0.08) 1.99 (0.05) 0.50 (0.07) 0.98 (0.08)
A1) overall air = poor or fair	role conflict pay (H vs. M/L) gender finance (others-sole) smoke (light vs other) smoke (heavy vs other) utilization yrs at workstation	1.88 (0.002) 0.61 (0.08) 0.59 (0.01) 0.53 (0.05) 3.06 (0.02) 2.20 (0.07) 0.84 (0.07) 0.93 (0.06)
A2) overall air = poor	pay (H vs. M/L) asthma space (part vs other) space (open vs other)	0.08 (0.001) 0.13 (0.05) 0.28 (0.002) 0.32 (0.02)

Appendix E (Continued)

Preliminary Stepwise Regression Analysis
Evaluation of Workplace/Personal/Medical Variables

M1) tension	role conflict job satisfaction finance (others-sole)	1.43 (0.0001) -1.28 (0.002) -1.56 (0.02)
M2) fatigue	used copier role clarity age	1.92 (0.003) -0.95 (0.003) -0.06 (0.04)
M3) vigor	job control age space (open vs other) role clarity	1.21 (0.0006) 0.11 (0.0002) 2.12 (0.007) 0.86 (0.02)

Appendix F

Effect of Environmental Parameters on Health Symptoms: Odds Ratios Controlling for Workplace/Personal/Medical Factors[1]

	—MEASURED—			—PERCEIVED—		
	Temp	RH	T_{Δ}	Hot	Dry	Cold
H1) non-spec. IAQ	1.13	1.03	0.98	***2.04***	***2.10***	***2.16***
H2) mucous membrane	1.14	1.00	0.98	***2.41***	***3.56***	***3.16***
H3) H1 & H2	1.12	1.02	1.04	***2.64***	***3.94***	***3.44***
H4) flu-like sx	1.09	1.04	1.12	***2.86***	***1.67***	***1.68***
H6) HA/nausea	1.13	***1.05***	0.92	***2.25***	***2.09***	***1.80***
H7) nasal/cough	1.14	1.02	1.00	1.46	***3.42***	***2.16***
H8) chest sx	0.99	1.04	1.05	***4.01***	1.65	1.18
H10) throat sx	1.17	1.00	1.16	1.58	***3.03***	***1.99***
H11) tired/fatigue	1.10	0.97	1.10	***1.78***	1.47	***1.90***
H13) nervous system sx	1.20	1.02	1.08	***1.95***	1.57	0.72
H14) dizziness	1.28	1.08	0.99	1.73	***2.32***	1.48
H15) dry skin	1.09	0.96	0.84	1.80	***2.80***	***2.32***
H16) nasal sx	1.14	1.01	1.01	1.25	***3.63***	***2.10***
H17) eye irritation	***1.19***	1.01	1.04	***2.90***	***1.65***	***1.91***
H5) ergonomic sx	1.11	1.02	1.00	***1.73***	***1.79***	1.05
H12) ergo/aches	1.17	1.02	1.01	1.52	***1.72***	1.11
H9) eye sx	***1.21***	1.02	0.97	***2.72***	***1.65***	***2.14***
H18) eye strain	1.15	1.00	1.01	***2.14***	1.32	1.43

[1] Symptoms related to IAQ/respiratory problems (above solid line) controlling for gender, age, role conflict, external stress, contact lenses, copier use, chemicals/glue;

Symptoms related to ergonomic problems (below solid line) controlling for gender, chair comfort, lighting, glare, role conflict, financial situation

odds ratios significant at $p \leq 0.05$ in bold face italics

Appendix F (Continued)

Effect of Environmental Parameters on Health Symptoms:
Odds Ratios Controlling for Workplace/Personal/Medical Factors[1]

H1) non-spec. IAQ	***8.00***	1.49	0.92	***1.52***
H2) mucous membrane	2.10	0.92	0.92	1.39
H3) H1 & H2	4.71	1.05	0.81	***1.67***
H4) flu-like sx	6.11	1.17	0.95	***1.52***
H6) HA/nausea	2.05	1.40	0.85	1.25
H7) nasal/cough	3.45	1.02	0.91	***1.79***
H8) chest sx	31.50	1.45	1.40	1.68
H10) throat sx	2.43	0.49	0.90	1.22
H11) tired/fatigue	4.18	1.02	1.10	***1.51***
H13) nervous system	1.86	1.18	0.74	***2.14***
H14) dizziness	3.13	1.82	***0.46***	1.73
H15) dry skin	0.39	0.35	0.92	***2.32***
H16) nasal sx	2.56	1.01	0.85	***1.67***
H17) eye irritation	2.72	1.71	1.12	***2.12***
H5) ergonomic sx	1.25	0.73	1.04	***2.35***
H12) ergo/aches	1.52	0.82	0.97	***1.99***
H9) eye sx	2.27	***1.97***	1.01	***2.29***
H18) eye strain	1.80	1.21	0.97	***2.10***

[1] Symptoms related to IAQ/respiratory problems (above solid line) controlling for gender, age, role conflict, external stress, contact lenses, copier use, chemicals/glue;

Symptoms related to ergonomic problems (below solid line) controlling for gender, chair comfort, lighting, glare, role conflict, financial situation

odds ratios significant at $p \leq 0.05$ in bold face italics

Appendix F (Continued)

Effect of Environmental Parameters on Health Symptoms:
Odds Ratios Controlling for Workplace/Personal/Medical Factors[1]

Dependent Variable	ln(VOCs)				log(Bioaerosols)		
	V1	V2	V3	V4	Fungi	Bact	Therm
H1) non-spec. IAQ	0.88	0.58	1.34	0.82	1.17	1.26	0.55
H2) mucous membrane	1.09	1.21	1.09	1.07	1.03	1.54	0.85
H3) H1 & H2	1.10	0.97	1.27	0.91	0.95	1.70	0.60
H4) flu-like sx	1.05	1.32	0.93	0.66	1.14	1.47	1.29
H6) HA/nausea	1.00	0.55	1.24	1.12	1.44	0.69	1.17
H7) nasal/cough	0.97	0.75	1.09	0.81	1.20	1.25	1.15
H8) chest sx	1.58	0.26	0.98	1.55	1.41	1.20	1.95
H10) throat sx	1.03	0.85	1.48	0.68	0.63	1.05	0.90
H11) tired/fatigue	0.87	0.84	1.40	0.76	0.75	2.24	0.48
H13) nervous system sx	0.93	2.27	0.97	1.72	1.48	1.86	0.72
H14) dizziness	1.28	3.85	0.78	1.09	***3.63***	0.71	1.62
H15) dry skin	1.39	1.08	1.48	0.70	0.81	0.71	1.51
H16) nasal sx	1.08	0.90	1.09	0.89	1.15	1.29	1.07
H17) eye irritation	1.03	0.59	1.35	1.32	1.54	1.31	0.76
H5) ergonomic sx	0.91	1.82	0.75	0.98	1.26	1.34	1.01
H12) ergo/aches	0.96	1.92	0.70	0.99	1.55	0.99	1.35
H9) eye sx	0.92	0.70	1.06	1.25	1.16	1.38	0.99
H18) eye strain	0.73	1.37	1.12	1.08	1.23	0.93	1.26

[1] Symptoms related to IAQ/respiratory problems (above solid line) controlling for gender, age, role conflict, external stress, contact lenses, copier use, chemicals/glue;

Symptoms related to ergonomic problems (below solid line) controlling for gender, chair comfort, lighting, glare, role conflict, financial situation

odds ratios significant at $p \leq 0.05$ in bold face italics

Effect of Environmental Parameters on Comfort, Perception of Odors, Perception of Air Quality: Odds Ratios Controlling for Workplace/Personal/Medical Factors[1]

	Temp	RH	T_{Δ}	Hot	Dry	Cold
C1) hot/stuffy	***1.23***	0.99	***1.35***	XXX	XXX	XXX
C2) too dry	0.92	***0.93***	0.87	XXX	XXX	XXX
C4) too cold	***0.78***	***1.06***	0.95	XXX	XXX	XXX
O2) odors	0.97	0.99	0.95	1.48	1.26	1.01
A1) IAQ=poor/fair	1.17	1.05	0.94	***7.92***	***2.66***	***2.70***
A2) IAQ=poor	1.22	1.05	0.96	***3.67***	1.55	***2.87***

B. CO_2, Respirable Particulates, Odors

Dependent Variable	ln(CO_2)	–ln(Resp. Part.)– Temp.	Int.	ODORS
C1) hot/stuffy	1.20	1.75	1.35	***1.65***
C2) too dry	1.38	1.09	1.31	***1.48***
C4) too cold	0.71	***0.33***	1.00	0.86
O2) odors	2.22	1.01	0.75	XXX
A1) IAQ=poor/fair	***8.58***	1.07	0.87	***1.68***
A2) IAQ=poor	17.39	1.22	1.03	1.31

[1] controlling for gender, age, role conflict, external stress, contact lenses, copier use, chemicals/glue; ***odds ratios significant at $p \le 0.05$ in bold face italics***

Appendix F (Continued)

Effect of Environmental Parameters on Comfort, Perception of Odors, Perception of Air Quality:

Dependent Variable	--- ln(VOCs) --- V1	V2	V3	V4	log(Bioaerosols) Fungi	Bact	Therm
C1) hot/stuffy	0.87	1.54	0.70	0.94	0.71	***2.19***	0.75
C2) too dry	1.40	***0.18***	1.21	1.83	1.16	0.78	1.15
C4) too cold	1.06	1.39	0.76	0.61	1.05	1.23	0.66
O2) odors	0.79	1.23	0.87	1.36	1.07	1.99	0.89
A1) IAQ=poor/fair	1.33	0.89	***1.73***	0.94	0.95	1.43	0.65
A2) IAQ=poor	1.87	0.33	1.28	1.16	1.17	0.45	2.63

[1] controlling for gender, age, role conflict, external stress, contact lenses, copier use, chemicals/glue; ***odds ratios significant at $p \leq 0.05$ in bold face italics***

Effect of Environmental Parameters on Mood States:
Beta Coefficients (Slopes) Controlling for

	Temp	RH	T_{Δ}	Hot	Dry	Cold
M1) tension	***0.46***	0.02	0.37	0.68	0.34	-0.04
M2) fatigue	0.27	-0.09	0.56	***1.32***	0.15	0.45
M3) vigor	-0.22	0.11	-0.02	-0.99	0.26	-0.61

B. CO_2, Respirable Particulates, Odors

Dependent Variable	$\ln(CO_2)$	-- ln(Resp. Part.)-- Temp.	Int.	ODORS
M1) tension	1.83	0.31	-0.45	0.06
M2) fatigue	-1.96	-0.38	-0.38	0.62
M3) vigor	-1.44	-1.74	0.53	0.22

C. Volatile Organic Compounds, Bioaerosols

Dependent Variable	--ln(VOCs)-- V1	V2	V3	V4	log(Bioaerosols) Fungi	Bact	Therm
M1) tension	-0.10	0.20	0.14	0.13	-0.22	0.20	-0.07
M2) fatigue	-0.09	0.27	-0.19	-0.84	-0.59	0.25	0.08
M3) vigor	0.52	***3.28***	***-1.25***	0.13	0.04	0.28	0.14

[1] *controlling for gender, age, role conflict, external stress, contact lenses, copier use, chemicals/glue;*
betas significant at p ≤ 0.05 in bold face italics

Comparison of Environmental Conditions at the Madison Building
During the Survey Week and at Other Times

A limitation of the study design is the fact that measurements were taken at only one point in time, providing a "snapshot" of the environmental conditions and health concerns experienced at the given point that the monitoring took place. Concern was voiced to study investigators by a number of employees during the week of environmental monitoring that conditions were much better than usual and that they felt that some deliberate improvements were made by building engineers because of the study. There is some evidence that speaks against this possibility.

NIST Study

First, in the comprehensive study of the ventilation system at the Madison Building performed by NIST,[9] no substantial differences were found between the week of the survey (February 27-March 3, 1989) and other weeks during the year. The weekly average air exchange rate during the test week was only slightly higher than the average of the weeks preceding the test week (0.90 air changes per hour (ACH) versus a mean of 0.86 ACH for the period January 30 through February 26) and no different from the following weeks (0.90 ACH versus a mean of 0.89 ACH from March 6 through April 23, 1989). In addition, daily peak carbon dioxide concentrations were reported for the working days of each week, and there was no significant difference in the test week average and the average reported for other weeks.

Temperature and Humidity Logs

In addition, temperature and humidity logs are routinely maintained by building maintenance personnel. A study of those logs was made comparing the readings made between 6:00 am and 6:00 pm at 30 locations in work spaces of the Madison Buildings for the week before the survey and the survey week. The hourly readings for each station for the pre-survey week were paired with the hourly readings for the survey week. Nine of the 30 stations (30%) had temperatures which did not differ statistically ($p>0.05$). Four of the stations had temperature readings that were warmer during the survey week, but the mean temperature was only 0.3° warmer than those from the same hours of the pre-survey week. Temperature readings at the remaining 17 stations (57%) were cooler during the survey week by a mean difference of 1.0°. Most of the stations (28/30) had lower humidity readings during the survey week by an average of 2.1 percentage points.

Temperature readings were more uniform and showed less variation across lower by an average of [illegible] percentage points during the survey week.

Comparisons were also made of the day by day temperature and humidity (e.g., Monday of pre-survey week was compared to Monday of survey week, etc.) There was no statistical difference in the mean temperature readings from all locations on Wednesday. The average temperatures from all locations was 0.5° lower during the survey week on Monday, Tuesday, and Friday. The average temperature on Thursday was 0.8 cooler during the survey week. The average temperature was 0.8° cooler in the mornings and 0.6° cooler in the afternoons during the survey week. The average humidity readings during mornings was 1.6% lower and the average afternoon humidity reading was 1.7% lower during the survey week as compared to the pre-survey week.

Although many of the sets of comparisons yielded statistically different results, the actual differences of temperature and humidity (for hours, days, mornings, afternoons, and weeks) were small in magnitude. It is unlikely that the heating, ventilation, and air-conditioning (HVAC) system was manipulated differentially for the survey week.