The Psychology of the Sick Building Syndrome

by

Alan Hedge, William A. Erickson and Gail Rubin

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ABSTRACT

A sample of 4,479 workers from 27 air conditioned office buildings was surveyed. Workers completed a questionnaire on environmental conditions, sick building syndrome (SBS) symptoms, job satisfaction, job stress, occupational and personal information, at the same time as indoor air quality measures were taken. Indoor air quality met current ASHRAE guidelines in all buildings. Logistic regression analyses, conducted for individual symptoms, revealed environmental correlates for workers' reports of environmental conditions, but few environmental correlates for reports of SBS symptoms. The total number of SBS symptoms was related linearly to computer use, job stress, and job satisfaction, number of allergies, migraine, and eye wear, with separate intercepts necessary for each gender, and interactions of gender with age and PIAQ. Allergy did not replace gender in the regression equations. Effects of environmental conditions and SBS symptoms on work disruption were assessed.

INTRODUCTION

Throughout the past decade, concerns have grown about the association between indoor air quality (IAQ) in the workplace and a variety of health complaints, including symptoms of the sick building syndrome. The sick building syndrome (SBS), as originally defined by the World Health Organization, comprises a collection of nonspecific symptoms including eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritation, which seem to be linked with occupancy of certain workplaces (W.H.O., 1983). More recently it has been suggested that the SBS may also include odor or taste complaints (Mølhave, 1989). These symptoms are relatively commonplace among the population, and SBS is distinguished by the fact that symptoms are more prevalent among office workers, and only experienced in the workplace. Because of this, the SBS is thought to be caused by exposure to something inside buildings. It is, however, important to recognize that the SBS is based on prevalence data and therefore it applies at the level of a building, not necessarily at the level of the individual, and that there is no consensus on what may or may not constitute a "sick" building.

The World Health Organization (1983) also originally distinguished between "temporary" SBS and "permanent" SBS. The label "temporary" SBS was proposed to describe instances where an acute outbreak of symptoms follows from an identifiable trigger event, e.g. office redecoration, building maintenance and renovation work, etc. In such situations chemical pollutants, especially volatile organics, may be responsible for symptoms. The label "permanent "SBS refers to situations where indoor air quality, according to measures of gaseous pollutants, does not appear to be problematic, but SBS symptoms are widespread and chronic among workers. Part of the confusion in the SBS literature stems from that fact that subsequent research studies generally have failed to make this distinction in investigating the SBS phenomenon.

To distinguish SBS symptoms from those possibly caused by infectious diseases that are also linked with buildings, such as Legionnaire's disease, SBS symptoms often have been defined as those which are present when at work but are alleviated when away from work for a period of time (see Hedge, 1990). Over the past decade, most studies of SBS among office workers have attributed SBS symptoms directly to problems with the indoor climate, and indoor air quality frequently has been investigated as the cause of symptoms (Hedge et al., 1987; Skov et al., 1987; Menzies et al., 1993; Jaakkola et al., 1991). Although a number of indoor air pollutants have been suspected, the physical cause or causes of SBS symptoms remains unclear.

Several studies have investigated factors which might cause permanent SBS . Finnegan et al. (1984) conducted an interview study which compared self-reports of SBS symptoms among workers in 9 office buildings and found evidence that symptoms were more prevalent among those workers occupying air-conditioned buildings than those in naturally ventilated buildings. In air-conditioned buildings the air may pass through several potential sources of contamination, (e.g., ducts, humidifier, chiller), whereas in naturally ventilated buildings ventilation depends solely on operable windows.

Hedge (1984) conducted a questionnaire survey of workers from 6 office buildings and found differences in the prevalence of eye, nose, and throat symptoms between air-conditioned and naturally ventilated offices. Reports of headache did not differ between offices as a function of type of ventilation, but they did vary as a function of office layout, with the greatest prevalence being reported in deep, open-plan office spaces. Hedge also found that other health symptoms, similar to those of the SBS, were significantly more widespread among women than men in these offices. More recently, Burge et al. (1987), Wilson and Hedge (1987), and Hedge et al. (1989) have reported similar results from a nationwide questionnaire survey of 4,373 office workers in 47 office buildings in the UK.

Their results confirm an overall difference in SBS symptom prevalence between air-conditioned and unconditioned offices, but this study also showed a variety of unexpected findings. Symptoms were actually less prevalent in mechanically ventilated buildings (i.e., those with ducted air or forced air extract but with no conditioning of the supply air), than in naturally ventilated buildings, which previously had been thought to be the healthiest type of offices. Symptoms were more prevalent in buildings with air-conditioning, but contrary to expectations, among the air conditioned buildings, symptoms generally were less prevalent in variable air volume heating, ventilating and air-conditioning (HVAC) systems which re-circulate a greater proportion of the office air than in either central types of HVAC systems (i.e., those with ceiling induction or fan-coil units in which air is ducted from a central plant room and then either heated or cooled in the room),or local HVAC systems (i.e., those with no ducting but where air is directly supplied to the office from the outside by wall-mounted units without any ducts). They also found that a variety of individual factors (gender, age, perceived control, attitudes to environmental conditions), occupational factors (VDT use, job stress), and organizational factors (organization type, office type) influenced symptom prevalence in addition to the type of ventilation system used in the building. Unfortunately, these U.K. surveys did not include any measures of the physical environment conditions, and so the extent to which symptoms might also have been a consequence of exposure to polluted indoor air in offices cannot be established.

Robertson et al. (1985) compared symptom reports for workers in adjoining air conditioned and naturally ventilated office buildings. As expected, SBS symptoms were more prevalent among workers in the air conditioned offices than among their counterparts in the naturally ventilated offices. Measurement of a variety of physical environmental parameters (air temperature, globe temperature, air velocity, negative and positive air ion concentrations, formaldehyde, carbon monoxide, and ozone) failed to show any significant differences in the environmental conditions in the two buildings. Hedge et al. (1987)

compared symptom reports and environmental conditions for workers in the same organization occupying adjacent air-conditioned and naturally ventilated office buildings. Significant differences in SBS symptom reports between the two buildings were found but few differences in indoor air quality, apart from higher concentrations of total volatile organic compounds (TVOC) in the air-conditioned building. A significant association between formaldehyde levels and reports of leaving work early because of feeling unwell was found for both buildings.

Skov et al. (1987) surveyed 4,369 office workers in 14 Danish town halls and 14 associated office buildings, and at the same time they conducted extensive analyses of the physical conditions and indoor air quality in these buildings. Their results showed that there was considerable variation in the prevalence of SBS between buildings, but that there was no difference in symptom prevalence between mechanically ventilated and naturally ventilated buildings (Valbjørn and Skov, 1987; Skov et al., 1987). A recent re-analysis of these data (Mendell & Smith, 1990), has shown that only one of the mechanically ventilated Danish buildings was, in fact, air-conditioned, and when the data are re-analyzed to take account of this they fit the pattern of the U.K. data reported by Finnegan et al. (1984) and Burge et al., (1987). The Danish results also showed that none of the indoor air pollutants measured correlated with symptom reports, although symptoms were correlated with a fleece factor (the area of material surface divided by the room volume), a shelf factor (the area of open-shelving divided by the volume of the room), total dust, and air temperature. They also found that the highest prevalence of SBS symptoms was in the building with the highest level of TVOC. However, associations between TVOC and the SBS are unclear, and Sundell et al. (1993) report a negative correlation between these variables.

Jaakkola et al. (1989) report a linear relationship between the total number of SBS symptoms and an increase in air temperature above 22°C, but this has not been consistently confirmed in other studies. Helsing et al. (1989) found that increasing the ventilation rate seemed to reduce complaints of SBS symptoms even though concentrations of carbon dioxide and other indoor air pollutants were all below current the ASHRAE standard (ASHRAE, 1989), whereas Menzies et al. (1990, 1993) found that increasing ventilation provision to workers did not reduce SBS complaints. Jaakkola et al. (1990) found no difference in the prevalence of SBS symptoms in a building between ventilating this with 100% outdoor air or 25% outdoor air. Unique results have been reported by Hodgson et al. (1987) who found that SBS symptom reports were correlated with vibration from nearby mechanical ventilation equipment.

Armstrong et al. (1989) investigated SBS symptoms in a high rise public office building and found that symptoms were associated with total suspended particulates but not with any other indoor air pollutants. Similarly, in a detailed study of micro-environmental conditions in a "sick" building, Hodgson and Collopy (1989) and Hodgson et al. (1991) found that symptoms did not correlate with any indoor air quality measures apart from respirable suspended particulates. Harrison et al. (1990) studied 13 office buildings and found a negative correlation between the number of SBS symptoms and total airborne particulates when the data were analyzed across ventilation classes, but a positive correlation between total airborne particulates and SBS symptoms when the data were analyzed within a ventilation class. Recently, other significant associations between dust and the SBS have been reported. Hedge et al. (1993) found a high correlation between mineral fibers in settled office dust and SBS symptoms, and Gyntelberg et al. (1994) found correlations between SBS symptoms and allergenic materials, fibers, and TVOC in settled dust.

Norbäck et al. (1989) studied the prevalence of SBS symptoms among different occupational groups: hospital workers and industrial workers who were exposed to airborne gaseous irritants, and office workers who, according to hygiene measures, were not exposed to comparable levels of these irritants. They found that SBS symptoms were more prevalent among the office workers even though chemical exposures were lower for this group. They also found that women reported more symptoms than men, but that individual factors (i.e., mean age, atopy frequency, and smoking habits), and occupational factors (i.e., work stress, work satisfaction) were not related to symptom reporting. However, in this study SBS symptoms were not defined using a work-related criterion, and the confounding effects of this are unclear.

There is greater agreement between studies in evidence for associations between the SBS and a number of non-environmental variables, such as personal factors, such as gender, and occupational factors, such as use of a video display terminal (VDT) and job stress (Burge et al., 1987; Hedge, 1988; Hedge et al., 1989; Skov and Valbjørn, 1989, Tamblyn and Menzies, 1992). Zweers et al. (1992) surveyed 7,000 Dutch workers in 61 offices and also found that worker's gender , job satisfaction, and VDT use were among the most significant correlates of symptom reports. Although workers associated their symptoms with environmental conditions, daily fluctuations in temperature and humidity and reported symptoms of dry nose or nasal congestion were not correlated, but SBS symptoms correlate with self-reported work stress (Morris and Hawkins, 1987).

Lenvik (1987) found that the prevalence of SBS symptoms did not differ by job type or job satisfaction among 764 workers in 3 office buildings but did differ by worker's gender, with women reporting most symptoms. Men also were found to report greater job satisfaction. However, no multivariate analyses of these data were conducted and it cannot be concluded that work factors do not affect SBS reports in offices. Klitzman and Stellman (1989) surveyed over 2,000 US. office workers and found significant correlations between perceived indoor air quality and psychological well-being, and between psychosocial job factors and symptoms. Unfortunately, symptoms tested were not exclusively those of the SBS.

Some studies have failed to find significant correlations between SBS symptoms and either job stress or job satisfaction (Norbäck et al., 1989). When results were adjusted for differences in nickel allergy, hyperreactivity and infection proneness gender differences in symptom reports are insignificant (Norbäck, 1990). Unfortunately, in this work job stress and job satisfaction have been measured by a single question, analog rating scale, whereas most other recent studies have used multiple item fixed-point rating scales. Also, unlike most other studies, SBS symptoms have not specifically been defined as being work-related.

Although research studies repeatedly have shown that SBS symptoms are more prevalent among workers in air-conditioned offices than in naturally ventilated offices, most of these studies also have found stronger associations between a variety of organizational, occupational, and personal variables and symptoms than between these and environmental conditions (see Mendell, 1993 for a review). This calls into question the role of environmental variables in the SBS.

The present study was undertaken further investigate the relationship between personal factors, occupational factors, and self-reports of SBS symptoms in a large number of air-conditioned offices in the U.S.A.

MATERIALS AND METHOD

Survey Method

Twenty seven office buildings, mostly occupied by private sector financial, insurance, sales, and marketing companies, were investigated. The buildings surveyed were selected according to the type of organization, type of ventilation, and office layout. Most of the buildings did not have any known indoor air quality problems. Smoking was prohibited in 6 of the buildings; restricted to separately ventilated areas in 4 buildings; restricted to smoking areas not separately ventilated in 5 buildings; restricted to smoking areas without separate ventilation but with local air filtration devices in 6 buildings; and restricted to each worker's workstation or office in 6 buildings. Smoking policy effects on indoor air quality were not statistically significant for the office areas which were surveyed (Hedge et al., 1994). Main office spaces in all buildings were ventilated by either a variable air volume or constant air volume system with air recirculation. All buildings studied were located in the Eastern U.S.A.: Alabama, Georgia, Indiana, Kentucky, Massachusetts, Michigan, New York State, Ohio, and Virginia. Each building was studied in the period from January to June.

Survey Questionnaire

A self-report questionnaire was distributed in each building. This questionnaire gathered data on employee perceptions of ambient environmental conditions (16 questions); occupational factors (12 questions: 6 job satisfaction, 5 job stress, and one on general work environment); work-related health and SBS symptoms (17 symptoms: 15 SBS symptoms and 2 unrelated symptoms), and personal information (sex, age, smoking status, allergy). People who did not indicate their sex were excluded from regression analyses. Answers to the ambient environment and the SBS symptoms were made on the same frequency scale applied to those for the past month in the building (never; 1-3 times/month; 1-3 times/week; every day). Jobs were grouped into 5 categories: managerial, professional, technical, clerical, and secretarial. Where jobs did not fit these categories, cases were excluded from regression analyses. Hours of VDT use were categorized as never (0), <1 hr. per day (0.5), 1 hr. per day (1), then separately into 2,3,4,5,6 hrs. per day, and finally 7 hrs. per day or more (7.5). Job stress and job satisfaction questions were answered on a 5-point rating scale (strongly agree to strongly disagree). Job satisfaction was measured using 6 items adapted from a short version "Job Satisfaction Scale" (Brayfield and Rothe, 1951). Job stress was measured using 5 items adapted from previous studies of self-reported job stress effects (Hedge, 1988).

Survey Administration

In each building, both indoor air quality and questionnaire surveys were conducted at each of the sample sites in the office areas. Typically, two sites were surveyed in the morning and two different sites in the afternoon on each of two consecutive days, giving a total of 8 sites per building. Measures were taken for carbon monoxide, carbon dioxide, formaldehyde, nicotine, respirable suspended particulates, ultraviolet particulate matter, air temperature, relative humidity, and illuminance. For details of the IAQ methods and results, see Hedge et al. (1994). The majority of the pollutant concentrations which were measured fell within levels for acceptable indoor air quality given in the ASHRAE 62-1989 standard (ASHRAE, 1989).Only those environmental data associated with symptom reports will be described here.

At each office site approximately 30 questionnaires were manually distributed to employees in the immediate vicinity of each of the indoor air sample locations (approx. 235 questionnaires were distributed and around 170 were returned in each building). The majority of questionnaires were collected by the researchers on the same day. If an employee could not complete the questionnaire on the same day, a pre-addressed envelope was provided. Less than 2% of employees refused to participate in the survey, and of the 6,335 questionnaires distributed 4,479 were returned (average 72% return rate).

Data analysis

Descriptive, logistic, and multiple regression analyses were performed using SAS (v.5.18), and factor analysis was performed using SPSSx (v.4.0). Missing values for environmental conditions and symptom questions ranged from 3% to 7%, and these were recoded to "never" for construction of the PIAQ and TSBS scales. Responses to all of the environmental conditions, job stress, and job satisfaction questions were analyzed using factor analysis with varimax rotation (Rummel, 1970; Manly, 1986). In the questionnaire both positive and negative job stress and job satisfaction items were presented, but these were all recoded to a positive direction when scales were created. Multiple regression analysis was used to model the relationships between occupational and personal factors, and the total number of SBS symptoms per person (TSBS). Cases with missing data on any of the variables included in these models were excluded from the analyses; a total of 4,384 cases were analyzed. The reliability of multiple item scales was assessed using Cronbach's alpha (Cronbach, 1970). Values of alpha > 0.67 indicate acceptable internal consistency (Klitzman and Stellman, 1989).

RESULTS

Physical Measures and Perceived Environmental Conditions

Responses to questions about the environmental conditions experienced in the month prior to the questionnaire survey are summarized in Table 1. About one quarter of workers complained that IAQ was inadequate every day, although comparatively few workers complained of frequent odors. Around three quarters of workers complained that thermal conditions had been either too warm and/or too cold at least once in the previous month.

A count was taken of the number of workers reporting that they were experiencing each of the environmental conditions at the same time as the physical measures were being made (this count was termed current conditions). The correspondence between current conditions and those conditions reported for the previous month was tested using the Cochran Mantel-Haenzel Chi Square test. For the IAQ and thermal comfort questions all associations were highly significant ($p \leq 0.001$), which indicates that respondents were being internally consistent in their judgements about their environmental conditions.

INSERT TABLE 1 ABOUT HERE

Logistic regression was used to test the association between physical measures of environmental conditions and reports of current conditions. Separate intercepts were needed for each building ($p = 0.0001$) in these analyses. Results showed that increasing air temperature increased the chance of experiencing conditions that were too warm, too humid, too little air movement or insufficient ventilation. Decreased mean air temperature and increased mean relative humidity increased the chance of reporting that it was too cold. Perception of uncomfortable drafts increased with decreasing mean air temperature and with increasing mean relative humidity and mean CO_2. Perception of unpleasant odors increased with increasing mean relative humidity. Reports that the air was too dry increased with increasing formaldehyde, and complaints of stale air increased with increasing mean CO_2 (Table 2).

INSERT TABLE 2 ABOUT HERE

Because smoking was allowed in some of the office buildings surveyed, logistic regression was used to test the association between nicotine, used an indicator of environmental tobacco smoke exposure, and reports of symptoms among non-smokers working in the buildings where smoking was allowed at individual office workstation. Separate intercepts were needed for each building ($p = 0.0001$) in these analyses. Results showed that reports of stuffy, congested nose (slope = 0.06 ± 0.02, $p = 0.004$: 191 of 827 non-smokers reported this symptom), and hoarseness (slope = 0.06 ± 0.03, $p = 0.043$: 59 of 829 non-smokers reported this symptom) were associated with increasing concentrations of nicotine. No other SBS symptoms were significantly associated with nicotine levels.

Physical Measures and the Sick Building Syndrome

Table 4 gives the prevalence of SBS symptoms in the survey sample. Analysis of individual symptom profiles showed that 66.7% of men and 81.4% of women reported at least one SBS symptom (see table 4).

INSERT TABLES 3 AND 4 ABOUT HERE

The number of workers reporting each SBS symptom at the same time as the physical measures were being taken was counted (these were termed current symptoms). The correspondence between current symptoms and the frequency of those reported for the previous month and categorized as work-related (i.e. the symptom is alleviated when away from the building) was tested using the Cochran Mantel-Haenzel Chi Square test. For all symptoms the associations were highly significant ($p = 0.001$) which indicates that respondents were being internally consistent in their judgements about their health. Separate intercepts were needed for each building ($p = 0.0001$) in these regression analyses. Results showed that increasing levels of formaldehyde increased reports of mental fatigue, headache, dry skin and dry eyes; increases in mean relative humidity increased reports of stuffy or runny nose; and increased mean illumination increases complaints of tired eyes, irritated eyes, and lethargy (Table 4). These analyses were repeated using the maximum values for air temperature and CO_2. Results showed that the only additional association to emerge was between increased reports of nervousness and increases in maximum temperature (slope = -0.170, $p = 0.038$).

Non-environmental Influences on Sick Building Syndrome

The job and the environmental conditions questions were analyzed using factor analysis. The best fit solution for the environmental conditions questions gave a 3 factor solution (see Table 5). Items which loaded significantly (factor loading > 0.3) on the first factor were used to create a perceived indoor air quality (PIAQ) scale. Experience of static electricity shocks was dropped from the PIAQ because this is a function of low relative humidity, and this duplicated responses about the air being too dry. The items used in the PIAQ were insufficient ventilation, too little air movement, too warm, too dry, unpleasant odors, stale air, and dusty air. Positive responses to these items were summed for each respondent to for use subsequent analyses to create a scale with a range from 0 to 7. The reliability coefficient (Cronbach's alpha) for the PIAQ scale was satisfactory ($\alpha = 0.85$). Responses to each of the PIAQ questions, categorized by worker's gender, are shown in table 6.

INSERT TABLES 5 AND 6 ABOUT HERE

Analysis of the job questions showed two orthogonal factors: job satisfaction (6 items) and job stress (5 items: see Table 7). The reliability coefficients (Cronbach's alpha) for the job satisfaction and job stress scales were satisfactory (job satisfaction: $\alpha = 0.71$; job stress: $\alpha = 0.89$). Mean ratings for the job satisfaction and the job stress questions were used in subsequent regression analysis.

INSERT TABLE 7 ABOUT HERE

The total number of workplace-related SBS symptoms experienced at least once per month was counted for each worker (total SBS symptoms, TSBS, ranged from 0 to 15). The frequency of the TSBS for the sample is shown in table 8. Multiple regression analysis was used to model the effects of personal and occupational variables on TSBS. Job grade and smoking status were not significantly associated with TSBS. The appropriate regression model for TSBS has separate intercepts for men and women, a common slope for VDT use, job stress, job satisfaction, number of allergies, migraine, eye wear, and interactions of sex with PIAQ and with age ($R^2 = 0.33$, $F_{11,4372} = 198.93$, $p = 0.0001$: see Table 9). Men reported an average of 2.77 SBS symptoms and women an average of 4.33 SBS symptoms. Hours of daily computer use were positively associated with average symptoms per person (no use = 2.79; 0.5 hrs. = 2.65; 1 hr.= 2.67; 2 hrs. = 3.12; 3 hrs. = 3.41; 4 hrs.= 3.77; 5 hrs. = 3.89; 6 hrs. = 4.29; 7.5 hrs. = 4.40). Mean job stress ratings were positively associated with an increase in symptom reports (1 = 2.64; 2 = 2.79; 3 = 3.00; 4 = 4.17; 5 = 5.04, where 1 = not at all stressful , 3 = neutral, and 5 = very stressful). Mean job satisfaction ratings were negatively associated with symptom reports (1 = 7.33; 2 = 5.02; 3 = 4.03; 4 = 3.62; 5 = 3.24, where 1 = very dissatisfied , 3 = neutral, and 5 = very satisfied). The number of allergies reported by workers was positively associated with mean number of symptoms (no allergies = 3.24; 1 = 4.29; 2 = 5.34; 3 = 6.16), as was susceptibility to migraine headaches (yes = 5.33; no = 3.52). Wearing eye wear (spectacles or contact lens) was associated with a slight increase in symptom reports (yes = 3.84; no = 3.40). Statistically significant interactions were found between sex and PIAQ for TSBS scores (see Figure 1) and between sex and age for TSBS scores (see Figure 2).

INSERT TABLES 8 AND 9 AND FIGURES 1 AND 2 ABOUT HERE

Work Disruption

The survey questionnaire asked workers how much each environmental condition and each SBS symptom disrupted their work. Table 10 shows the percentage responses for the environmental conditions, ordered from most to least disruptive. Results showed that the greatest disruptions were from uncomfortable thermal conditions, distracting noise, and poor lighting. Table 11 shows the percentage responses for the SBS symptoms, ordered from most to least disruptive. Results showed that the greatest disruptions were from eye symptoms, mental fatigue, and headache

INSERT TABLES 10 AND 11 ABOUT HERE

DISCUSSION

The results of this study show that a large majority of workers, over 76%, in air-conditioned buildings with acceptable indoor air quality, as defined by the current US ventilation standard (ASHRAE 62-1989), report at least one work-related SBS symptom per month. This finding agrees well with previous reports of SBS conducted outside of the US. (e.g. Wilson and Hedge, 1987). A number of non-environmental variables were significantly associated with the number of work-related SBS symptoms reported by each worker. In the appropriate regression worker's gender separated the intercept of the regression equation, and it also interacted with perceptions of indoor air quality and with age. Previous work has also found that worker's gender is an important variable to consider when examining prevalence data for SBS reports (Hedge et al., 1989; Skov et al., 1989; Tamblyn and Menzies, 1992; Zweers et al., 1992). These studies confirm that symptom prevalences are lower among men than women in the same settings. Nörback (1990) has suggested that the effect of gender on SBS reports is eliminated if susceptibility to nickel allergy is controlled for. We did not collect data specifically on nickel allergy, however, the survey questionnaire did ask whether the respondent suffered from hay fever or from other allergies. The number of allergies reported was a statistically significant variable in the regression equation, but it did not displace gender. Other studies have found that the use of eye wear (spectacles or contact lens) displaces gender and gives a marginally better fit to the data (Hedge et al., 1995), but for the present data both gender and eye wear were accommodated in the same regression model. The extent to which gender directly is affecting symptom reporting, or is acting as a surrogate for the influence of other variables remains to be clarified. In making judgements about the "sickness" of a building based on prevalence data, however, the importance of a gender effect on symptom reports must be considered, because it is possible that as the gender profile of a workplace changes so the apparent "sickness" of that workplace also will change. Studies of the reporting of physical symptoms have also found similar gender effects (Pennebaker, 1982), and further research is needed to investigate the basis for this gender effect.

Perceived indoor air quality played an important role in symptom reporting in this study, and this interacted with gender. Reports of SBS symptoms increased with more negative perceptions of poor indoor air quality, and this increase was steeper for women than for men. The PIAQ scale included questions on thermal conditions and odor. The prevalence data showed that reports of thermal problems, especially that conditions were too warm, were the most common components of perceptions of poor indoor air quality. Previous studies have found an increase in SBS symptom reports with air temperatures above 22°C. Air temperatures in the office we studied were actually quite consistent around 23 °C to 25 °C, and air temperature was statistically associated with response to the question that conditions were too warm. The lack of an association between air temperature and individual SBS symptoms may reflect the limited range of the air temperature data, or alternatively the fact that air temperature is only one component of perceived thermal comfort. Gender differences in thermal comfort research have been reported in some, but not all studies Parsons, 1993). Where effects have been found they show that women may be more sensitive to deviations away from an optimum comfort temperature and may prefer warmer conditions than men, although this may be due to clothing and activity differences. Also, gender differences in odor sensitivity have been reported in several studies (see Engen, 1991). However, the gender difference in responses to the air being too warm and to unpleasant odors were statistically significant but small, relative to the magnitude of gender differences in response to questions on air movement and satisfaction with ventilation.

Significant associations between symptom reports and hours of computer use, level of job stress, amount of job dissatisfaction were found. Workers who used their computers full-time reported more symptoms than infrequent users or non-users. Associations between computer use and the SBS have been confirmed in several studies (e.g. Hedge et al., 1989; Skov et al., 1989; Zweers et al., 1992). Environmental changes resulting from computer use, such as the electrostatic field generated by a VDT screen, may attract more particulate contaminants into a worker's breathing zone, and this may be responsible for the increase in symptom reports among computer users (Norbäck, 1990). There also may be stress effects associated with computer use. Worker's reporting high job stress reported more symptoms. Job stress may change a worker's perception of their somatic condition, their awareness of symptoms, and/or their awareness of the environment. Stress might also directly cause a number of the SBS symptoms, such as headache, nausea, dizziness, and difficulty breathing. Job stress can cause psychosomatic complaints in male blue-collar workers, and some of these complaints, such as headache, are similar to those listed as symptoms of the SBS (Frese, 1985). A number of the symptoms of SBS are similar to those that have been attributed to working at a computer, such as complaints of headache, irritated eyes, and fatigue, and these may be stress induced symptoms (Norbäck et al., 1989). Research has shown gender differences in perceived job stressors, choice of coping response, and long-term mental and physical health problems (Barnet et al., 1987).

Workers reporting low job satisfaction also reported more symptoms. These findings generally support of those of previously studies (e.g. Hedge et al., 1989; Skov et al., 1989; Zweers et al., 1992; Hodgson et al., 1992; Tamblyn and Menzies, 1993; Menzies et al., 1994)

Previously it has been argued that occupational and personal factors may act as mediating variables in the etiology of SBS (Hedge et al., 1989), and that physiological changes associated with higher levels of job stress possibly may change the body's sensitivity to indoor air pollutants (Hedge et al., 1992). Future studies should investigate associations between physiological stress measures and SBS symptom experiences. It is possible that the lack of association between symptoms and environmental variables in this study may have arisen because none of the buildings surveyed truly was a "sick" building. Indeed, only one of the buildings initially was chosen because of suspected IAQ problems. However, the prevalence of complaints in this building was not dramatically greater than that in the other buildings studied.

The regression models which have been described suggest that multifactorial and complex relationships influence reports of SBS symptoms. Although the model accounts for a statistically significant proportion of the variability in the number of SBS symptoms reported in the buildings which were surveyed, it still only describes around 33% of the variability in the data, which suggest that other as yet undiscovered factors are influencing results. Unfortunately, this multiple regression analysis suffers the weakness of a confounded dependent variable, because two identical symptom counts could reflect quite different symptoms with quite different causes. When individual symptoms were analyzed statistically significant associations between formaldehyde levels with symptoms of mental fatigue, headache, dry eyes, and dry skin, were found but the odds ratios for these are weak. Also, current symptoms could not be defined as being work-related, merely as being experienced in the workplace. Other physical environmental variables and IAQ measures tested in this study did not exert a significant influence on reports of SBS symptoms. Results suggest the need to carefully consider a broad range of non-environmental variables in building investigations.

Although we were unable to objectively measure worker productivity in this study workers were asked to indicate how much their work had been disrupted by each of the environmental conditions and SBS symptoms. Results showed that inappropriate thermal conditions, both too warm and too cold; inadequate ventilation, especially a lack of perceived air movement and sensations of stale air; distracting noise, and glaring lighting, were the most disruptive to work. For the SBS symptoms results showed that eyestrain and other eye problems, mental fatigue, and headache were the most disruptive to work. Many of these symptoms are not specific to poor IAQ and could be a consequence of poor lighting and stressful work conditions.

There is no accepted criterion of how prevalent symptoms must be before a building is classified as a "sick" building, although Levy (1990) has suggested that "the use of a questionnaire survey to get an impression of the extent of symptoms/complaints in the rest of the workforce is recommended. If the frequency of symptoms is high above 20% we have to deal with an epidemic, not only endemic symptoms, and the costs for a 'cure' may be high"(p.239). For the buildings surveyed in this study most of the SBS symptoms exceed this 20% criterion, even though most of these buildings were not under investigation for suspected indoor air quality problems. These results challenge conventional views of the sick building syndrome as simply an environmentally-induced disorder arising as a consequence of exposure to polluted air, and instead suggest that the SBS reflects the outcome of multifactorial processes governing the interplay between a person and his/her environment. In these processes, psychological variables are of considerable importance, and yet they are all but neglected in the majority of SBS investigations which continue to search in vain for the single environmental cause. In keeping with our view, Menzies et al. (1994) recently reported a study of 2,317 workers from 11 non problem and 5 problem office buildings in which they found no significant differences in the prevalence of SBS symptoms between buildings that had been labeled as either "sick" or "healthy", and no associations between symptoms and measured environmental conditions. Indeed, there was a complete overlap in the prevalence of symptoms between buildings. They conclude "that to label an entire buildings as sick or healthy has no scientific foundation" (p.37).

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TABLE 1

Percentage responses to the environmental conditions questions

Condition	Never	1-3 times per month	1-3 times per week	Every Day
temperature too warm	24.7	36.0	27.3	12.0
temperature too cold	29.4	34.6	25.1	11.0
lighting too dim	77.0	10.4	3.0	9.6
glare problems	57.5	16.9	8.8	16.8
insufficient ventilation	42.9	20.2	12.8	24.1
uncomfortable drafts	60.4	20.2	9.9	9.5
too little air movement	40.9	20.5	13.0	25.6
air too dry	47.0	16.9	11.3	24.7
air too humid	77.5	14.5	5.3	2.7
distraction ambient noise	46.8	23.9	12.0	17.3
unpleasant odor in air	63.1	24.6	6.5	5.7
stale air	49.1	22.1	12.1	16.8
dusty air	63.9	17.7	8.4	10.0
electrostatic shocks	63.4	22.6	6.9	7.0

TABLE 2

Odds ratios and 95% confidence intervals obtained from logistic regression models containing physical environment measures and concurrent self-reports of environmental conditions

Condition	Physical factor	Odds Ratio	95% CI	P value
Too warm	Air temperature	1.84	1.59 - 2.13	0.0001
Too little air	Air temperature	1.50	1.31 - 1.71	0.0001
Air too humid	Air temperature	1.47	1.24 - 1.76	0.0001
Insufficient Ventilation	Air temperature	1.40	1.23 - 1.60	0.0001
Too cold	Air temperature	0.62	0.60 - 0.63	0.0001
	Relative Humidity	1.05	1.02 - 1.08	0.0039
Uncomfortable drafts	Carbon Dioxide	4.86	0.60 - 12.90	0.0015
	Air temperature	0.68	0.55 - 0.82	0.0002
	Relative Humidity	1.04	1.00 - 1.08	0.0346
Unpleasant odor	Relative Humidity	1.05	1.00 - 1.11	0.0353
Stale air	Carbon dioxide	3.39	1.56 - 7.38	0.0021
Air too dry	Formaldehyde	1.45	1.13 - 1.86	0.0030

TABLE 3

Percentage prevalence of SBS Symptoms

Symptoms	Never	1-3 times per Month	1- 3 times per Week	Every Day
Excessive mental fatigue	55.6	22.9	13.5	8.1
Headache across forehead	61.1	22.3	11.7	5.0
Dry eyes	60.9	14.5	12.2	12.5
Irritated, sore eyes	60.0	16.5	14.0	9.5
Tired, strained eyes	45.3	18.0	20.5	16.3
Nervousness, irritability	63.5	22.7	9.7	4.1
Unusual tiredness, lethargy	67.7	19.6	8.3	4.4
Stuffy, congested nose	70.8	11.9	9.1	8.2
Sore, irritated throat	76.5	14.2	6.3	3.0
Runny nose	80.5	11.1	5.1	3.3
Hoarseness	84.2	9.8	4.2	1.8
Dry skin	84.3	4.7	4.1	6.9
Dizziness	89.0	8.6	2.0	0.4
Wheezing, chest tightness	91.5	5.8	1.8	0.9
Nausea	91.8	6.9	1.1	0.3
Skin irritation, rashes	95.4	3.1	0.7	0.8

TABLE 4

Odds ratios and 95% confidence intervals obtained from logistic regression models containing physical environment measures and concurrent self-reports of sick building syndrome symptoms

Symptom	Physical factor	Odds Ratio	95% CI	P value
Irritated eyes	Illumination	1.01	1.00 - 1.02	0.0010
Tired eyes	Illumination	1.01	1.00 - 1.02	0.0001
Lethargy	Illumination	1.01	1.00 - 1.02	0.0017
Stuffy nose	Relative Humidity	1.03	0.99 - 1.06	0.0182
Runny nose	Relative Humidity	1.04	0.99 - 1.08	0.0218
Dry eyes	Formaldehyde	1.28	1.00 - 1.63	0.0537
Mental fatigue	Formaldehyde	1.55	1.15 - 2.07	0.0036
Headache	Formaldehyde	1.54	1.15 - 2.06	0.0033
Dry skin	Formaldehyde	1.38	1.09 - 1.76	0.0337

TABLE 5

#10 ?

Factor analysis of the environment condition questions. items loading on Factor 1 were used for the perceived indoor air quality scale (PIAQ).

Condition	FACTOR 1	FACTOR 2	FACTOR 3
Insufficient ventilation	.81	.04	.21
Insufficient air movement	.84	-.08	.17
Air too dry	.69	.22	.09
Too warm	.67	-.20	.05
Unpleasant odors in air	.48	.14	.20
Stale air	.81	.07	.16
Dusty air	.66	.20	.15
Electrostatic shocks	.44	.24	-.04
Too cold	.06	.86	.02
Uncomfortable drafts	.10	.84	.13
Glare from lighting	.21	.11	.68
Lighting too dim	.11	.02	.84
Eigenvalue	4.31	1.57	1.01
% Common Variance	35.9	13.1	8.4

TABLE 6

Responses of men and women to any experience of the environmental conditions questions comprising the PIAQ scale for the month prior to the survey.

Question	% Men	% Women
Air too warm	73.0	77.3
Insufficient ventilation	50.7	61.6
Too little air movement	52.5	63.8
Air too dry	39.3	62.0
Unpleasant odor in air	33.0	39.7
Stale air	42.3	56.9
Dusty air	23.6	44.2

TABLE 7

Factor analysis of the job questions.

Questionnaire Item	"Job Satisfaction"	"Job Stress"
My job is usually interesting	0.84	0.16
I'm happy in my job	0.89	-0.05
I dislike my job	-0.83	0.07
I am satisfied with my job	0.81	-0.04
I'm enthusiastic about my job	0.84	0.02
My job is rather monotonous	-0.68	-0.10
My job is not very stressful	-0.05	-0.51
I usually have to work fast	0.04	0.66
I often feel stressed at work	-0.20	0.82
My job demands a lot of concentration	0.32	0.58
I often feel overworked	-0.14	0.78
Eigenvalue	4.29	2.41
% Common Variance	35.80	20.10

TABLE 8

Percentage of workers reporting different numbers of symptoms (TSBS).

TSBS count	% response
0	23.8
1	10.3
2	11.1
3	9.9
4	9.4
5	7.9
6	6.4
7	5.8
8	4.4
9	3.3
10	2.3
11	1.8
12	1.7
13	0.7
14	0.6
15	0.4

TABLE 9

Parameter Estimates of Regression Model for the Number of SBS Symptoms Per Person

	Men	Women
Intercept	0.61 ± 0.44	1.59 ± 0.39
VDT use	0.11 ± 0.02	0.11± 0.02
Job stress	0.60 ± 0.06	0.60 ± 0.06
Job satisfaction	- 0.43 ± 0.05	- 0.43 ± 0.05
Perceived IAQ	0.55 ± 0.03	0.68 ± 0.02
Allergy	0.48 ± 0.07	0.48 ± 0.07
Migraine	0.62 ± 0.14	0.62 ± 0.14
Eyewear	0.22 ± 0.10	0.22 ± 0.10
Age	0.001 ± 0.007	-0.02 ± 0.006

TABLE 10

= 11 response of 2 or 3

Percentage of the total sample reporting that their work was either somewhat or very disrupted by any experience of each of following environmental conditions for the month prior to the survey.

Condition	% response
temperature too warm	51.4
temperature too cold	44.1
insufficient ventilation	39.4
distracting ambient noise	39.0
too little air movement	38.2
air too dry	33.0
glare problems	32.2
stale air	30.7
uncomfortable drafts	25.6
dusty air	22.6
unpleasant odor in air	22.0
lighting too dim	15.5
electrostatic shocks	15.2
air too humid	13.7

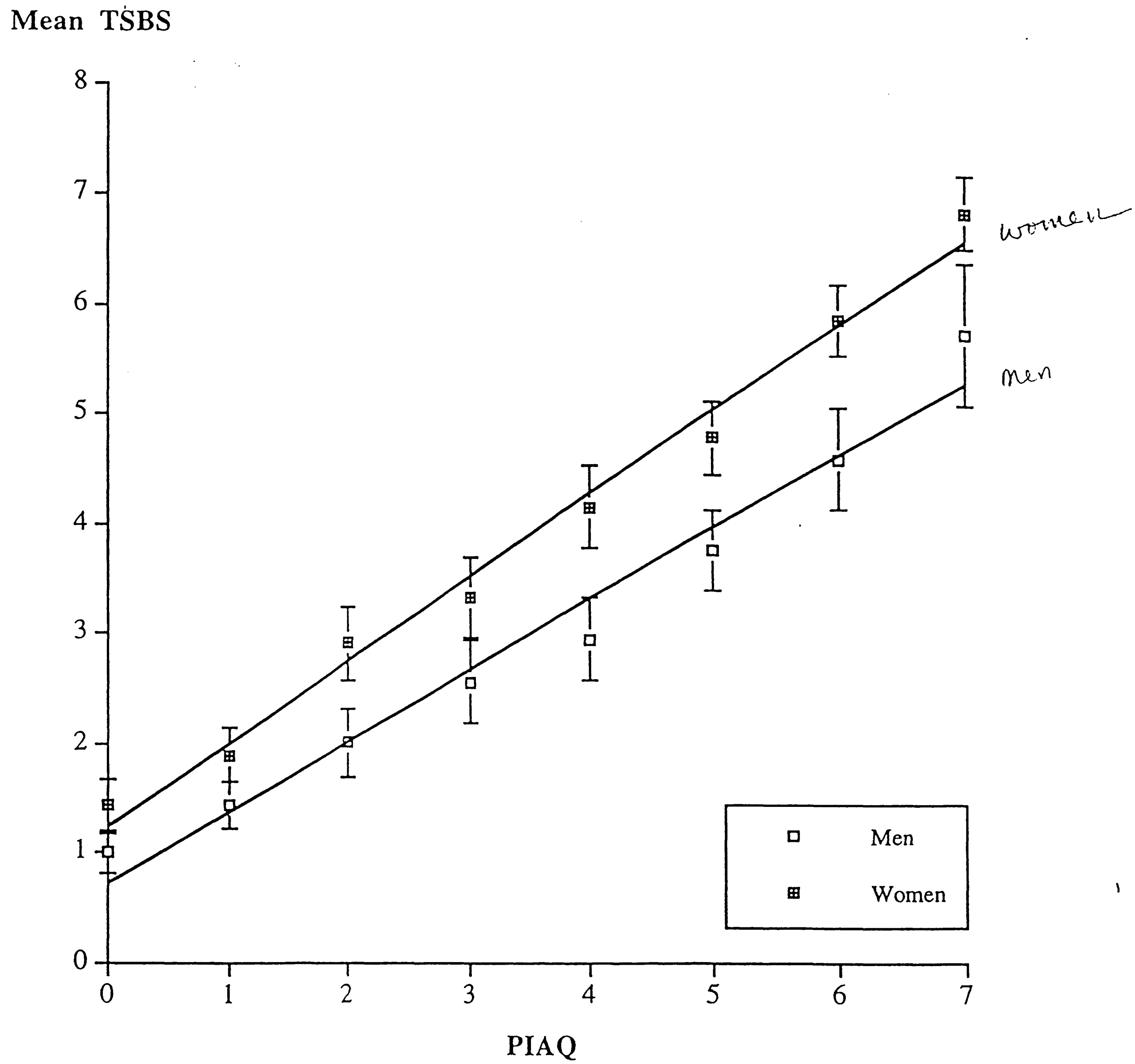
TABLE 11

Percentage of the total sample reporting that their work was either somewhat or very disrupted by any experience of each of following SBS symptoms for the month prior to the survey.

Symptom	% response
Tired, strained eyes	46.0
Mental fatigue	38.8
Headache	33.1
Sore eyes	32.8
Dry eyes	30.5
Nervousness, irritability	28.8
Stuffy, congested nose	20.5
Sore, irritated throat	15.3
Runny nose	13.6
Hoarseness	9.6
Dizziness	8.7
Dry skin	6.8
Nausea	6.4
Chest tightness	5.9
Skin rashes	2.6

FIGURE 1

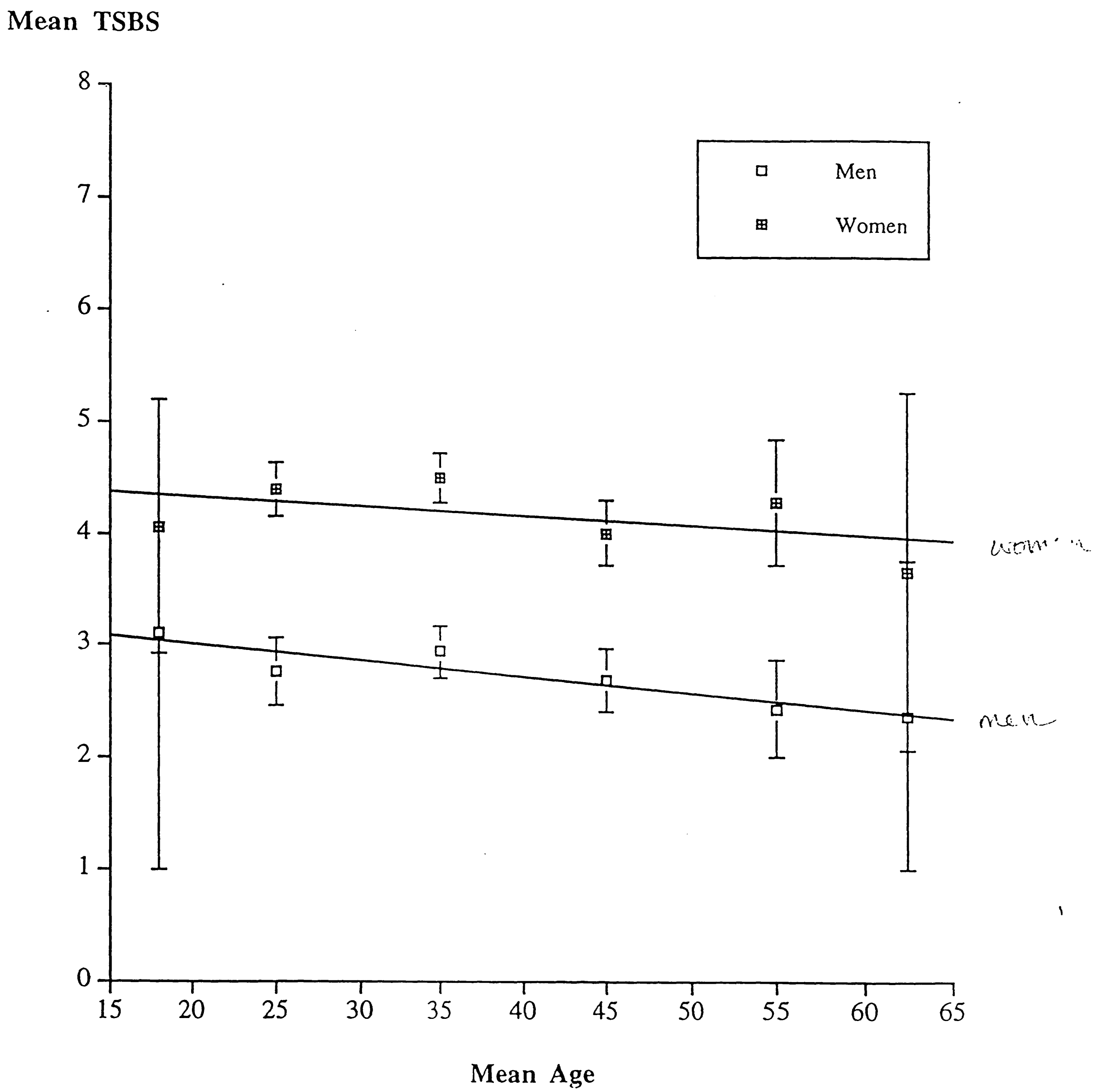
Plot of the interaction of worker's gender and PIAQ scores for mean TSBS, showing best-fit simple linear regression lines and 95% confidence intervals.



? < PIAQ < ?   => PIAQ = 0
1
2
3
.
.
7

FIGURE 2

Plot of the interaction of worker's gender and age for mean TSBS, showing best-fit simple linear regression lines and 95% confidence intervals.


Mean TSBS
8
7
6
5
4
3
2
1
0
Men
Women
15
20
25
30
35
40
45
50
55
60
65
Mean Age
men