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Influence of Building-Related Symptoms on Self-Reported Productivity

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ABSTRACT

The sick building syndrome occurs in many modern office buildings. Health symptoms and dissatisfaction related to the office environment may result in decreased worker productivity. The impact of building-related symptoms on self-reported productivity was investigated in the Library of Congress Indoor Air and Work Environment Study. Questionnaires were distributed to all workers. Respondents rated how frequently symptoms reduced their ability to work and caused them to leave work early or stay at home. Further, occupants reported on workstation characteristics, symptoms, thermal comfort, health status, and social dynamics. Canonical correlation analyses employing composite scores for symptom and productivity variables showed that 18% of the variance in the productivity measures was explained by work-related mucosal symptoms ($R_c = 0.42$, $p = 0.0001$) and 30% by all work-related symptoms ($R_c = 0.55$, $p = 0.0001$). In multivariate logistic regression analyses, additional factors predictive of productivity were gender, self-reported sensitivity, allergies, history of flu or chest illness, job title, perceived air quality, job satisfaction, and role conflict.

INTRODUCTION

In recent years, an increasing number of office building investigations have been conducted in response to health complaints by occupants. The symptoms, considered building related when improvement occurs with absence from the building, are mostly sensory reactions such as mucous membrane irritation. Health symptoms and dissatisfaction related to the indoor work environment may result in decreased productivity and economic loss; 800,000 to 1,200,000 commercial buildings in the United States were estimated to have problems with 30 to 70 million exposed occupants (Woods 1989).

Few studies have tried to determine the impact of building-related symptoms on productivity. In a British study, workers rated how much the physical conditions at work influenced productivity. The response choices allowed for increased or decreased productivity. The number of symptoms had a significant effect on productivity, but there had to be more than two symptoms to have a negative effect (Raw et al. 1990). Other factors may also affect productivity. Productivity ratings were associated with the number of people in the room and ratings of temperature, ventilation, perceived air quality, lighting, environmental tobacco smoke and age (Raw et al. 1990). Preller et al. (1990) reported that spray and steam humidification, lack of adjustable temperature controls, VDU work, gender, low education, smoking, allergy, and negative job satisfaction scores were associated with the self-reported number of times and number of days of sick leave due to "sick building symptoms." No associations between symptom rates and productivity measures were reported. Results from another study showed an association between increased sickness absence rates and air-conditioning as compared to natural ventilation (Robertson et al. 1990).

Studies employing objective measurements of human performance are limited. Berglund et al. (1983) found no difference in a battery of psychological tests in 48 subjects exposed to a "sick" and a "clean" Swedish preschool. Exposures were for two days only and may have been too short to measure such effects.

In the Madison Building of the Library of Congress, workers had complained about health symptoms and poor indoor air quality since building occupancy in 1980. A full-scale building investigation was conducted in 1989. This paper reports on the associations between mucous membrane symptoms and self-reported productivity.

MATERIALS AND METHODS

The Madison Building has six floors, plus a ground floor, basement, and sub-basement, for a total of about 1.5 million square feet. Windows are not openable, and the indoor climate is controlled by a heating, ventilating, and air-conditioning system with primarily steam humidification. The outdoor air intake is constant, and the air-handling systems operate every day for 24 hours.

In February 1989, self-administered questionnaires, pretested in a pilot study, were distributed to all 3,176 full-time employees. Information was collected on workstation characteristics, occurrence of symptoms over the past year, the impact of symptoms on productivity, perceptions of air quality, demographic variables, and social dynamics.

Occupants were asked to rate how frequently symptoms reduced their ability to work and how frequently symptoms

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TABLE 1
Worker-Reported Impact of Symptoms on Productivity, Frequency (%)

	Never	Rarely	Sometimes	Often	Always*	N
Symptoms reduced ability to work	713 (26)	853 (31)	983 (36)	201 (7)	14 (1)	2764
Symptoms caused to leave/stay home	1060 (39)	738 (27)	863 (32)	69 (3)	–	2730

*not a response option for symptoms caused to leave work/stay home
N = total number of respondents

caused them to stay home from work or leave work early during the past year. The associations between symptoms and these productivity variables were first assessed with canonical correlation analyses. This procedure determines the correlation between composite scores for the symptom and productivity variables. For logistic regression analyses, a binomial score for productivity was created that was positive if the symptoms were rated to have an impact on productivity sometimes, often, or always (vs. rarely or never). Predictor variables were added to the model in a stepwise procedure with a significance level of $p < 0.05$. The magnitudes of the effects were derived from the maximum likelihood estimates and adjusted odds ratios, and 95% confidence intervals were calculated.

For analysis, symptoms were grouped based on results from principal components analyses and interpretability. The most important factor, i.e., the factor explaining the most variation within the symptoms, included eight mucosal symptoms. Then, a symptom score was created for each occupant. The binomial symptom score for the mucosal symptoms was positive if one or more symptoms were experienced. Mucosal symptoms included dry/itching/tearing eyes, burning eyes, stuffy nose/sinus congestion, runny nose, dry throat, hoarseness, sore throat, sneezing, and cough. To associate symptoms with the building, the condition was imposed that symptoms improved when not at work and that they occurred often or always during the past year.

RESULTS

A total of 2,845 office workers returned their questionnaires for a 90% response rate. The reported impact of symptoms on productivity is shown in Table 1. While more than one-third reported that the symptoms reduced their ability to work or caused them to stay home or leave work early at least sometimes, only 8% reported that the symptoms reduced their ability to work often or always, and only 3% reported that the symptoms caused them to leave work/stay home often. For the combined score, 51.4% of the workers reported that symptoms decreased their productivity sometimes, often, or always.

Forty-one percent of the respondents experienced one or more mucosal symptoms often or always during the past year. Mucosal symptoms were significantly associated with both productivity variables (Chi-square: $p < 0.0001$). Table 2 shows that the magnitude of the association increases with decreasing productivity.

In the canonical correlation analyses, only the first canonical variate was associated with a substantial amount of shared variance. Variates beyond the first were significantly different from zero due to the large sample size, but no substantial amount of variance was shared and therefore they are not reported here. The canonical correlation analyses indicated that 18% of the variance was shared between work-related mucous membrane symptoms and the productivity variables ($R_c = 0.42$, $p = 0.0001$). Including all 31 symptoms assessed in the questionnaire showed that 30% of the variance was explained ($R_c = 0.55$, Pr > F: 0.0001). The latter model, however, may not be reliable, since it was based on only 56% of the data due to missing values. In either case, a large proportion of the variance in the self-reported productivity variables was not explained by the reported symptoms.

The results of the logistic regression analyses are shown in Table 3. Variables that were significant predictors of self-reported productivity in addition to the mucous membrane symptoms included gender, sensitivity, allergy, flu or chest illness, job title, the perceived air quality indicators for dusty and hot/stuffy work station conditions, job satisfaction, and role conflict. Some variables were also related to symptoms, e.g., gender, sensitivity, flu or chest illness, allergy, and the perceived air quality indicators of hot/stuffy and dusty conditions. Interactive terms between mucosal symptoms and other covariates were not significant. Decreased productivity due to symptoms was more frequently reported by females and individuals reporting sensitivity, allergies, flu or chest illness, dusty or stuffy workstation conditions, and those with lower job satisfaction and higher role conflict. Compared to workers in administrative support, managers reported less and professionals more decreased productivity. No association was found for the technical or "other" job categories.

TABLE 2
Associations Between Mucosal Symptom Cluster and Self-Reported Productivity*

Productivity Indicator	Mucosal Symptoms
Symptoms reduce ability to work:	
Rarely	1.93
Sometimes	4.59
Often/always	8.31
Symptoms cause to leave work early/stay home:	
Rarely	1.72
Sometimes	3.72
Often	7.30

* Crude odds ratios
Reference group: Those who report symptoms never affect productivity

DISCUSSION

The primary objective of this study was to examine the association between work-related symptom prevalence and the decrease in self-reported productivity. Neither the mucosal

TABLE 3
Factors Predictive of Self-Reported Productivity

Effect	Odds Ratio	95% Confidence Interval
Mucosal irritation: *yes* vs. *no*	2.08	1.72 - 2.53
Gender: *female* vs. *male*	1.31	1.09 - 1.59
Sensitivity: *yes* vs. *no*	1.44	1.18 - 1.47
Allergy: *yes* vs. *no*	1.24	1.02 - 1.51
Flu/chest illness: *yes* vs. *no*	2.03	1.69 - 2.46
Job:		
other vs. *administrative support*	1.65	0.92 - 1.08
manager vs. *administrative supp.*	0.48	0.31 - 0.72
professional vs. *adminis. supp.*	1.61	1.18 - 2.20
technical vs. *adminis. supp.*	1.12	0.77 - 1.63
Dusty workstation: *yes* vs. *no*	1.53	1.26 - 1.85
Hot/stuffy air: *yes* vs. *no*	1.64	1.25 - 2.15
Job satisfaction: *lower* vs. *higher*	1.96	1.63 - 2.37
Role conflict: *lower* vs. *higher*	0.78	0.67 - 0.91

Total number of respondents = 2,337

symptoms nor the complete set of symptoms assessed in this study explained all of the variation in self-reported productivity. Although these findings generally confirm earlier study reports in the literature, comparisons are difficult since assessments of productivity, symptoms, and other covariates vary.

Raw et al. (1990) reported that the number of symptoms had a significant effect on productivity, but only more than two symptoms had a negative effect on productivity. The worker-estimated effect was a 10% reduction in productivity with 7 symptoms and a less than 20% reduction with 10 symptoms. In this study, a binomial score for the presence or absence of symptoms was used as a predictor of productivity rather than the number of symptoms due to the high covariance between symptoms. Occupants with mucosal symptoms reported decreases in productivity twice as often as occupants without such symptoms. Similar to this study, other factors were also found to influence productivity. Gender, perceived air quality, allergies, and negative job satisfaction have been previously reported to be associated with productivity ratings (Raw et al. 1990; Preller et al. 1990).

It was reported that, in general, women tend to spend more days in bed, restrict their activities more, and take more time off for health problems than men even when reproductive conditions are accounted for (Verbrugge 1985). Raw et al. (1990), on the other hand, reported that gender modified the effect of symptoms. Men rated productivity more negatively as the number of symptoms increased. Such an interactive effect was not observed in this study.

Productivity ratings were also associated with thermal discomfort and reported dusty conditions at the workstation. Although such factors may impact productive attitudes rather than productivity, improvement in the office environment, such as office layout and furnishing, was found to increase productivity by 21%, as well as general satisfaction ratings (Dressel and Francis 1987). Therefore, savings in maintenance and operating costs, in capital assets, such as equipment and furniture, and in space by higher occupant densities may be lost through decreased worker productivity (Woods 1989).

The strengths of the Madison Building investigation were the large sample size and the large number of variables included in the questionnaires. No selection bias was expected, since the whole building population was included and a high response rate achieved (90%). Response bias was possible, since reporting was based on memory for symptoms over the past year as well as productivity and other factors such as perceived air quality and health. This kind of bias cannot be ruled out in observational studies relying on self-reports of outcome variables and covariates. To date, no major studies have validated the accuracy of these self-reports. Occupants had been complaining for almost 10 years, and everyone was aware that the building investigation was conducted to assess potential indoor air quality problems. The nature of the symptoms is often called "nonspecific," since they may arise from a variety of different causes. Further, the response choices of "never," "rarely," "sometimes," "often," or "always" left room for subjective interpretation.

These findings show that building-related symptoms and perceived adverse physical conditions in the work environment can lead to decreases in productive attitudes. However, the actual amount of work time lost cannot be determined. The reported impact of symptoms on productivity may indirectly show how severely occupants experienced symptoms. Future studies need to employ objective measures of productivity.

REFERENCES

Berglund, B., U. Berglund, and T. Engen. 1983. "Do 'sick buildings' affect human performance? How should one assess them?" *Reports from the Department of Psychology*, University of Stockholm, Number 609.

Dressel, D.L., and J. Francis. 1987. "Office productivity: Contributions of the workstation." *Behavior and Information Technology*, Vol. 6, No. 3, pp. 279-284.

Preller, L., T. Zweers, B. Brunekreef, and J.S.M. Boleij. 1990. "Sick leave due to work-related health complaints among office workers in the Netherlands." *Proceedings Indoor Air '90*, Canada Mortgage and Housing Corporation, Ottawa, Vol. 1, pp. 227-230.

Raw, G.J., M.S. Roys, and A. Leaman. 1990. "Further findings from the office environment survey: Productivity." *Proceedings Indoor Air '90*, Canada Mortgage and Housing Corporation, Ottawa, Vol. 1, pp. 231-236.

Robertson, A.S., K.T. Roberts, P.S. Burge, and G. Raw. 1990. "The effect of change in building ventilation category on sickness absence rates and the prevalence of sick building syndrome." *Proceedings Indoor Air '90*, Canada Mortgage and Housing Corporation, Ottawa, Vol. 1, pp. 237-242.

Verbrugge, L.M. 1985. "Gender and health: An update on hypotheses and evidence." *Journal of Health and Social Behavior*, Vol. 26, No. 3, pp. 156-182.

Woods, J.E. 1989. "Cost avoidance and productivity in owning and operating buildings." *Occupational Medicine: State of the Art Reviews*, Vol. 4, No. 4, pp. 753-770.