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IEQ and the Impact on Employee Sick Leave

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When selecting minimum ventilation rates, employers should balance the well-recognized energy costs of providing higher minimum ventilation rates with the expected, but less well quantified, health benefits from a higher ventilation rate. This is a summary of the paper by Milton, et al.[1] that found low employee sick leave associated with high ventilation rates in a set of buildings located in Massachusetts. A simple cost-benefit analysis also is presented.

Methodology

As part of an evaluation of occupational and environmental health programs at Polaroid Corporation, the authors analyzed the sick leave records of 3,720 hourly workers in 1994. The study population worked in 115 independently ventilated work areas within 40 buildings. Because an analysis of total sick leave was dominated by the extended periods of leave of a small number of workers, a second analysis considered only short-term sick leave.

Sick leave data were determined from time cards. Corporate records were used to identify the personal and job characteristics of each worker (e.g., age, gender, work shift, years of employment, work location), to determine building characteristics (e.g., presence of humidification), and to determine if occupants of each space had filed a formal IAQ complaint within the past three years.

An industrial hygienist rated different work areas as having either "moderate" ventilation (~25 cfm/person [12 L/s per person]) or "high" ventilation (~50 cfm/person [24 L/s per person]) based on his knowledge of the ventilation systems and the average end-of-day CO_2 measurements. Ventilation rates were estimated from CO_2 measurements based on a steady-state mass balance calculation. Although several sources of errors exist when ventilation rates are estimated from CO_2 data, this approach enables the identification of two sets of work areas with clearly different average ventilation rates.

A statistical analysis technique, called Poisson regression, was used to analyze the relationship of sick leave with ventilation rate category. The analysis controlled for potential confounding by age, gender, seniority, hours of non-illness absence, work shift, ethnicity, crowding, and type of job (office, technical, or manufacturing worker) by including demographic variables in the regression equations. Crowding was defined as less than 100 ft^2 (9 m^2) per employee. To eliminate the possibility of uncontrolled confounding of sick leave by occupational factors, a separate analysis considered only 636 office workers.

The average cost of outside air ventilation in the buildings that were studied was based on estimates of $3.22/cfm per person per year.

Results

Ventilation was rated as "moderate" in areas occupied by 17.5% of workers and high for the remaining workers. Humidification was provided to the spaces occupied by 90% of workers. Smoking was not permitted inside any building.

Higher total and short-term sick leave rates were associated with moderate ventilation rates (relative to high ventilation rates) and with humidification. Complaint areas were associated with increased short-term sick leave but not with increased total sick leave. Crowded areas tended to have lower sick leave rates. Key results are summarized in *Table 1*.

A lower ventilation rate was associated with a 130% greater rate of total sick leave, with 95% confidence limits of 54% to 244%. These results imply that 57% of total sick leave in the population with a lower ventilation rate (~5 days per year) was attributable to lower ventilation rate.

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Humidification was associated with a 96% greater rate of total sick leave, with 95% confidence limits of 25% to 208%. However, results of analyses of total sick leave are dominated by a small number of outliers. Therefore, the analyses of short-term sick leave among office workers may be more informative.

For the analyses of office workers, the power to examine the effects of humidification was low. Therefore, data from the 36 office workers in non-humidified areas was excluded. In the resulting population, with approximately an equal number of employees in moderate- and high-ventilation spaces, a lower ventilation rate was associated with a 53% greater rate of short-term total sick leave, with 95% confidence limits of 22% to 92%. These results imply that 35% of short-term sick leave in the office worker population with the lower ventilation rate (~1.5 days per person per year) was attributable to lower ventilation. Complaint area status was associated with a 52% greater short-term total sick leave rate, with 95% confidence limits of 18% to 97%.

Risk Factor	Percent Change (95% Confidence Limits)	
	Total Sick Leave Within Hourly Workers	Short-Term Sick Leave Within Office Workers
Lower Ventilation Rate	130% (54% to 244%)	53% (22% to 92%)
Humidification	96% (25% to 208%)	Not Analyzed
Complaint Area	No Association	52% (18% to 97%)
Crowding	–46% (–39% to –76%)	Not Analyzed

Table 1: Association of suspected risk factors with sick leave.

An economic analysis (*Table 2*), assuming that the association observed was causal, indicated that the annual cost of increasing ventilation rates by 25 cfm (12 L/s) per person ($80 per employee) would be easily offset by the savings from reduced sick leave ($480 per employees), for a net savings of $400/employee per year. Assuming that the 93.5 million full-time workers in the United States are provided the currently recommended ventilation rates (~20 cfm [9 L/s] per occupant for offices), and applying these results, the estimated lost productivity would be $23 billion (assuming an hourly compensation of $20), and $15 billion in net savings per year could be obtained by doubling ventilation rates.

Outcome	Annual Cost (Savings) Per Employee*
Ventilation Energy Costs 25 cfm/worker × $3.22/cfm/year	$80
Sick Leave Costs Sick Leave avoided (1.5 days per workers)	($480)
Net Savings	($400)
*Assumes Hourly Compensation of $40.	

Table 2: Potential economic costs and benefits of increasing the ventilation rate by 25 cfm (12 L/s) per person.

Discussion and Limitations

Two likely mechanisms exist for a causal association of increased sick leave with lower ventilation rate and humidification: 1) irritant and allergic reactions to pollutants that decrease with ventilation and increase with humidification; and 2) increased respiratory illness due to either airborne spread of infection or an increase in susceptibility. This study cannot confirm either mechanism. However, the results more strongly support the second mechanism because controlling for complaints did not reduce the association of sick leave with either a lower ventilation rate or humidification. A few prior studies have found lower prevalences of respiratory illnesses with higher ventilation rates. Many prior studies have found that higher ventilation rates are associated with a reduction in irritant and allergic-like health symptoms.[2]

The method used to estimate ventilation rates (CO_2 data and expert judgment) is one of the limitations of this study. While there is little doubt that that the "high" ventilation rate spaces in this study have a higher average ventilation rate than the "moderate" ventilation rate spaces, the average ventilation rates presented are rather rough estimates.

Confirmation of these results in a study with better ventilation rate measurements is desirable. An experimental study, i.e., one that modifies ventilation rates, would be stronger than another observational or cross-sectional study. Objective tests to confirm respiratory infections are recommended to elucidate underlying mechanisms.

Practical Implications

This study shows that the energy cost of providing additional ventilation may be more than offset by the savings that result from reduced sick leave. The study suggests substantial benefits from increasing ventilation rates above the minimum rates specified for offices in ANSI/ASHRAE Standard 62-1999, *Ventilation for Acceptable Indoor Air Quality*. These findings should be considered in future revisions of the standard. Because building energy efficiency is important for environmental protection and for the nation's energy security, future research is needed to identify other less energy intensive methods of reducing sick leave.

References

1. Milton, D. P., et. al. 2000. "Risk of sick leave associated with outdoor air supply rate, humidification, and occupant complaints." *Indoor Air* 10(4):212–21.

2. Seppanen, O.A., Fisk, W.J., and Mendell, M.J. 1999. "Association of ventilation rates and CO_2 concentrations with health and other human responses in commercial and institutional buildings." *Indoor Air* 9:226–252. LBNL-43334.