Sickness absence as a function of the physical work environment: The interactive effect of noise exposure and lighting

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Abstract

Not enough is known about how important characteristics of the physical work environment affect absenteeism. We examined the interactive effects of noise exposure and lighting levels, on sickness absence among 797 white-collar employees across 21 industrial organizations in Israel. The results supported the expected interactive effect of noise and lighting on sickness, although this interaction was shown to be more complex than expected. That is, the presence of either high ambient noise or poor lighting (high darkness) was sufficient to increase sickness absence, regardless of the level of the other environmental stressor (noise or lighting). Jointly, high levels of noise and low levels of lighting did not contribute to higher sickness absence beyond the contribution of each of them independently. In contrast, jointly, these two important environmental characteristics did contribute to reduced levels of sickness absence, such that sickness absence was maximally reduced when noise was low and lighting was high, simultaneously. Implications of the results and suggestions for future research are discussed.

The growing cost of absenteeism in a competitive market for both employers and employees has increased interest among scholars and practitioners in understanding the determinants of work absenteeism (see review by Johns, 1997). In particular, sickness absence is one form of absenteeism which is recognized as highly important because of its cost to society and its adverse effects on employee productivity and quality of work life (see e.g., Kivimaki, Vahtera, Thompson, Griffiths, Cox & Pentti, 1997)). An important factor believed to contribute to sickness absence is the physical surroundings of the work environment (cf., Oldham, Cummings, & Zhou, 1995). However, previous studies have neglected to systematically explore the degree to which absenteeism is influenced by physical characteristics in the work environment (cf., Johns, 1997).

Two important factors in the physical work environment that have been shown to affect sickness and related sickness absence at work are noise and lighting levels (i.e., darkness or dimness) (e.g., Kryter, 1994). There are other characteristics of the physical work environment, such as space-related characteristics (e.g., workspace density, architectural openness, social density) that may also have negative effects on sickness and sickness absence (cf., Oldham, et al., 1995). However, there is a paucity of research on such characteristics, even though research has indicated that they are important contributors to employee well-being (e.g., Oldham, et al., 1995). Moreover, it is well known that in a typical work environment several negative characteristics may be present simultaneously. Suprisingly, there is a paucity of research examining the interactive effect among these physical characteristics on sickness absence. This is in spite of evidence indicating that these characteristics have stronger joint effects than independent, main effects, on employee reactions (Oldham et al, 1995). The present study was designed to explore the joint effect of noise and lighting, two important variables in the work environment, on sickness absence.

Noise and sickness absence

Evidence indicates that noise is the most prevalent stressor in the physical work environment in the industrial work force in the United States and Europe (Kryter, 1994). Most industrialized nations have restrictive laws and regulations prohibiting high noise levels because this contributes not just to hearing loss, but also to adverse psychological and stress-related physiological reactions. However, evidence suggests that, over time, exposure to even moderate noise levels will also contribute to adverse psychological and stress-related physiological reactions, including, for example, cardiovascular disease, or sleep-related disorders (e.g., Babish, 1991).

Similarly, laboratory studies indicate that exposure to acute noise, even at moderate levels, contributes to stress-related physiological outcomes, such as higher vascular resistance, heart rate, blood pressure, and stress hormones. Similar findings have also been obtained in chronic exposure to noise (e.g., Melamed & Bruhis, 1996). Such adverse physiological reactions are expected to contribute to sickness and absence due to sickness. Indeed, the expected relation between noise and absence behavior has also been supported by several field studies conducted in actual work settings (e.g., Melamed et al., 1992).

Theoretically, adverse physical characteristics such as noise or low lighting may affect sickness absence because of their contribution to information overload at work (cf., Cohen, 1980). According to the information overload model, individuals have a finite capacity for information processing (e.g., Cohen, 1980). Distractions at work are expected to contribute to cognitive overload which would adversely affect employee reactions (e.g., Cohen, 1980). With regard to noise specifically, exposure to noise at work can be expected to increase cognitive load, because people are asked to allocate a share of cognitive capacity to accommodate the noise, thereby reducing the cognitive resources available for job performance. This increase in cognitive load often causes adverse stress-related physiological reactions such as elevated blood pressure, increased secretion of stress hormones, or sleep-related disorders (see, e.g., Kryter, 1994), which in turn contribute to sickness and related sickness absence (cf., Cohen, 1980).

We chose noise as a focal variable to study because, as indicated, exposure to even moderate levels of noise is recognized as a major stressor at work, which may significantly contribute to sickness absence. An interesting question is whether the adverse effect of noise on sickness absence is modulated by other important physical characteristics in the work setting. More specifically, a key research question here is whether the effect of noise is contingent upon the level of lighting in the setting. There is, however, a paucity of research on whether and how the dominant influence of noise is modulated by the presence of other characteristics of the physical environment such as lighting.

Lighting and sickness absence

Lighting has been shown to have an important effect on people's reactions. There is evidence, for example, that darkness (poor lighting) tends to lead to visual strain and fatigue which further tax people's mental and physical energy (e.g., Horino, 1997; Kroemer & Grandgean, 1997). Furthermore, a number of studies have indicated that individuals perceive darker settings as smaller and more crowded compared to well-lit settings (e.g., Mandel, Baron, Fisher, 1980). Other studies have also indicated that dark settings were associated with the perception of having a less spacious work area (e.g., Oldham & Fried, 1987). Because of the experience of low spaciousness these employees may feel cramped and uncomfortable in pursuing their task. Moreover, they may also engage in more social interferences, because people who feel cramped are more likely to intrude into each others' space (cf., Cohen, 1980). As a result, employees in darker areas are more likely to experience low privacy and perceived crowding while working, which, in turn, contribute to higher cognitive overload.

In sum, employees who are working in darker areas are more likely to experience visual strain, fatigue, low privacy, and crowding, all of which are expected to significantly tax their mental capacity, and contribute to adverse cognitive overload, associated with higher sickness and related sickness absence (see, e.g., Oldham, et al). Yet, to our knowledge, there are only a few studies in the English literature that examined the association between poor lighting and sickness absence. The few existing studies found a positive association between poor lighting and higher sickness absence. Based on this literature, it is expected that, like noise, poor lighting also adversely affects employee sickness absence.

The interactive effect of noise and lighting on sickness absence

A more fundamental question concerns the interactive effect of noise and lighting on sickness absence. The literature cited above appears to suggest that when both high noise and low lighting are present simultaneously, the taxation on mental capacity should be maximized. This, in turn, should also maximize the level of cognitive overload and as a result also the rate of sickness and related sickness absence (cf., Cohen, 1980).

Similarly, one can further argue that in order to reduce or maintain low sickness absence both noise and darkness should be low. That is, when noise is low and lighting is high simultaneously, the constraints on individuals' ability to process information and function successfully are minimized. Thus, the situation of low noise and high lighting contributes to an optimal level of cognitive load, which, in turn, is expected to reduce the level of sickness and related sickness absence. Thus, we hypothesize the following:

> **Hypothesis 1**: Sickness absence will be maximally enhanced when noise is high and lighting is low, simultaneously.
>
> **Hypothesis 2**: Sickness absence will be maximally reduced when noise is low and lighting is high, simultaneously.

Method

Sample and Procedure

Participants in the current investigation were part of the CORDIS (Cardiovascular Occupational Risk Factors Determination in Israel) study, which is a multidisciplinary, cross-sectional, and longitudinal epidemiological project aimed at identifying occupational risk factors for cardiovascular disease. The screening was offered free of charge on company time and was utilized by about 60% of employees. Data were collected on a multitude of medical, biochemical, ergonomic, environmental, and psychological variables. The present study is based on data collected during Phase 1 of CORDIS (1985-1987) from 21 manufacturing plants: six textile, five moderately heavy metal works, two light metal industries, three plywood/Formica, two electronics, two food products and one printing press.

The initial sample consisted of 1542 employees. Missing data reduced the sample to 797. The sample consisted of 351 men and 446 women in 151 white-collar jobs (e.g., computer programmers, mechanical engineers, laboratory technicians, secretaries, accounting clerks, and chemists). These employees worked in 271 different work stations. The average age and tenure of these employees were, respectively: 38.1 (S.D. = 11.0), 9.0 (S.D. = 7.7).

Measures

Noise exposure level. Ambient noise levels at each workstation were measured by qualified environmental technicians, using a Quest sound level meter type SL-215 (area sampling) (Quest Electronics, Oconomovoc, WI, USA), tripod-mounted and adjusted to a height of 150 cm from the floor. Noise levels were sampled twice a day (morning and afternoon) in both winter and summer. In each sampling period which lasted one half-hour, five to 15 readings were taken, contingent upon noise fluctuations. Results were noted in decibels (dB A) and averaged for each of the four sampling periods. Noise exposure level was determined by the geometric mean exposure across the four samplings. Higher scores indicate higher levels of noise.

Illumination level. This refers to direct lighting in a given workstation. Qualified environmental technicians measured light intensity in Lux twice a day (morning and afternoon) in both winter and summer, at the same times as noise was measured. In places with fairly consistent lighting, only one reading was taken on each occasion. In contrast, in places with fluctuating lighting, several readings were taken on each occasion. Results were averaged across the four time periods. Higher scores indicate higher lighting levels.

Sickness absence. Sickness absence data (medically-certified absence) for the years 1985-1987 (when the medical and psychological data were collected), including 1-day absences, were compiled from original medical sick-leave certificates or from the insuring institute's database. These records were available because Israeli labor law requires that each day of absence (starting from day one) due to sickness in industrial firms be supported by a formal note from a physician.

In our analysis, we relied on spells (frequency) as our measure of absenteeism because spells is considered to be a more reliable (stable) measure than workdays lost. Twenty-four months was estimated to represent sufficient time to reduce skewness and kurtosis. In actuality, however, the absenteeism data remained considerably skewed. Therefore we applied a log transformation to the data, thereby reducing the skewness and kurtosis to acceptable levels for analytic purposes (not exceeding 1.5 for both measures for either men or women). Number of spells ranged from one (1) to 24, with an average (before the transformation) of 2.22 (S.D. = 3.69).

We assessed the reliability of the sickness absence data by calculating the correlation between absences in the first half of the measurement period and those in the second half, for the same workers. This correlation, which was based on the log transformed data, was .52. This correlation should be considered as high, given the long time span of the study and the fact that it is a behavioral measure, and so is likely to be affected by a large number of factors (cf., Johns, 1997).

Covariates. The effects of seven theoretically relevant confounding variables were controlled in our regression analysis: age, organizational tenure, gender, industry, job classification, hearing protection device (HPD) use and somatic complaints. Research indicates that both voluntary and involuntary absenteeism tends to be negatively associated with age (see meta-analytic reviews by Hackett, 1990, and Martoccio, 1989). Organizational tenure also has been found to be related to absenteeism (Johns, 1997); however, its documented effect has not been as consistent as the documented effect of age. Gender (1=males, 2=females) was also used as a covariate because research has indicated that women tend to be absent from work more than men (see, e.g., Johns, 1997). Industry may also have a confounding effect in the present study because different industries tend to have different policies regarding permission and consequences of employee absenteeism, potentially affecting attendance. As our sample was drawn from six industries (heavy metal works, light metal, plywood/Formica, electronics, food products, and printing), we created five dummy-coded variables to represent these industries, with electronics serving as the comparison group to the other industries. Job classification is a potential confounding variable because different jobs may be associated with different levels of tolerance toward employee absenteeism. The white-collar employees were classified into five job categories: computers, planning, secretary, engineering, and other. The last served as the comparison group.

Two other variables, hearing protection device (HPD) use and somatic complaints, were included in the analysis as covariates because of their potential as confounds. Both were assessed using a self-report survey of the participant employees. HPD use is expected to act as a confounder because it attenuates exposure to noise. It was coded as a dichotomous variable: ‘yes’ (using either earplugs or ear muffs) or ‘no’. Because of missing data on HPD use, the total sample size was reduced to 797 employees. Somatic complaints, which serve as indicators of subjective poor physical well-being were assessed by 10 items from the index reported by Caplan, Cobb, French, Harrison, and Pinneau (1975). This index measured the frequency with which certain symptoms (e.g., dizziness, shortness of breath, sleep problems, and headaches) were experienced during the month prior to participation in the study. The response scale ranged from ‘never’ (1) to ‘very often’ (4). By including somatic complaints as a covariate in the regression analysis, we increase our confidence that the remianing variance of sickness absence, after controlling for the effect of somatic complaints, represents absenteeism due to actual physical symptoms rather than negative psychological well-being (somatic complaints).

Results

Table 1 presents means, standard deviations, and intercorrelations among all variables. It is worth noting that both noise and, more noticeably, illumination had sufficient variance to suggest differences among people concerning their exposure to noise and lighting.

Table 1 Descriptive Statistics and Intercorrelations Among Variables

Variables	M	S.D.	1	2	3	4	5	6
1. Sickness Absence (log)	-.54	1.76						
2. Noise	62.82	6.33	.13*					
3. Lighting	739.2	295.7	.08*	.10*				
4. Gender	1.56	.50	.12*	-.24*	-.05			
5. Tenure	9.00	7.71	-.14*	.01	-.09*	-.12*		
6. Age	38.13	10.99	-.16*	-.03	-.11*	-.14*	.62*	
7. Somatic complaints	1.47	.37	.14*	.02	.01	.19*	.10*	-.03

Note: N=797, * $p \leq .05$, two-tailed.

The regression analysis enables us to examine the main and interactive effects of noise and lighting on sickness absence. Controlling for the multiple covariates, the positive beta weight of noise (.12) and the negative beta weight of lighting (-.09), presented in Table 2, support previous research findings. The focus of this study was on the interactive (joint) effect of noise and lighting on sickness absence. To assess this interaction, we ran a moderated regression analysis in which we hierarchically regressed absence frequency on sets of predictors entered into the regression equation in the following order: (1) the covariates, (2) the main effects of noise and lighting, and (3) the cross-product of noise and lighting (see Cohen & Cohen, 1983). The regression analysis supported the hypothesized interaction. The incremental R^2 of noise and lighting was close to 1.5%. This regression is summarized in Table 2.

Table 2 Summary of Regression Evaluating the Joint Effect of Noise and Lighton Sickness Absenteeism

			Sickness Absenteeism		
Step	Predictors Entered	Beta	ΔR^2	Cumulative R^2	Adjusted R^2
1	**Covariates**		.254*	.254*	.240*
	Age	-0.04			
	Tenure	0.00			
	Gender	0.14*			
	Industry				
	Heavy industry	-0.41*			
	Textile	-0.29*			
	Light industry	-0.37*			
	Food	-0.41*			
	Wood	-0.05			
	Job				
	Computers	0.03			
	R & D	0.01			
	Clerical	0.06			
	Engineering	0.07			
	Somatice complaints	0.15*			
	Hearing protection device	0.04			
2	Noise	0.12*	.016*	.270*	.255*
	Lighting	-0.09*			
3	Noise x Lighting	1.39*	.014*	.284*	.269*

Note: N=797, * $p \leq .05$

In this regression, the set of the covariates entered at step 1 accounted for approximately 24% (adjusted R^2) of the variance in sickness absence. The main effect terms entered at step 2 accounted for approximatetly 1.5% of the variance. Together, both the covariates and main effect terms explained 25.5% (adjusted R^2) of the variance in sickness absence. Moreover, as expected, the entry of the noise x lighting term increased R^2 by 1.4%. Overall, the covariates, main effects and interactive term explained approximately 27% (adjusted R^2) of the variance in sickness absence.

To illustrate the nature of the obtained interaction, we followed the procedure outlined in Cohen and Cohen (1983). More specifically, we used the estimated regression coefficients and constant to plot the regression of sickness absence at two representative levels of lighting and noise: low (-1 SD below the sample mean) and high (+1 SD above the sample mean). To enhance the visual clarity of the resulting regression lines we produced two figures. Figure 1 presents the results with the values of lighting on the X axis, and noise as the moderator. Figure 2 shows the results with noise on the X axis, and lighting as the moderator.

Figures 1 and 2 represent the two-way interaction between noise and lighting. These figures failed to support hypothesis 1 by indicating that higher noise is associated with higher sickness absence regardless of the level of lighting, and that low lighting is associated with relatively high sickness absence regardless of the level of noise. Thus, the figures indicate that, contrary to expectation, the adverse effect of one negative physical characteristic (either high noise or low lighting) on sickness absence is not intensified by the presence of the second negative physical characteristic. On the other hand, the figures do provide support for hypothesis 2, by indicating that when noise is low and lighting is high simultaneously, sickness absence is at its lowest level. Thus, as hypothesized, sickness absence was maximally reduced when both low noise and high lighting were present at the same time.

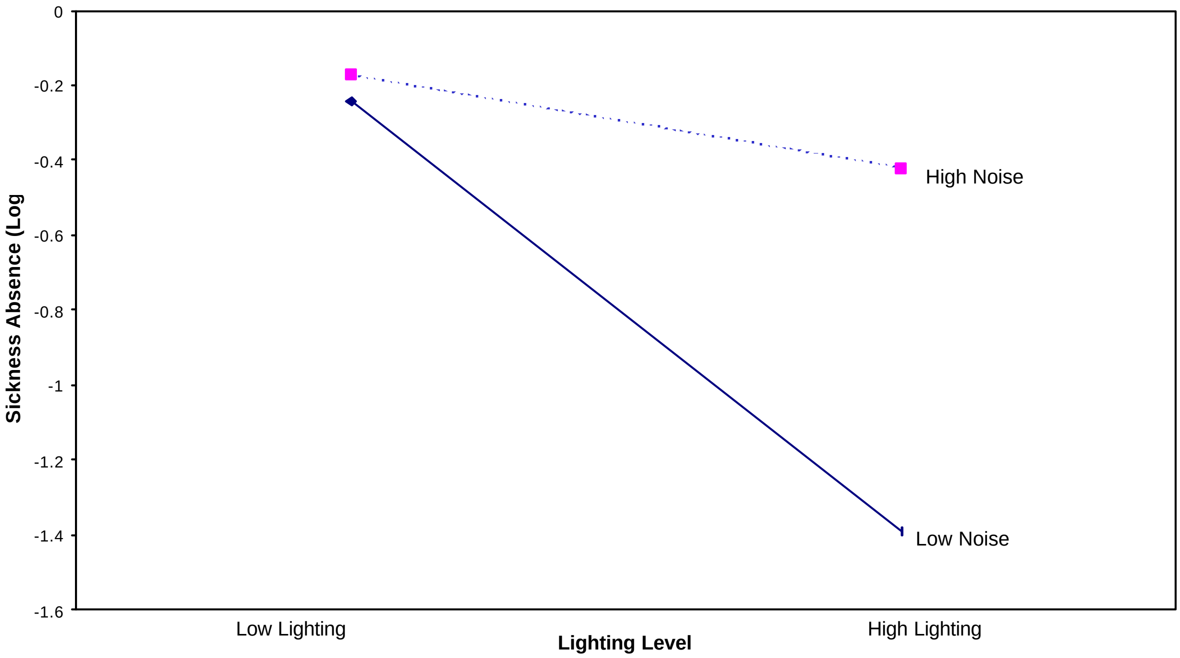

Figure 1: Interactive effect of noise and lighting on sickness absence, with light shown on the axis

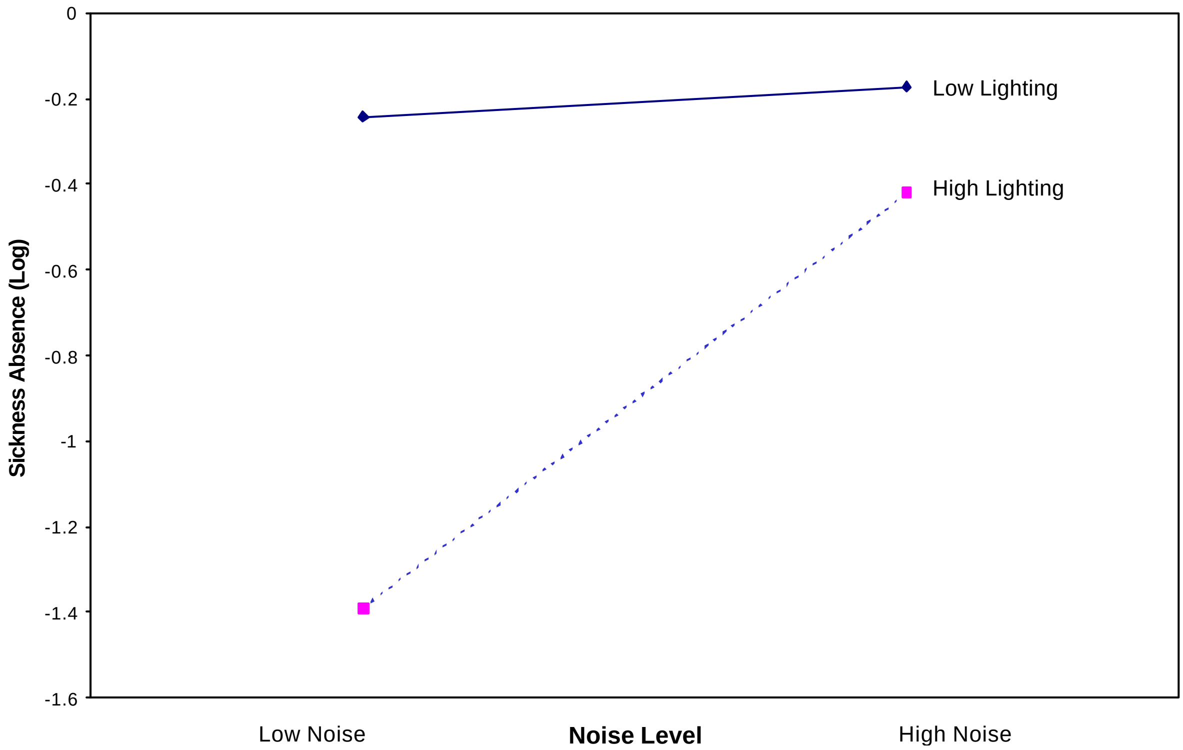

Figure 2: Interactive effect of noise and lighting on sickness absence, with noise shown on the axis

Discussion

The present study provided support for the notion that configurations of physical characteristics at work are important contributors to sickness absence. Examining how configurations of theoretically relevant variables affect employee reactions has been recommended in the literature as a viable approach to enhance our understanding about antecedents and consequences of employee reactions at work (see. e.g., Oldham & Fried, 1987).

Collecting objective data on exposure to high ambient noise levels and poor lighting among white collar employees from a large number of manufacturing plants enabled us to uncover the complex manner by which these variables interact to affect sickness absence, having controlled for a number of potential confounds. The findings supported previous findings concerning the main effects of noise or lighting on sickness absence. Thus, as the regression weights indicated (after controlling for the confounding variables), noise was positively associated with sickness absence and light was negatively associated with this outcome. The powerful effect of noise and lighting was further demonstrated via the moderated regression analysis concerning the interaction between the two variables. More specifically, the regression anlaysis, and the two figures associated with this analysis, indicated that high noise exposure contributed to higher sickness absence, and that this contribution was not mitigated by the ambient lighting levels. Similarly, poor lighting also served as a clear predictor of sickness absence, similar to that of high ambient noise, regardless of the noise levels. Thus, the results suggest that, contrary to expectation, sickness absence is not maximized by the joint presence of high noise and low lighting. Instead, the presence of either high ambient noise or poor lighting is sufficient to contribute to increased levels of sickness absence.

In contrast, the results indicate that the beneficial effect of low noise in reducing sickness absence exists only in the presence of good lighting. Similarly, the beneficial effect of good lighting is contingent upon the absence of high ambient noise. It therefore follows, as was hypothesized (Hypothesis 2), that in order to maximally reduce sickness absence, the physical environment should be optimal, as characterized by the joint presence of low ambient noise and good lighting. This finding is directly tied into the contribution of high noise and low lighting to sickness absence. That is, either high noise or low lighting contributed to higher sickness absence independently and regardless of the level of the other characteristic. It therefore follows that in order to maximally reduce sickness absence, both noise and darkness should be simultaneously low.

In sum, the present study contributes to the literature by indicating that noise and lighting indeed interact with each other in contributing to sickness absence. However, the results further indicate that the adverse versus beneficial effects of these important environmental factors are not symmetrical. That is, the results indicate that the presence of either high ambient noise or poor lighting is sufficient to contribute to increased sickness absence. On the other hand, only the combination of low ambient noise and adequate lighting maximally reduces sickness absence. Our confidence in the findings is enhanced for four major reasons. First, the study was based on a comprehensive and representative sample consisting of 797 white-collar employees from 21 organizations. Second, the focal variables in this study were measured by objective indicators (noise, lighting) and organizational archives (absenteeism), thus avoiding the problem of common method variance as a threat to the study's validity. Third, prior research on absenteeism has typically relied on short-cycle assessments of absenteeism over a period of only a few weeks or months. A serious problem of such short-term assessments is that they are very vulnerable to bias and low reliability. In contrast, in the present study we focused on absenteeism data over a two-year period, which, in turn, substantially increases the reliability (stability) of the measure (see also Kivimaki et al., 1997). Fourth, we have used an extensive list of personal and contextual variables as covariates to reduce the possibility of alternative explanations for the results.

This study has important practical implications for designing the physical work environment. First, organizations should attempt to focus on multiple dimensions such as the ambient noise exposure levels and lighting conditions. Second, engineering efforts should be made to improve all negative physical characteristics, rather than selective ones. In relation to the current study, this means that organizations should attempt to both reduce the levels of ambient noise and improve lighting in order to achieve maximum reduction in sickness absence.

Future studies should explore the joint effect of noise and lighting on other behavioral outcomes such as performance or absenteeism. Moreover, future studies may also benefit from exploring the joint effect of other work space characteristics, such as openness, number of enclosures, or interpersonal distance together with noise and lighting (cf., Oldham & Fried, 1987). It will be interesting to explore whether these workspace characteristics are indeed as dominant in their effect on sickness absence as noise and lighting are. There is also a need for research to examine the effect of individual differences on the relations between the various combinations of physical characteristics and work outcomes. Finally, to enhance the generalizability of the current findings, research should attempt to replicate the study in other cultures and countries and across other organizations.

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