AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 49:187–196 (2006)

Psychosocial Work Environment and Registered Absence From Work: Estimating the Etiologic Fraction

Martin L. Nielsen, MD,[1,2]* Reiner Rugulies, PhD,[1] Lars Smith-Hansen, BaTechnSoc,[1] Karl B. Christensen, PhD,[1] and Tage S. Kristensen, Dr.MedSci[1]

Background *Evidence is growing that an adverse psychosocial work environment increases sickness absence, but little is known on the magnitude of this problem or the impact of specific factors.*

Methods *Psychological demands, decision authority, skill discretion, social support from colleagues or supervisor, predictability, and meaning of work were assessed with questionnaires at baseline and sickness absence was followed-up in employers' registers for 1,919 respondents (response rate 75.2%, 68% women, mainly low-skilled jobs) from 52 Danish workplaces during a 2-year period. Etiologic fractions (EFs) were calculated with the most favorable quartiles as reference.*

Results *In the fully adjusted model, the following EFs were found: decision authority: 12%; social support from supervisors: 8%; psychological demands: 6%; and predictability: 5%. In total, the seven psychosocial factors explained 29% of all sick-leave days.*

Conclusions *The results suggest that improving the psychosocial work environment among the less favorable 75% may prevent substantial amounts of absence.* Am. J. Ind. Med. 49:187–196, 2006. © *2006 Wiley-Liss, Inc.*

KEY WORDS: decision authority; social support; psychological demands; predictability; absenteeism; attributable fraction; population attributable risk; prospective study; physical work environment; health behavior

INTRODUCTION

In the international literature on absence from work it is often implicitly understood that all absence can be prevented, which indicates that the optimal level of absence is zero. This is an unrealistic and potentially harmful assumption. Even in organizations with perfect working conditions there will be sickness absence due to the normal diseases of the working population. This level of absence should not be seen as a problem, but as a natural phenomenon of any workplace. The viewpoint of the present article is that a fraction of the absence days may be prevented by improving the working conditions of the workers. This fraction represents absence among workers exposed to stressors and other exposures at work that ought to be eliminated or reduced.

To effectively prevent this ''unnatural'' absence and its consequences, we need to know not only the factors statistically associated with absence, but also the size of their relative contribution. This is important in order to prioritize possible preventive measures. The relative contribution of a predictor to an outcome can be determined by

[1]National Institute of Occupational Health, Copenhagen, Denmark
[2]Clinic of Occupational Medicine, Hillerød Hospital, Denmark

This research work was performed at the National Institute of Occupational Health, Copenhagen, Denmark.

Contract grant sponsor: The National Health Fund for Research and Development; Contract grant number: 1400/9-189-1996; Contract grant sponsor: The Danish Health Insurance Fund; Contract grant number: 11/081-97; Contract grant sponsor: Danish Ministry of Research; Contract grant number: 9600123.

*Correspondence to: Martin L. Nielsen, Clinic of Occupational Medicine, Hillerød Hospital, Helsevej 2, DK 3400, Hillerød, Denmark. E-mail: malini@fa.dk

Accepted 25 November 2005
DOI 10.1002/ajim.20252. Published online in Wiley InterScience (www.interscience.wiley.com)

calculating the etiologic fraction (EFs), which is defined as the fraction of the outcome that was caused by the predictor in question [Miettinen, 1974].

Etiologic fractions have been used by the World Health Organization (WHO) on a global scale to estimate the burden of disease produced by different preventable causes throughout the regions of the world [Rodgers et al., 2002; Ezzati et al., 2003]. In the area of work environment, EFs have been calculated—among other things—to assess the proportion of heart disease caused by working environment factors [Olsen and Kristensen, 1991], to estimate the cost of occupational injuries and illnesses [Leigh et al., 2000], and to calculate the proportion of fatalities related to occupational factors [Nurminen and Karjalainen, 2001]. Most recently, a special issue of this journal was devoted to report several estimates of the global and regional burden of occupational diseases and injuries from the WHO comparative risk assessment (CRA), including lung cancer, leukemia, malignant mesothelioma, asthma, chronic obstructive pulmonary disease, pneumoconiosis, low back pain, contaminated sharps injuries in health care workers, noise-induced hearing loss, and occupational injuries [Eijkemans and Takala, 2005].

With regard to psychosocial work environment and sickness absence, the Belstress study has reported population attributable fractions of 8.3%–26.7% for job control in different strata of male workers [Moreau et al., 2003]. In absolute figures, this corresponds to 0.5–3.8 days of absence per worker per year. Recently, the French GAZEL study has presented an analysis of fractions attributable to stress-related and physical work factors [Melchior et al., 2005]. They found work factors to explain about 20% of all absence, particularly in manual workers and clerks, thereby explaining part of the social gradient in sickness absence. Physical factors explained a larger proportion of musculoskeletal disorders, and psychosocial factors had the largest impact on psychiatric disorders, but also some impact on musculoskeletal diagnoses.

Most other studies have not reported similar measures, but in a few cases it is possible to calculate EFs from the reported figures and they are generally within the same magnitude. When calculated in the same way as in the present article, an earlier article from the GAZEL-study showed that 17%–22% of the absence in men were explained by decision latitude and social support, and in women 13% of short absences were explained by psychological demands [Melchior et al., 2003]. The Finnish 10-town study showed that worktime control, job control, and job demands explained 15% of the medically certified absence periods of more than 3 days in men and 33% in women [Ala-Mursula et al., 2002]. In the British Whitehall II study, decision authority, skill discretion, job demands, and social support at work explained 11%–30% of short absence spells (1–7 days), and 6%–15% of long spells in both genders [Stansfeld et al., 1999].

A Danish report presented the EFs of work environment factors for self-reported absence in a large representative sample of the Danish working population and in a population of computer-users [Jensen et al., 2002]. In both samples different combinations of physical and psychosocial work environment factors explained more than one third of the absence.

One can summarize that, although there is an increasing interest in the relative contribution of psychosocial factors to sickness absence, only very few studies analyzed EFs or provided enough information for readers to calculate them by themselves. The knowledge in this field has to be considered still as sparse and provisional and more research is needed.

We studied the impact of the psychosocial work environment on sickness absence in the Intervention Project on Absence and Well-being (IPAW) [Nielsen et al., 2004]. We found that high levels of decision authority predicted low numbers of sickness absence days in both women and men after 2 years of follow-up. In men, high predictability at work was also associated with low sickness absence. Other factors, such as psychological demands or social support at work did not show statistically significant effects in the final model [Nielsen et al., 2002].

The focus of the present study is to reanalyze the IPAW dataset with regard to the relative contribution of the psychosocial variables to sickness absence days. A central research question in this respect is, if psychosocial exposure variables need to be brought to the presumed optimum (e.g., to increase decision authority to the highest level possible) to significantly reduce sickness absence or if already moderate improvements might produce positive effects. This question is especially important with regard to workplace interventions, which often will have to settle for less than optimal improvements of the work environment. Therefore, we analyzed differences between sickness absence rates across quartiles of exposures and calculated the contribution of both the single psychosocial variables (individual EF) and the common contribution of all psychosocial variables (overall EF).

The analyses are based on company-recorded sickness absence data, and feature two improvements compared to previous studies on psychosocial work environment and sickness absence. We adjusted the analyses for several potential confounders, including a wider range of physical work environment exposures, and we conceptualized and tested two new psychosocial factors: meaning and predictability at work.

STUDY POPULATION AND METHODS

The data analyzed in this report were collected in IPAW—a controlled intervention study with 5 years of follow-up [Nielsen et al., 2002]. The present study does not report on intervention effects, as they will be analyzed at a

later stage. Predictors and covariates were measured by the baseline questionnaire and the absence data were derived from the organizations' absence registries during a 2-year follow-up period.

Respondents and Worksites

IPAW includes 52 Danish worksites with 2,730 employees at baseline (excluding temporary contracts). At 22 of these worksites, interventions were conducted to improve the psychosocial work environment and thereby promote employees' well-being and reduce absence rates. The remaining 30 worksites were matched control groups with high (n = 14) and low absence (n = 16) at baseline, respectively. All 52 worksites belonged to three organizations: (1) a major pharmaceutical company (production factories, packaging units, laboratories, canteens, and cleaning departments; 13 workplaces, 731 respondents); (2) municipal workplaces in the care sector (15 nursing homes for the elderly and 7 institutions for mentally handicapped; 994 respondents); and (3) the technical services of the municipality (cemeteries, parks, workshops, sewage pumping stations, road construction and repair, administrative offices; 17 workplaces, 343 respondents). The workplaces in (2) and (3) belonged to the municipality of Copenhagen, and the Departments of the Pharmaceutical Company were also placed in the Copenhagen area.

The baseline questionnaire was sent to the participants between May 1996 and April 1997. Of the 2,730 employees, 2,053 completed the questionnaire, yielding a participation rate of 75.2%. We have information from absence registers for 1980 of the respondents. Only 53 respondents were 60 years or older, reflecting the common use of early retirement in Denmark. We consequently excluded these highly selected subjects. We further excluded eight trainees and apprentices, yielding a final sample of 1,919 subjects. The mean age was 40 years and 68% of the participants were women. The level of education and social status was generally low, 63% of the respondents were skilled, semi-skilled, or unskilled workers.

Measurement of Predictors and Co-variates

The questions in the scales on psychological demands, decision authority, and skill discretion, were derived from the Whitehall II study [Marmot et al., 1991] and translated into Danish [Netterstrøm et al., 1998], whereas questions on support from colleagues and supervisor were developed in a previous study [Netterstrøm et al., 1998]. These five scales consist of two to eight items, each with four response categories ranging from ''often'' to ''never.'' In addition, scales on meaning of work and predictability were developed and validated by our research group [Nielsen et al., 2002]. Meaning of work is present when the respondent finds the tasks meaningful, and feels that the work is important and useful for others. Predictability refers to relevant and useful information on major upcoming events at the workplace, for example, changes in organization, new technology, etc. The two scales have four items on meaning and two on predictability, each item with five response categories ranging from ''fits precisely'' to ''doesn't fit.'' All seven scales were coded according to their names, that is, high scores are unfavorable for psychological demands and favorable for the other variables. Cronbach's alphas for the scales were generally satisfactory (0.69–0.84), except for the two-item scale on psychological demands, which had an alpha of 0.56 [Nielsen et al., 2002].

Exposures in the physical work environment were measured by single questions on how much of the daily working time one is exposed to the following: twisting the back, stooping work position, lifting more than 30 kg, pushing/pulling heavy burdens, repeating the same job task many times per hour, loud noise, temperature fluctuations, cold, dust, and tobacco smoke from others. For each of those exposures, we asked the respondents how often they occurred, with six response categories ranging from ''almost all the time'' to ''never.'' We further asked them to rate the intensity of physical activity at work on a five-point scale ranging from ''very light'' to ''very heavy.''

The classification of socioeconomic status (SES) was based on questions about employment grade, education and job-title. For 1,796 of the 1,919 people we had sufficient data to code SES. As the study includes few participants in the higher SES groups and further stratification reduces power, we chose to classify the respondents into only two groups: Low SES (skilled, semi-, or un-skilled workers) with 1,126 participants (63%) and high SES (White-collar workers etc.) with 670 participants (37%).

Health behaviors were measured by questions on smoking, alcohol consumption, and by calculating body mass index (BMI) from self-reported height and weight.

We asked the participants if they lived with a partner or alone, for the total number of children living at home, and how many of these were below the age of 7 years. Based on this, we created the variable ''family status'' with the following categories: 1, single without children; 2, couple without children; 3, couple with children that are all 7 years or older; 4, couple with children below 7 years (including those with older siblings); 5, single parent.

Measurement of Absence

Absence data were drawn from the computer-based registers of the workplaces. For this study, we used data recorded during the 24 months after the completion of the questionnaire. For 75 persons who did not fill in the date of completion in the questionnaire, we inserted a date in the middle of the period, in which their colleagues had responded.

For every absence period, we received data on first and last day and a code of the type of absence. We collapsed consecutive or overlapping periods. We calculated absence due to the employees' own sickness, including work injuries and occupational diseases and excluded absence due to other reasons, such as a child's first sick-day or pregnancy-related absence, vacation, or maternity leave. These reasons for being absent were reported by the employees when contacting the workplace about taking sick leave. In Denmark, employers are not allowed to have information on the health conditions of their employees, and we as researchers did not have access to any reports or diagnoses from physicians.

Data Analysis

Analyses were made on individual data adjusted for potential confounders. We divided each of the seven psychosocial scales into quartiles and calculated crude and adjusted rate ratios (RRs) based on multiple Poisson regression with scale parameters to specify an over-dispersed model. This means that standard errors (SE) were adjusted according to the over-dispersion. Three hundred employees had left their jobs during follow-up. To account for this in the analyses, the logarithm of the actual observation time was included as an off-set variable, that is, a regression variable with a constant coefficient of one for each observation [McCullagh and Nelder, 1989].

Adjusted RRs were calculated in four models. Model I was adjusted for age, gender, family status, type of organization and assignment to intervention or control group. Model II was adjusted for the variables in Model I plus health behaviors. Model III was further adjusted for physical workplace exposures.

We also ran a fourth model, which included SES. This model might be an over-adjustment, because SES was mainly based on occupational status that is likely to act as a proxy measure for some psychosocial exposures. A priori, we decided that Model III would be the most appropriate model, but that for the matter of completeness, we would include also the results after adjustment for SES (Model IV).

Intervention assignment and organization were forced into the models to control for possible differences in unmeasured variables such as organizational culture, effects of intervention workplace selection that was not fully addressed by the matching of control workplaces, or changes at the intervention workplaces during follow-up, which might have influenced sickness absence. In addition, we repeated analyses for control workplaces only.

Intervention assignment, organization, and family status were treated as categorical variables.

Based on RRs, we calculated the EF of the psychosocial work environment scales for each of the four models.

The data have zero to 64 missing values for each variable, with the exception of SES, which had 123 missing. This reduces the effective sample size to 1,820 in Model I, 1,720 in Model II and 1,556 in Model III. When adjusting for SES, the sample is 1,457.

When calculating EF, we used the quartile with the most favorable psychosocial exposure as the reference group (low score for demands, high score for other variables). Based on the actual distributions of the scores, the size of the reference group for different variables could not always be 25%, but varies from 20.3% to 36.2%. The EF expresses the excess of absence in the three most unfavorable quartiles of exposure, or, in other words, how many percent of absence days that would not have occurred, if exposure for all employees had been at the level of the most favorable quartile.

Figure 1 illustrates the principle of the calculation by the example of Model I for decision authority [Miettinen, 1974; Olsen and Kristensen, 1991]. The width of the columns in the histogram corresponds to the proportion of participants in the group, and the height reflects the RR. The area of the column represents the amount of absence in the group, and the shaded area above the line parallel to the top of column 1 represent the absence that would not have occurred if all four groups had the absence rates of the group with the lowest exposure. The EF is calculated by dividing this area by the total area of the four columns.

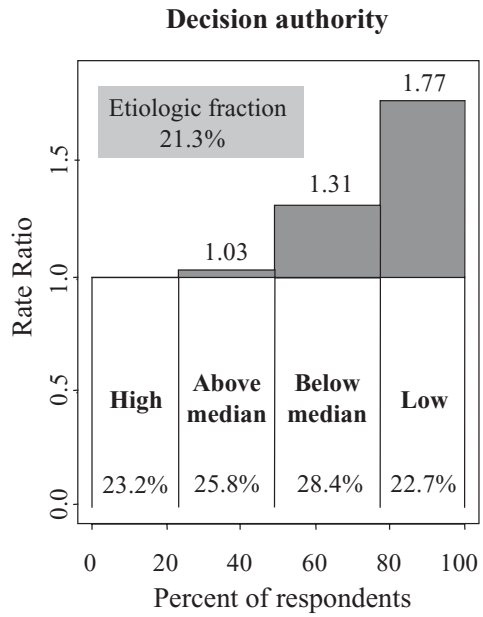

FIGURE 1. Example for calculation of etiologic fraction. Rate ratios of absence days in four quartiles of decision authority. The shaded area represents the surplus absence compared to the most favorable quartile with high decision authority, which is considered the reference group. The percentage of the respondents in each quartile is given in each column. The surplus absence (shaded area) is:

$$(0.03 \times 0.258) + (0.31 \times 0.284) + (0.77 \times 0.227) = 0.271$$

and the EF (shaded area in percent of total area) is:

$$0.271/(0.271 + 1) = 0.213 = 21.3\%.$$

After the calculation of the EF for each factor, we calculated the overall EF for the seven psychosocial factors by the sum-formula:

$$EF_{(total)} = 1 - (1-EF_{(a)})(1-EF_{(b)}) \ldots (1-EF_{(n)}) \text{ [Miettinen, 1974].}$$

The use of the sum-formula rests on two theoretical conditions: that there are no interactions between the effects of predictors on the outcome, and that predictors are not statistically correlated. For the present study, we will test interaction effects between the workplace conditions by adding interaction terms in the Poisson regression model. We have previously reported that the psychosocial work environment variables in IPAW are only moderately correlated with each other (0.04–0.44) [Nielsen et al., 2002]. To assess how much this can affect the result, we will calculate combined EFs in cases where correlations range between 1 and −1. Using the sum formula under these conditions can be illustrated by the example in Figure 2.

Consider the case of two dichotomous risk factors A and B. Denote the number of people exposed to neither factor, A but not B, B but not A, and both factors by N_{00}, N_{A0}, N_{0B}, and N_{AB} respectively, and let the RRs be denoted by RR_{A0}, RR_{0B}, and RR_{AB} respectively.

The situation with a correlation of 0 is illustrated in Figure 2. A positive correlation in the population would make the shaded area smaller and increase the combined EF, whereas a negative correlation would make the shaded area larger and decrease the combined EF.

For the example in the figure, $RR_A = RR_B = 2.0$ and no correlation between A and B, the combined EF is 55.6%, and increasing or decreasing the correlation between 1 and −1 lead to EFs ranging between 50.0% and 60.0%. For $RR_A = RR_B = 1.3$ and no correlation, the combined EF is 27.3%, and changing the correlation lead to EFs ranging between 23.1% and 31.0%.

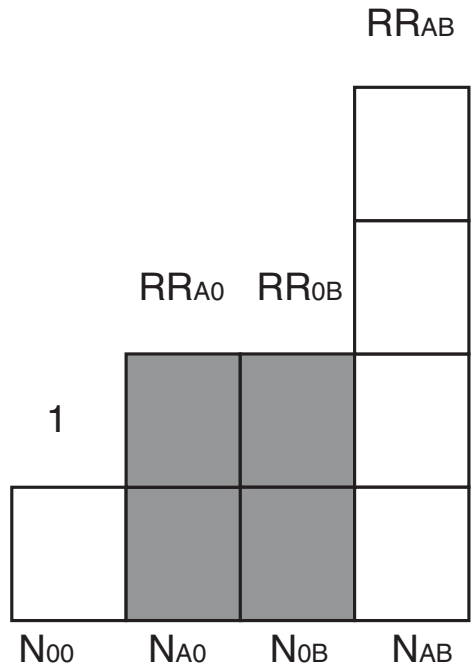

FIGURE 2. Illustration of the underlying assumptions when using the sum formula. In the figure, 50% are exposed to the risk factor A, and 50% to the risk factor B. As A and B are uncorrelated, there are 25% exposed to none of the factors (N_{00}), 25% exposed to only A (N_{A0}), 25% to only B (N_{0B}), and 25% to both (N_{AB}). As the RRs $RR_A = RR_B = 2$, then $RR_{AB} = 4$. The 4 units of area below the line RR = 1 equals the amount of absence if no surplus absence was caused by the risk factors A and B. The 5 units of area above this line represent the surplus absence, and thus the EF is $5/(4+5) = 55.6\%$. A positive correlation between A an B would increase the proportion of those exposed to both or none of the factors. This would increase the width of N_{AB} with a high RR and reduce the width of the shaded area with a lower RR, and thus increase the combined EF. If the correlation is 1, nobody will be exposed to only one of the factors. The area above RR = 1 is then 6, and EF is $6/(4+6) = 60\%$. A negative correlation would make the shaded area larger and decrease the combined EF. If the correlation is −1, half the population is exposed to A and the other half to B. The area above RR = 1 is then 4, and the EF is $4/(4+4) = 50\%$.

RESULTS

Overall, the mean number of absence days per year was 12.7 (95% CI: 11.7–13.8) for women and 11.8 (95% CI: 10.5–13.1) for men.

Table I shows the impact of the seven psychosocial workplace factors on sickness absence days, expressed in RRs and 95% confidence intervals (CI) after adjustment for age, gender, family status, organization, and intervention assignment. The last column shows *P*-values based on tests for trend. Low levels of decision authority, skill discretion, support from supervisors, and predictability were significantly associated with more sickness absence days. Psychological demands, with the CI of every quartile including the value 1, also showed a significant test for trend, whereas support from colleagues and meaning of work did not.

Figure 3 shows histograms for the psychosocial factors when adjusted for the covariates in Model I. Decision authority had by far the strongest association with absence followed by supervisor support, predictability, and skill discretion. However, there were different patterns. Decision authority and to a certain extent psychological demands showed a linear increase in RRs with increasing adverse exposure, whereas predictability and meaning of work showed elevated RRs only in the fourth (most adverse) quartile. Skill discretion and supervisor support had raised RR's already in the second quartile, with none or only small further increases in the third and fourth quartile. Support from colleagues had a more J-shaped association, with the second quartile having the lowest RR and only the fourth quartile being slightly above 1.

TABLE I. Exposure to Psychosocial Workplace Factors and Rate Ratios for Number of Sickness Absence Days per Year; 52 Danish Workplaces

	N	Absence days per year		
	(Total 1919)	Rate ratio	(95% CI)	*P* Test for trend
Psychosocial workplace exposure				
Decision authority				
High (reference)	443	1.00	—	
Above mean	492	1.03	(0.83, 1.28)	
Below mean	542	1.31	(1.07, 1.61)	
Low	433	1.77	(1.44, 2.18)	<.0001
Skill discretion				
High (reference)	543	1.00	—	
Above mean	397	1.19	(0.97, 1.46)	
Below mean	565	1.16	(0.96, 1.40)	
Low	404	1.23	(1.00, 1.50)	0.028
Psychological demands				
Low (reference)	449	1.00	—	
Below mean	491	1.05	(0.86, 1.29)	
Above mean	513	1.12	(0.92, 1.38)	
High	452	1.14	(0.92, 1.41)	0.046
Support from colleagues				
High (reference)	694	1.00	—	
Above mean	411	0.84	(0.69, 1.03)	
Below mean	447	0.97	(0.80, 1.16)	
Low	349	1.10	(0.90, 1.34)	0.41
Support from supervisor				
High (reference)	539	1.00	—	
Above mean	318	1.19	(0.96, 1.49)	
Below mean	707	1.17	(0.98, 1.41)	
Low	340	1.35	(1.09, 1.67)	0.0012
Meaning of work				
High (reference)	390	1.00	—	
Above mean	498	0.99	(0.80, 1.22)	
Below mean	594	1.01	(0.82, 1.24)	
Low	417	1.17	(0.93, 1.44)	0.20
Predictability				
High (reference)	466	1.00	—	
Above mean	307	1.00	(0.80, 1.27)	
Below mean	672	1.06	(0.88, 1.28)	
Low	445	1.31	(1.07, 1.60)	0.0051

Rate ratios calculated by Poisson regression adjusted for age, gender, family status, organization, and intervention assignment. Time under observation is included in the regression model as an offset variable to estimate absence days for respondents with incomplete follow-up time.

No significant interaction effects between the psychosocial factors occurred.

Table II shows EFs for each of the seven scales, and the sum for all scales. Model I gives estimates adjusted for sociodemographics, organization, and intervention assignment. When further adjusting for individual health behaviors in Model II, the estimates were only slightly reduced. When physical workplace exposures were added in Model III, the estimates became considerably smaller. The model gives a combined EF of 29%. Decision authority had the strongest impact on absence days (11.9%), followed by support from supervisors (8.3%), demands (6.0%), and predictability (5.2%). When we further adjusted for SES (Model IV), which might be considered over-adjustment, the total EF was

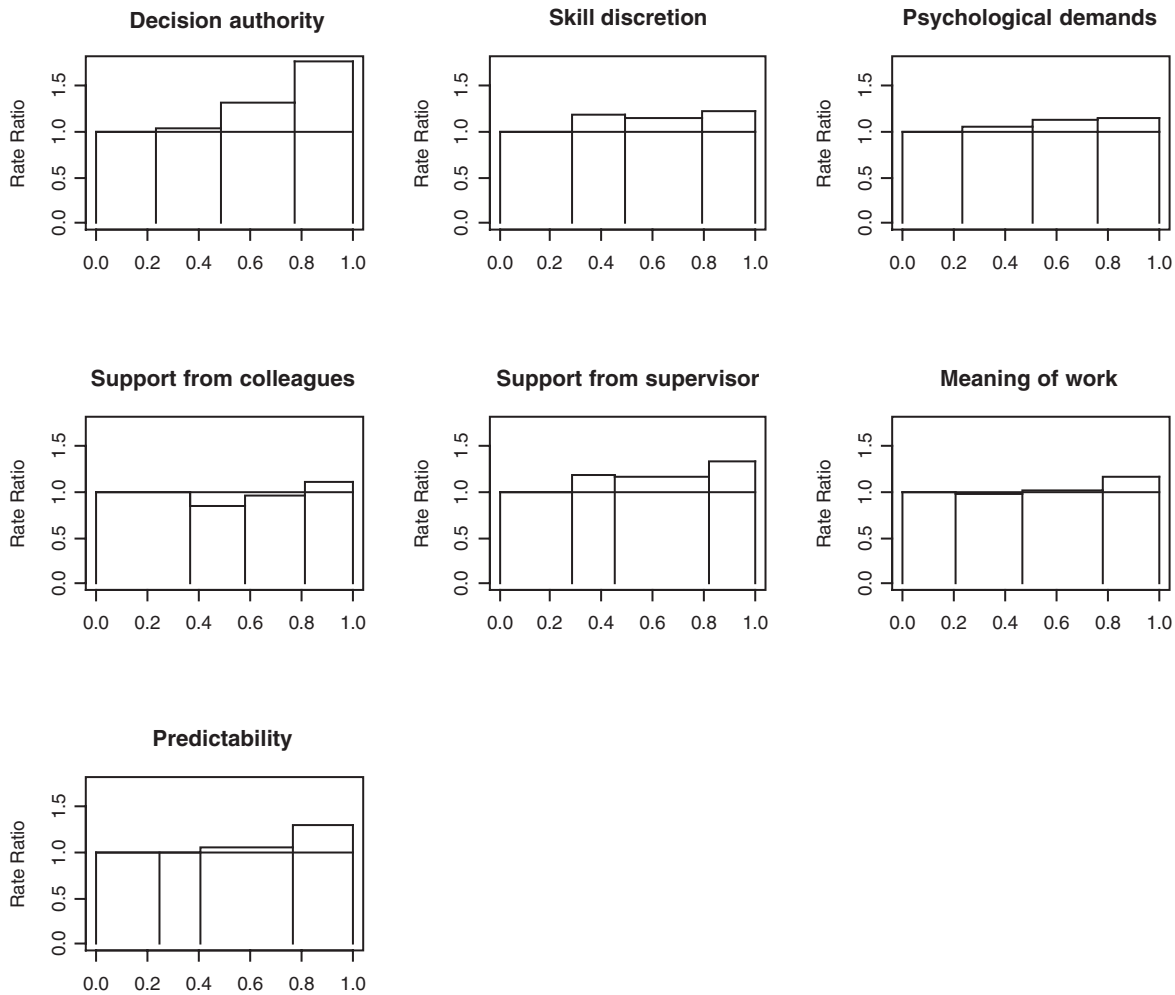

FIGURE 3. Histograms of the RRs for absence days by quartiles of the seven psychosocial work environment variables, adjusted for age, gender, family type, organization, and intervention assignment of the workplace; 52 Danish workplaces. The width of the columns in the histograms corresponds to the proportion of participants in the group, and the height reflects the Rate Ratio. The area above the line at RR = 1 reflect the proportion of absence caused by the factor.

reduced to 19%. Estimates of EFs of the main predictors changed only marginally (decision authority from 11.9% to 9.9%, supervisor support from 8.3% to 7.1%), whereas small and negative estimates became even smaller or more negative.

Repeating the analyses above with the 1,457 respondents with no missing data made no substantial changes in the results. Repeating Model III for participants from control workplaces only, produced similar results for most variables, however estimates increased for decision authority (20.5%) and support from colleagues (9.0%).

DISCUSSION

In this prospective study, the psychosocial work environment factors explained a considerable part of sickness absence days during 2 years of follow-up. When adjusting for demographic variables, health behavior, and physical work environment factors, the total EF was 29%.

As expected, employees of higher SES had a more favorable exposure profile, including higher decision authority. For this reason, it would be interesting to adjust the results for SES. However, the association between SES and absence is likely to be at least partly mediated by different psychosocial working conditions in the different socioeconomic groups and therefore including SES in the analyses could imply over-adjustment [North et al., 1996]. We therefore believe that the model without adjustment for SES is the most appropriate in our study. For the matter of completeness, however, we have also reported the EF when analyses were adjusted for SES, which resulted in a drop from 29% to 19%. Interestingly, the EF of the two strongest independent variables, decision

TABLE II. Fraction of Sickness Absence Attributable to each Psychosocial Workplace Exposure; 52 Danish Workplaces

Psychosocial workplace exposure	Model			
	I	II	III	IV
Decision authority	21.2%	22.6%	11.9%	9.9%
Skill discretion	11.8%	10.2%	2.6%	2.2%
Psychological demands	7.2%	8.1%	6.0%	6.1%
Support from colleagues	−2.4%	−1.7%	−1.6%	−3.4%
Support from supervisor	13.6%	12.6%	8.3%	7.1%
Meaning of work	3.5%	1.1%	−0.2%	−4.2%
Predictability	8.7%	6.6%	5.2%	2.4%
Total by sum-formula	**50%**	**48%**	**29%**	**19%**

Percentages indicate the proportion of absence days that would be reduced if absence levels of the participants would move from the level of the three least favorable exposure quartiles to the level of the most favorable exposure quartile.
Model I: Adjusted for age, gender, family status, organization, and intervention assignment.
Model II: Model I plus adjustment for smoking, alcohol consumption, and body mass index.
Model III: Model II plus adjustment for physical workplace exposures: stooping work position, twisting the back, lifting >30 kg, pushing/pulling heavy burdens, repetitive tasks, loud noise, temperature fluctuations, cold, dust, and heavy physical activity.
Model IV: Model III plus adjustment for socioeconomic status.

authority and supervisor support, were affected only marginally.

The single items on physical work environment exposures are not optimal measures, and therefore we did not calculate the EFs for these variables. However, the change of the EF estimate for the psychosocial factors from 48% to 29% when adjusting for these variables suggests that physical work environment also makes a considerable impact on the number of absence days.

IPAW has some strong features contributing to the validity of the results. The cohort includes a large number of workers of both genders and different types of jobs in both private and public sectors. Many variables of interest were measured and analyzed, including psychosocial and physical work environment, health behaviors, and demographic variables. These measures are theory based, well validated, and most of them are comparable to previous results from other studies [Nielsen et al., 2002]. Furthermore, we contribute by testing two new concepts of theoretical interest, meaning of work and predictability. Absence data are based on employers' registers. Because the data comprise two full years, seasonal variation could not have influenced the results.

There are also some limitations in our study. Possible changes in work environment during the follow-up, which would tend to underestimate the associations, were not assessed and could therefore not be analyzed. The majority of the workers were in lower social strata, where work environment problems are most prevalent and contribute most to absence. This means on the one hand that our study was conducted within a group, in which psychosocial exposures and absence is of high relevance. On the other hand, this means that the associations reported here might be stronger than in studies with participants in higher social strata, and that the weight of predictors might be different in different job-groups. Melchior et al. [2005] stated that they probably underestimated the level of absence and the impact of work factors, because their study cohort had a higher mean social status compared to the population at large. One needs also to consider that the majority of our study population are women, and geographically the study is restricted to the Copenhagen area. In that sense, the generalizability may be limited.

The use of the sum-formula rests on the two conditions that predictors are not statistically associated, and that they do not interact. We found no significant interaction effects between the independent variables, and we showed that the impact of even large changes in correlations is small. As the actual correlations for most exposure variables are small, we consider it acceptable to use the sum-formula to calculate total EFs. We included all seven variables in the calculation of the sum. If some of the EFs were chance findings, they should sum up to zero, and therefore should not distort the total sum. Therefore, we consider the calculated sum to be an acceptable measure of the total impact. We did not adjust the psychosocial factors for each other, because this would imply calculating the effect of a situation where one factor was changed while holding all other factors constant, an assumption, which is unrealistic in practical preventive efforts at the workplace.

When we repeated the analysis in Model III without individuals from intervention workplaces, the estimates of EF's for decision authority and support from colleagues increased. This may indicate that these factors were improved during intervention and the effects on absence thereby ameliorated. This would cause a weaker association at follow-up and thus an underestimation of the true impact.

The histograms in Figure 3 make it clearly visible that the risk of becoming absent is different for the different aspects of the psychosocial work environment. For predictability and meaning of work an increased risk of absence is only present in the least favorable fourth quartile, whereas for decision authority and demands risk of absence increases more or less linearly across the quartiles. For skill discretion and supervisor support risk of absence is higher in the three less favorable quartiles, but the RRs do not differ much between these three quartiles.

The findings indicate that the effect of preventive interventions might be expected to differ. With regard to predictability and meaning of work, interventions should be

directed toward increasing very low levels, that is, the least favorable fourth quartile to the level of the third quartile. One should not expect that a further improvement of meaning and predictability of work would result into more reduced absence. For skill discretion and supervisor support, on the other hand, it looks as if an effect on absence should only be expected if exposure is reduced to the level of the most favorable quartile. Improving decision authority and psychological demands would positively affect absence, without a visible threshold effect.

If one considers situations, where it is not feasible to reduce exposure to the level of the most favorable quartile, the effect of other strategies could be calculated from figures in Table II. For example, one could set the aim of improving quartile three and four to the median level, or to improve quartile four to the level of quartile three, quartile three to the level of quartile two etc.

The 29% EF of the psychosocial work environment factors in this study is within the range of the 6%–33% that was found in the Belstress, Gazel, Whitehall II, and 10-town studies [Stansfeld et al., 1999; Ala-Mursula et al., 2002; Melchior et al., 2003, 2005; Moreau et al., 2003]. We included seven psychosocial variables, and used the most favorable quartile as reference, whereas the other studies included between one and four psychosocial variables and some used the median or the most favorable tertile as reference. This will favor a higher EF in our study. On the other hand, we adjusted the analyses by a larger set of physical factors, which reduced the estimate considerably.

In a Danish report based on a representative national survey with self-reported absence, Jensen et al. [2002] have calculated that five physical and psychosocial work environment factors including job insecurity explain 38% of the absence days. The EF differed markedly by socio-economic strata, from 22% in managers and academics to 49% in unskilled workers. A social gradient was also found in the GAZEL study (without giving figures for the attributable fraction) [Melchior et al., 2005].

In the IPAW project, we have studied a cohort, where more than half of the women and three-quarters of the men are skilled, semiskilled, or unskilled workers. The results show that the potential for reducing absence is considerable in these groups. When we get to analyze the effects of interventions to improve psychosocial work environment in the IPAW workplaces, it will be very interesting to see if—and to what degree—this potential was realized.

ACKNOWLEDGMENTS

The authors would like to thank Klaus Stagis Hansen, Hans Klausen, and Anders Ingemann Larsen from the three participating organizations' occupational health services for their support and enthusiasm in initiating the project, the members of the project committees for ideas, criticism and support, and the management and employees at the participating workplaces for their time and many helpful suggestions. The National Research Councils, the National Health Fund for Research and Development, and the Danish Health Insurance Fund financially supported the project. The project is part of the SARA program (Social And welfare consequences of the use of human Resources At work). This program received support from the Danish Ministry of Research.

REFERENCES

Ala-Mursula L, Vahtera J, Kivimaki M, Kevin MV, Pentti J. 2002. Employee control over working times: Associations with subjective health and sickness absences. J Epidemiol Comm Health 56:272–278.

Eijkemans GJ, Takala J. 2005. Moving knowledge of global burden into preventive action. Am J Ind Med 48:395–399.

Ezzati M, Hoorn SV, Rodgers A, Lopez AD, Mathers CD, Murray CJ. 2003. Estimates of global and regional potential health gains from reducing multiple major risk factors. Lancet 362:271–280.

Jensen C, Lund T, Mossing R, Nielsen ML, Labriola M, Burr H, Villadsen E. 2002. Working environment and absence. København: Arbejdsmiljøinstituttet. 23p. (in Danish).

Leigh JP, Markowitz SB, Fahs M, Landrigan PJ. 2000. Costs of occupational injuries and illnesses. Ann Arbor, MI: University of Michigan Press.

Marmot MG, Smith GD, Stansfeld S, Patel C, North F, Head J, White I, Brunner E, Feeney A. 1991. Health inequalities among British civil servants: The Whitehall II study. Lancet 337:1387–1393.

McCullagh P, Nelder JA. 1989. Generalized linear models. London: Chapman and Hall.

Melchior M, Niedhammer I, Berkman LF, Goldberg M. 2003. Do psychosocial work factors and social relations exert independent effects on sickness absence? A six-year prospective study of the GAZEL cohort. J Epidemiol Comm Health 57:285–293.

Melchior M, Krieger N, Kawachi I, Berkman LF, Niedhammer I, Goldberg M. 2005. Work factors and occupational class disparities in sickness absence: Findings from the GAZEL cohort study. Am J Public Health 95:1206–1212.

Miettinen OS. 1974. Proportion of disease caused or prevented by a given exposure, trait or intervention. Am J Epidemiol 99:325–332.

Moreau M, Valente F, Mak R, Pelfrene E, de Smet P, De Backer G, Kornitzer M. 2003. Occupational stress and incidence of sick leave in three sectors of activity of the Belgian workforce: The belstress study. Arch Pub Health 61:101–125.

Netterstrøm B, Kristensen TS, Møller L, Jensen G. 1998. Angina pectoris, job strain, and social status: A cross-sectional study of Employed Urban Citizens. Int J Behav Medi 5:312–322.

Nielsen ML, Kristensen TS, Smith-Hansen L. 2002. The Intervention Project on Absence and Well-being (IPAW): Design and results from the baseline of a 5-year study. Work & Stress 16:191–206.

Nielsen ML, Rugulies R, Christensen KB, Smith-Hansen L, Bjorner JB, Kristensen TS. 2004. Impact of the psychosocial work environment on

registered absence from work: A two-year longitudinal study using the IPAW cohort. Work & Stress 18:323–335.

North FM, Syme SL, Feeney A, Shipley M, Marmot MG. 1996. Psychosocial work environment and sickness absence among British civil servants: The Whitehall II Study. Am J Pub Health 86:332–340.

Nurminen M, Karjalainen A. 2001. Epidemiologic estimate of the proportion of fatalities related to occupational factors in Finland. Scand J Work Environ Health 27:161–213.

Olsen O, Kristensen TS. 1991. Impact of work environment on cardiovascular diseases in Denmark. J Epidemiol Comm Health 45:4–9.

Rodgers A, Vaughan P, Prentice T, Edejer T, Evans D, Lowe J. 2002. The World Health Report 2002. Reducing risks, promoting healthy life. Geneva, Switzerland: World Health Organization.

Stansfeld S, Head J, Ferrie J. 1999. Short-term disability, sickness absence, and social gradients in the Whitehall II Study. Int J Law Psychiatry 22:425–439.