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Sleep disturbances and fatigue: independent predictors of sickness absence? A prospective study among 6538 employees

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Background: Although sleep disturbances and fatigue are common conditions, frequently shown to be associated with sickness absence, only a few studies have prospectively investigated their independent effects on sickness absence, while adjusting for depressive symptoms. This study aims (i) to examine whether sleep disturbances and fatigue are independently related to the onset of register-based sickness absence of ≥3 weeks during a 1-year follow-up in a representative sample of the Danish workforce and (ii) to determine if possible associations are gender-specific. **Methods:** Data were used from the Danish Work Environment Cohort Study and linked with sickness absence data from the Danish National Register of Social Transfer Payments. A total of 6538 employees, 3178 men and 3360 women, were included in the analyses. **Results:** Sleep disturbances predicted risk of sickness absence after adjustment for covariates, but lost statistical significance after further adjustment for depressive symptoms. Fatigue among men predicted risk of sickness absence [Hazard ratio (HR) = 1.25, 95% confidence intervals (CI) 1.00–1.56] after adjustment for covariates, depressive symptoms and sleep disturbances. **Conclusion:** Sleep disturbances in both genders and fatigue in women did not predict sickness absence after depressive symptoms were taken into account. In men, fatigue was significantly related to future sickness absence, also when adjusted for depressive symptoms and sleep disturbances. Further prospective studies are needed to explore the pathways from fatigue to sickness absence in more detail. The study suggests that early detection and treatment of fatigue in men should be high on the stakeholder's agenda.

Introduction

Sleep disturbances and fatigue are common conditions in the working population and are important health problems. Sleep disturbances are prospectively associated with a wide range of diseases, such as heart disease and diabetes[1–3] and have been found to be both a precursor and a consequence of depression.[4–6] Fatigue is a common complaint and associated with chronic diseases and psychological ill-health.[7–10] Although several studies have shown that sleep disturbances and fatigue are associated with sickness absence and work disability,[11–17] only a few studies have prospectively examined the independent effect of sleep disturbances and fatigue on sickness absence—while adjusting for depressive symptoms. Though different definitions and measurements of predictors and outcomes, different social security settings, and different response rates hamper a direct comparison of results, several prospective studies showed that either sleep disturbances or fatigue were related to the onset of sickness absence. Vathera *et al.*[15] found that disturbed sleep was associated with a higher rate of subsequent sickness absence after family death or illness, also, when adjusted for psychological distress, anxiety and lifetime depression. Likewise, a Norwegian study showed that sleep problems, after adjustment for health, behavioural and work-related factors, predicted sickness absence at follow-up.[18]

In another study by Eriksen *et al.*, sleep complaints did not increase the risk of sickness absence, while fatigue did.[19] Recently, Siversten *et al.*[20] found insomnia to be a strong independent predictor of sickness absence, after adjustment for a broad range of confounders, including physical and mental symptoms, and conditions and socio-demographics.

For fatigue, an increased risk of both short- and long-term sickness absence was shown after adjustment for socio-demographic and work-related confounders.[17] Another study found that fatigue was associated with the onset of long-term sickness absence in men only.[16] After adjustment for the presence of a chronic disease, the effect was attenuated and no longer statistically significant. These studies did not adjust for depressive symptoms or sleep disturbances.

Only one study, conducted by Akerstedt *et al.*,[12] demonstrated that disturbed sleep and fatigue, both measured with a single item, independently predicted intermediate (14–89 days) and long-term (≥90 days) sickness absence two years later. Gender-specific analyses showed relationships between fatigue and long-term sickness absence in both genders, and between disturbed sleep, intermediate and long-term sickness absence in women. These results indicate that sleep disturbances and fatigue may affect the risk of sickness absence independently from each other and that effects may be different for men and women. A limitation of the study by Akerstedt *et al.* was, though, that adjustment for important health-related variables, such as the presence of a doctor-diagnosed disease or depressive symptoms, was not possible. For the development of adequate preventive measures and

management of sickness absence, it is important to explore whether these conditions can be distinguished from each other.

Hence, the objectives of this study are (i) to examine whether sleep disturbances and fatigue are independently related to the onset of register-based sickness absence of ≥3 weeks during a 1-year follow-up in a representative sample of the Danish workforce, while also adjusting for depressive symptoms and (ii) to determine if possible associations are gender specific.

Methods

Study design and sample

This prospective study is based on baseline survey data from the Danish Work Environment Cohort Study (DWECS)[21] in 2005 and on data of registered sickness absence of ≥3 weeks during a 1-year period from the Danish National Register of Social Transfer Payments (DREAM).[22] Records were linked using the participants' personal identification numbers from the Central Population Register. Full details of DWECS have been reported elsewhere.[21,23]

In 2005, 19 855 Danish residents, aged 18–74 years and representative of the Danish workforce, were invited for participation in DWECS. Of those, 12 413 (62.5%) completed the survey. The participation rate was lower among males, young individuals and individuals living in the city centres.[24] Fatigue and depressive status in 2000 did not predict participation in 2005.[25]

Data were collected by telephone interview, self-administered paper or Internet questionnaire. Among the participants, 8427 were employees. Participants in job training (*n* = 596), employed under special working conditions (e.g. modified duty due to illness; *n* = 256), on sick-leave at baseline (*n* = 114), with a sickness absence period of ≥3 weeks during the last 3 months (*n* = 255) or with missing values on any variable used in the analyses (*n* = 668) were excluded. The final study sample consisted of 6538 employees, 3178 men (49%) and 3360 women (51%). The mean ages were 42.4 (SD 10.5) for men and 42.8 (SD 10.5) for women.

Measures

Sickness absence

The cumulative incidence of a sickness absence episode of ≥3 weeks during a 1-year follow-up was obtained from DREAM, which contains weekly updated information on all public transfer payments, including sickness absence compensation. The compensations is paid from the municipalities to the employers, usually after three weeks of sickness absence (before June 2008: after two weeks of sickness absence). However, sickness absence compensation from the municipalities can be paid from the first day of sickness absence when the sick-listed employee is (i) registered with a chronic disease or (ii) employed in a small private company with a special state-run insurance policy. A more detailed description of DREAM has been published elsewhere.[22] DREAM data were available for all participants.

Sleep disturbances

Sleep disturbances at baseline were measured with four items: two items have been adapted from the Karolinska Sleep Questionnaire[26] in consultation with Akerstedt, the other two items and the response categories have been derived from preparatory work for the Short Form(SF)-36.[27] Participants were asked to rate the amount of time during the past four weeks they (i) had difficulties falling asleep, (ii) woke up and had difficulties falling asleep again, when they should have been sleeping, (iii) slept poorly or restlessly and (iv) woke up too early and were unable to fall asleep again. Response categories were: (i) 'none of the time'; (ii) 'a little of the time'; (iii) 'some of the time'; (iv) 'a good part of the time'; (v) 'most of the

time'; and (vi) 'all of the time'. The scores for the four questions were added up, resulting in a sum score ranging from 4 to 24 points, with higher scores indicating more sleep disturbances. The Cronbach's α was 0.88.

Fatigue

Fatigue at baseline was assessed with the Danish version of the 4-item vitality scale, a subscale of the SF-36.[28,29] The vitality scale is meant to measure fatigue and energy level. Participants were instructed to indicate the amount of time during the past four weeks they (i) felt full of life, (ii) had a lot of energy, (iii) felt worn out and (iv) felt tired. The response options for each item were identical with the above-described sleep disturbance scale. After items c and d were reversed, the responses to the individual items were added up, resulting in a sum score ranging from 4 to 24, with higher scores indicating more fatigue.

Covariates

In DWECS 2005, employees provided information on age, cohabitation, children below 3 years and occupational grade. Occupational grade was defined based on employment grade, job title and education: (I. Executives and/or having a university degree; II. Middle managers and/or having >3–4 years of vocational education; III. Other white-collar workers; IV. Skilled blue-collar workers; V. Semi- or unskilled blue-collar workers). Smoking was categorized into 'current smokers' vs. 'current non-smokers'. Alcohol consumption was dichotomized in 'no or moderate consumption' vs. 'heavy consumption', with heavy consumption defined as drinking more than two (women) and three (men) units per day, respectively. A unit was defined as one small bottle of beer (33 cl), one glass of wine or one shot of liquor. Leisure-time physical activity was assessed with 'When you describe your leisure-time physical activity in the past year, including commuting to or from work, to what group do you belong?' with four response categories; sedentary, light, moderate and strenuous physical activity. The body mass index (BMI) was calculated from self-reported information on weight and height and categorized into 'underweight' (BMI <18.5), 'normal weight' (BMI 18.5–24.9), 'overweight' (25–29.9) and 'obese' (≥30). The presence of a doctor-diagnosed disease was measured by a list of severe health problems (e.g. cardiovascular disease, cancer, diabetes, psychological disorders) and asking the participants to indicate whether a physician had ever told them that they had one of these health problems. Participants who indicated at least one of the health problems were categorized as having a doctor-diagnosed disease. Depressive symptoms were measured with the 5-item Mental Health Inventory, a subscale of the SF-36.[28,29] Although originally constructed as a scale to measure mental health, in general, several studies have shown that the scale has a high validity for assessing depressive symptoms.[30–32]

To control for the effects of survey method, a variable was included indicating by which method (telephone interview, paper or Internet questionnaire) data were collected.[33]

Statistical analysis

Pearson's correlations were calculated for sleep disturbances and fatigue in men and women. The prospective associations between baseline sleep disturbances and fatigue and the onset of a sickness absence spell of ≥3 weeks during 1-year follow-up were analysed with Cox proportional hazard models. Possible violations of the proportional hazard assumptions were analysed by Schoenfeld residuals. Hazard ratios (HRs) and 95% confidence intervals (95% CIs) were calculated per standard deviation increase in sleep disturbances and fatigue, and adjusted for gender, age, cohabitation, children below 3 years, occupational grade, data collection method, health behaviours and self-reported doctor-diagnosed

disease (Model 1). HRs were further adjusted for depressive symptoms (Model 2). Finally effects of fatigue and sleep disturbances were mutually adjusted (Model 3). Participants were followed until onset of sickness absence of ≥3 weeks, emigration, death or end of follow-up, whichever came first. Analyses were conducted for the total sample and for men and women separately. Data were analysed using STATA, version 8.

Ethics

The study has been notified to and registered by the Danish Data Protection Agency (Datatilsynet, see http://www.datatilsynet.dk/english for details). Danish questionnaire- and register-based studies do not require approval from the Danish National Committee on Biomedical Research Ethics (Den Centrale Videnskabsetiske Komité, see http://cvk.im.dk/cvk/site.aspx?p=119 for details).

Results

Sleep disturbances, fatigue and sickness absence

Sleep disturbances and fatigue were moderately correlated, in both men ($r = 0.40$) and women ($r = 0.35$). The cumulative incidence for the onset of sickness absence of ≥3 weeks during the 1-year follow-up was 5.6% ($n = 368$), 4.2% ($n = 133$) in men and 7.0% ($n = 235$) in women. Table 1 shows the study population characteristics and the incidence of sickness absence.

Table 2 shows the prospective associations between baseline sleep disturbances and the risk of sickness absence during follow-up. In the total sample, a 1 SD increase of the sleep disturbance scale predicted a 10% increased risk in sickness absence (HR = 1.10, 95% CI 1.01–1.21) after adjustment for covariates (Model 1). When additionally adjusted for depressive symptoms at baseline, the effect of sleep disturbances was attenuated and lost statistical significance (Model 2). Further adjustment for fatigue at baseline (Model 3) did not change results substantially. Gender-stratified analyses showed similar results. When we tested for a multiplicative interaction effect of gender and sleep disturbances on risk of sickness absence, we found *P*-values of 0.98 (crude analysis) and 0.99 (adjusted for covariates in Model 3), respectively. Proportional hazard assumption was fulfilled in all models.

Table 3 shows the prospective associations between baseline fatigue and the risk of sickness absence during 1-year follow-up. In the total study sample, a 1 SD increase in fatigue predicted a 16% increased risk of sickness absence (HR = 1.16, 95 CI = 1.05–1.28) after adjustment for covariates (Model 1). When additionally adjusted for depressive symptoms at baseline, the effect of fatigue was attenuated and lost statistical significance (Model 2). Further adjustment for fatigue at baseline (Model 3) did not change results substantially. Gender-stratified analyses showed marked different results for men and women. Among men, the effect of fatigue on sickness absence was substantially stronger than among women, and

remained statistically significant in all three models. In Model 3, fatigue among men predicted a 25% increased risk of sickness absence (HR = 1.25, 95% CI 1.00–1.56). When we tested for a multiplicative interaction effect of gender and fatigue on risk of sickness absence we found *P*-values of 0.24 (crude analysis) and 0.19 (adjusted for covariates in Model 3), respectively. Proportional hazard assumption was fulfilled in all models.

Post hoc analysis

Because of the gender-specific effect of fatigue on sickness absence, and the more pronounced attenuation of the effect size when

Table 1 Characteristics of the study population ($N = 6538$)

	Participants N (%)	Sickness absence N (%)
Gender		
Men	3178 (48.61)	133 (4.19)
Women	3360 (51.39)	235 (6.99)
Cohabiting		
Living alone	1312 (20.07)	88 (6.71)
Living with partner	5226 (79.93)	280 (5.36)
Children <3 years		
Yes	644 (9.85)	24 (3.73)
No	5894 (90.15)	344 (5.84)
Occupational grade		
Executive/university degree	1238 (18.94)	32 (2.58)
Middle manager/vocational education	1512 (23.13)	95 (6.28)
Other white-collar workers	1718 (26.28)	110 (6.40)
Skilled blue-collar workers	1092 (16.70)	62 (5.68)
Semi- or unskilled blue-collar workers	978 (14.96)	69 (7.06)
Smoking		
Current smokers	1448 (28.27)	134 (7.25)
Current non-smokers	4690 (71.73)	234 (4.99)
Alcohol consumption		
No or moderate consumption	5615 (85.88)	309 (5.50)
Heavy consumption	923 (14.12)	59 (6.39)
Leisure-time physical activity		
Sedentary	1007 (15.40)	54 (5.36)
Light activity	3968 (60.69)	244 (6.15)
Moderate activity	1375 (21.03)	61 (4.44)
Strenuous activity	188 (2.88)	9 (4.79)
BMI		
Underweight (<18.5)	94 (1.44)	3 (3.19)
Normal weight (18.5–24.9)	3619 (55.35)	175 (4.84)
Overweight (25–29.9)	2182 (33.37)	138 (6.32)
Obesity (≥30)	643 (9.83)	52 (8.09)
Self-reported doctor-diagnosed disease		
Yes	1276 (19.52)	117 (9.17)
No	5262 (80.48)	251 (4.77)
Age, mean (SD)	42.61 (10.51)	44.26 (10.34)
Depressive symptoms,[a] mean (SD)	81.62 (13.01)	79.03 (15.26)

a: Depressive symptoms were measured with Mental Health Inventory (range 0–100 with higher scores indicating fewer symptoms)

Table 2 Sleep disturbances as predictor of sickness absence of ≥3 weeks in total study sample and stratified by gender

Sleep disturbances	HR (95% CI) Model 1	HR (95% CI) Model 2	HR (95% CI) Model 3
Total ($n = 6538$)			
Sleep disturbances (per 1 SD increase)	1.10 (1.01–1.21)	1.05 (0.94–1.16)	1.04 (0.94–1.16)
Men ($n = 3178$)			
Sleep disturbances (per 1 SD increase)	1.12 (0.95–1.32)	1.03 (0.85–1.24)	1.01 (0.83–1.21)
Women ($n = 3360$)			
Sleep disturbances (per 1 SD increase)	1.11 (0.99–1.24)	1.06 (0.93–1.20)	1.06 (0.93–1.21)

Model 1: (gender), age, cohabitation, children below age of 3 years, occupational grade, data collection method, smoking, alcohol consumption, physical activity, BMI, doctor-diagnosed disease
Model 2: Model 1 + depressive symptoms
Model 3: Model 2 + fatigue

Table 3 Fatigue as predictor of sickness absence of ≥3 weeks in total study sample and stratified by gender

Fatigue	HR (95% CI) Model 1	HR (95% CI) Model 2	HR (95% CI) Model 3
Total (*n* = 6538)			
Fatigue (per 1 SD increase)	1.16 (1.05–1.28)	1.08 (0.95–1.24)	1.08 (0.94–1.24)
Men (*n* = 3178)			
Fatigue (per 1 SD increase)	1.29 (1.10–1.52)	1.25 (1.01–1.55)	1.25 (1.00–1.56)
Women (*n* = 3360)			
Fatigue (per 1 SD increase)	1.09 (0.96–1.24)	0.99 (0.83–1.18)	0.98 (0.82–1.17)

Model 1: (gender), age, cohabitation, children below age of 3 years, occupational grade, data collection method, smoking, alcohol consumption, physical activity, BMI, doctor-diagnosed disease
Model 2: Model 1 + depressive symptoms
Model 3: Model 2 + sleep disturbances

adjusting for baseline depressive symptoms among women, we wondered whether the association between baseline fatigue and depressive symptoms might have been considerably stronger among women compared with men. However, when we calculated *post hoc* gender-stratified correlations between fatigue and depressive symptoms at baseline, we found similar high correlations in the two genders. The correlation coefficients were $r = 0.65$ among men and $r = 0.70$ among women.

Discussion

The present study prospectively investigated the independent associations between sleep disturbances, fatigue and subsequent sickness absence in both genders, while accounting for depressive symptoms. The main finding of this study is that in the total study sample, both sleep disturbances and fatigue predicted the onset of sickness absence, when adjusted for a wide range of covariates, but both were no longer predictive when adjusted for depressive symptoms at baseline. Fatigue remained a strong and statistically significant predictor of sickness absence even after adjustment for depressive symptoms and sleep disturbances in men, but not in women.

That the effect of sleep disturbances was greatly attenuated after adjustment for depressive symptoms is not surprising. Sleep disturbances are closely related to depressive symptoms as sleep disturbances are both a precursor and a symptom of depression.[4–6] As delineated in the introduction, a Swedish study has found a prospective effect of sleep disturbances on intermediate and long-term sickness absence.[12] However, this study did not adjust for depressive symptoms or the presence of disease.

Fatigue was shown to be a strong, independent predictor of sickness absence in men, but not in women. The null finding for women is in line with earlier results from a Dutch study, which showed that 'being a case of prolonged fatigue' did not predict the onset of sickness absence (≥42 consecutive days) among women.[16] In the above-mentioned Swedish study,[12] fatigue was prospectively related to intermediate sickness absence (14–89 days) in women and to long-term sickness absence (≥90 days) in both genders. These associations, however, were not adjusted for depressive symptoms or the presence of disease. When we tested for multiplicative interaction, the fatigue × gender interaction was not statistically significant. However, investigating interactions requires large study samples and it is possible that our study lacked the statistical power for detecting an interaction. Given the marked differences between men and women in the HRs, it is reasonable to consider that the effect of fatigue on risk of sickness absence may be modified by gender, even though the statistical testing of interaction was not significant.

An explanation for the stronger effect of fatigue among men could be that men more often than women work in jobs that are incompatible with increased fatigue levels. Hence, men might more often than women face demands in their jobs that cannot be dealt with, if fatigue levels are above a certain point. Another explanation could

be that women are more successful in coping with fatigue so that fatigue has a smaller effect on their work ability than among men. For example, it is well-known that women more frequently see their general practitioners than men. If early signs of fatigue cause women, but not men, to see their general practitioner, women might have a higher chance of getting early treatment and preventing further deterioration of health and subsequent sickness absence. It is also possible that fatigue in men is different than in women. It has been argued that among men reasons for fatigue might be more physical, whereas among women reasons might include more psychosocial factors.[34] If this is true, the adjustment for depressive symptoms in the present study would, to a larger extent, have attenuated fatigue among women than among men. However, when we investigated the baseline correlation between fatigue and depressive symptoms, we found very similar high correlations for both men and women.

When studying the consequences of fatigue in terms of sickness absence in the working population, other, probably related, conditions such as burnout have to be acknowledged. Although the literature suggests that there is a considerable overlap between the main symptoms of exhaustion and subjective fatigue, fatigue and burnout also occurred separately from each other.[35] It was also demonstrated that pure fatigue seemed to be more associated with health-related factors, whereas pure burnout seemed to be more associated with work-related factors.[35] Research findings also suggest that fatigue and burnout influence each other in time.[36] As for the present study, it remains unclear why the relationship between fatigue and sickness absence is stronger among men than among women. To further elucidate the temporal relationships between sleep disturbances, fatigue, depressive symptoms and sickness absence and to disentangle mediators from confounders, studies with repeated measurements of all measures during a longer follow-up period are warranted.[11,15]

Strengths and limitations

The study's strengths are the prospective design, the representative sample of the Danish employed workforce, and the record linkage with administrative sickness absence data. The prospective design helps to establish a temporal sequence between exposure and outcome; the use of the representative samples for generalizing the findings to the Danish workforce. The record linkage of the cohort data with objective sickness absence data from a national register is another advantage of this study. Moreover, all analyses were conducted for the total sample and stratified by gender, which provides insight in differential, i.e. gender-specific, effects of sleep disturbances and fatigue on sickness absence. In contrast to previous studies,[12] all analyses were adjusted for a broad range of potentially confounding factors, such as indicators of health (i.e. self-reported doctor-diagnosed disease and depressive symptoms) and health behaviour (i.e. smoking, alcohol consumption, leisure-time physical activity, BMI).

A limitation of the study is the absence of an established measure for sleep disturbances. In contrast to the single-item measure used

by Akerstedt *et al.*,[12] the measure was based on items adapted from the Karolinska Sleep Questionnaire[26] though slightly differently phrased. Fatigue was assessed with the Danish version of the SF-36 vitality scale. Further research is needed to elaborate on these measures of sleep disturbances and fatigue—also in relation to other conditions such as burnout or anxiety, for which no data were available in the present study. With respect to the outcome measure, registered sickness absence, it has to be acknowledged that DREAM does not contain diagnosis information because it is not required to report a diagnosis of sickness absence, i.e. the outcome concerns 'sickness absence due to any cause'. It is important to note, however, that DREAM has been deemed sufficiently accurate for register-based follow-up of social and economic consequences of disease.[22]

Conclusion

After adjustment for depressive symptoms, sleep disturbances were not related to the risk of future sickness absence. In men, but not in women, fatigue predicted the risk of sickness absence, even after depressive symptoms and sleep disturbances were taken into account. Further prospective studies in other populations are recommended to explore the pathways from fatigue to sickness absence in more detail, thereby also addressing the differential effects in men and women. To further elucidate the temporal relationships between sleep disturbances, fatigue, depressive symptoms and sickness absence, studies with repeated measurements of all measures during a longer follow-up period are needed. In all—and in view of the high social and economic cost implications of sickness absence—the early detection and treatment of fatigue in men should be high on the stakeholders' agenda.

Funding

Conflicts of interest: None declared.

Key points

- Sleep disturbances in both genders and fatigue in women were not associated with future sickness absence after depressive symptoms were taken into account.
- In men, fatigue predicted the risk of future sickness absence even after depressive symptoms and sleep disturbances were taken into account.
- In view of the high social and economic cost implications of sickness absence, the early detection and treatment of fatigue in men should be high on the stakeholders' agenda.

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The development and validation of two prediction models to identify employees at risk of high sickness absence

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Background: Sickness absence (SA) is a public health risk marker for morbidity and mortality. The aim of this study was to develop and validate prediction models to identify employees at risk of high SA. **Methods:** Two prediction models were developed using self-rated health (SRH) and prior SA as predictors. SRH was measured by the categories excellent, good, fair and poor in a convenience sample of 535 hospital employees. Prior SA was retrieved from the employer's register. The predictive performance of the models was assessed by logistic regression analysis with high ($\geq$90th percentile) vs. non-high (<90th percentile) SA days and SA episodes as outcome variables and by using bootstrapping techniques to validate the models. **Results:** The overall perform-ance as reflected in the Nagelkerke's pseudo R^2 was 11.7% for the model identifying employees with high SA days and 31.8% for the model identifying employees with high SA episodes. The discriminative ability, represented by the area (AUC) under the receiver operating characteristic (ROC), was 0.729 (95% CI 0.667–0.809) for the model identifying employees with high SA days and 0.831 (95% CI 0.784–0.877) for the model identifying employees with high SA episodes. The Hosmer–Lemeshow test showed acceptable calibration for both models. **Conclusions:** The prediction models identified employees at risk of high SA, but need further external validation in other settings and working populations before applying them in public and occupational health research and care.

Introduction

Sickness absence (SA) is an economic risk marker for disability pensioning[1,2] and a public health risk marker for morbidity and mortality.[3,4] In a Finnish 10-town study, the overall mortality rate in municipal employees who had more than one long-term (>3 days) SA episode per year was 4.3 times higher in men and 3.3 times higher in women as compared with employees without long-term absences.[3] From the French Gazel cohort, it was reported that employees with long-term ($\geq$7 days) SA episodes over a 3-year period had a 60% excess risk of early death.[4] Structured early con-sultations with occupational health providers were found to identify employees with unrecognized clinical disorders. Of 142 employees who attended preventive occupational health consultations, 64 (45%) were referred to specialists for further diagnosis and treatment.[5] It was shown that preventive consultations were cost-effective in reducing SA in employees with a high SA risk, but not in those with moderate or low SA risks.[6] Hence, it is important to identify employees with high SA. Although question-naires have been developed to detect employees at risk of high SA,[5–9] questionnaire surveys frequently have moderate to low response rates and healthy employees may be more likely to respond than employees with health problems.[10]

Prediction models and rules are alternatives to identify high-risk employees. In public health, various prediction models have been developed to predict the future occurrence of disease and