

SLEEP DISTURBANCES, PSYCHOSOCIAL WORKING CONDITIONS, AND DEPRESSION

The Role of Sleep Disturbances in the Longitudinal Relationship Between Psychosocial Working Conditions, Measured by Work Demands and Support, and Depression

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Study Objectives: Because work demands and lack of social support seem to be prospectively linked to sleep problems, and sleep problems are linked to depression, sleep problems may play a role in the relationship between these work characteristics and depressive symptoms. In order to shed more light on this relationship, the current study investigated whether disturbed sleep is a mediator in the longitudinal relationships between work demands, social support, and depression.

Design: Longitudinal cohort study with repeated survey measures on four occasions.

Setting: Swedish workforce.

Participants: 2,017 working participants from the Swedish Longitudinal Occupational Survey of Health in 2006, 2008, 2010, and 2012.

Measurements and results: Work demands (four items) and social support (six items) were assessed with the Demand Control Questionnaire, disturbed sleep (four items) with the Karolinska Sleep Questionnaire, and depressive symptoms with a brief subscale (six items) from the Symptom Checklist. Autoregressive longitudinal mediation models using structural equation modeling were tested. The work characteristics, and disturbed sleep, were found to be separately associated with depressive symptoms in subsequent waves. However, only demands were found to be longitudinally related to subsequent disturbed sleep. The longitudinal autoregressive models supported a weak mediating role of disturbed sleep in the relationship between demands and depressive symptoms (standardized beta 0.008, $P < 0.001$), but not between support and depressive symptoms.

Conclusions: These results indicate that higher demands at work might cause an increase in depressive symptoms, in part, by increasing disturbed sleep, although the mediated effect was relatively small compared to the total effect.

Keywords: causal pathways, demand-control-support model, depressive disorders, longitudinal mediation, sleep problems, structural equation modeling

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INTRODUCTION

Relationship Between Sleep Problems and Depressive Symptoms

Sleep problems, including difficulties in initiating or maintaining sleep and nonrestorative sleep, often co-occur with other medical conditions, such as depressive disorders.¹ Sleep problems can as accompanying symptoms—in combination with depressed mood and loss of interest or pleasure—contribute to the diagnoses of depression. As many as 90% of patients with major depression seem to report disturbed sleep^{2,3} but the relationship is multifaceted. Sleep problems can occur in relation to onset, relapse, and reoccurrence of depression and may persist despite treatment.⁴ Bidirectional associations have been demonstrated,⁵ though sleep problems often seem to precede depression.⁶ People with these types of sleep problems had more than two times higher risk of developing depression in a recent meta-analysis.⁷ Lifestyle changes that lead to improved sleep patterns may thus serve as a preventive measure, by positively

influencing physiological pathways of relevance for depression and other noncommunicable diseases.⁸

Relationship Between Work Characteristics and Sleep Problems

Previous research has also established that there is a close connection between stress and sleep.⁹ Longitudinal evidence on psychosocial work characteristics and sleep problems is still limited, however.¹⁰ The most influential model in research on psychosocial work characteristics is the demand–control–support model. This model consists of several components including psychological demands, job control/decision latitude (or its subcomponents, decision authority and skill discretion), and social support. High demands, low control, and poor support are presumed to be work stressors that may have negative consequences on health through physical or emotional stress responses, especially when in combination (such as the combination of high demands and low control that is often referred to as job strain) and if poor working conditions are protracted.^{11,12} Through cross-lagged analyses we have previously observed that demands and social support at work were longitudinally related to sleep problems, although the main relationships were weak. Some reciprocal patterns were also demonstrated, suggesting that sleep problems could also lead to changes in psychosocial work characteristics or a changed perception of the psychosocial work environment.¹³ Most prospective studies do, however, suggest an association between job demands in particular and sleep problems.¹³⁻¹⁵ Low job control or job strain¹⁴

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Table 1—Descriptive statistics according to background variables at baseline (n = 2,017).

	Mean	Min	Max	SD
Age, y	46.7	20	67	8.9
Sex	%			
Male	44.8	—	—	—
Female	55.2	—	—	—
Education				
Compulsory	12.3	—	—	—
2 y upper secondary	23.6	—	—	—
3-4 y upper secondary	19.3	—	—	—
University or equivalent less than 3 y	15.2	—	—	—
University or equivalent 3 y or more	29.5	—	—	—
Marital status				
Married	78.6	—	—	—
Unmarried	21.4	—	—	—

SD, standard deviation.

are also potential risk factors as well as poor social support at work,^{13,16} high effort at work that exceeds the rewards received in return (effort–reward imbalance),^{16,17} organizational injustice,¹⁸ overtime work,¹⁹ and shift work.²⁰ However, the evidence base is more limited for these conditions.²¹

Relationship Between Work Characteristics and Depressive Symptoms

Job demands/job strain and lack of social support in particular may also increase the risk of depression, as has been indicated in previous prospective studies.^{22,23} There is also some support for prospective associations between other psychosocial working conditions such as effort–reward imbalance,²⁴ organizational injustice,^{25,26} and violence or bullying and depression.^{22,27,28} Also, reciprocal relationships have been observed between work characteristics and depression or distress, but work factors seem to be stronger predictors of mental health or distress than mental health or distress appear to be of work characteristics.^{29,30} A longitudinal study with a long follow-up found job strain to be a predictor of distress and depression using both a 2-y and a 6-y time lag, although the associations were stronger with the shorter time lag, and similar results were found for job demands and decision latitude separately.³¹

Hypothesized Interrelationship Between Work Characteristics, Sleep Problems, and Depressive Symptoms

Because working conditions such as demands and social support are suspected to be prospectively linked to sleep problems, and sleep problems in turn are linked to depression, sleep problems may play a role in the relationship between work characteristics and depressive symptoms. Specifically, it has been hypothesized that sleep problems can be a result of, or maintained by, changes in the arousal system accompanied by stress, and when these changes become chronic an alteration of emotional regulation or the functioning of the cognitive system can slowly occur.⁶ However, the role of sleep problems in the longitudinal work stress–depression relationship has not been

clearly elucidated. Estimates of potential mediation based on cross-sectional or half-longitudinal (i.e., either exposure preceding mediator or mediator preceding outcome but not allowing for time to elapse between both exposure to mediator and mediator to outcome) studies can be severely biased.³¹ These types of questions should thus be investigated through longitudinal designs that also consider issues of directionality.⁶ At least three waves are needed to appropriately incorporate the temporal ordering of all three measures in the modeling of mediation.³² In this article we investigate the hypothesis that sleep problems is a mediator in the longitudinal relationships between work demands and depressive symptoms, and between workplace social support and depressive symptoms, based on multiple repeat measures of work demands, social support, disturbed sleep, and depressive symptoms.

METHODS

Study Population

The study population consisted of participants of the Swedish Longitudinal Occupational Survey of Health (SLOSH) study, a nationally representative longitudinal cohort survey focusing on work-life participation, social situation, and health and wellbeing. The first wave of SLOSH took place in 2006, following up on participants from the Swedish Work Environment Survey (SWES) of 2003 (n = 9,214). SWES is composed of a sample of gainfully employed individuals between 16–64 y of age from the entire country, stratified by county, and citizenship. About 2 y later, all eligible SWES participants were followed up by means of postal self-completion questionnaires—one version addressed to those gainfully employed working at least 30% of full time, and another to those working less than 30% or who had left the labor force temporarily or permanently. The participants in SWES were then asked to respond to more detailed questions about their working life or nonworking life and health. The SLOSH questionnaire additionally includes a range of questions on private life situation and health behaviors. Wave 1 received 5,985 respondents (65%).^{33,34} All SWES participants who were not deceased, who had a known address in Sweden, and who had not actively opted out were asked to fill in questionnaires again in 2008 (Wave 2; 5,557 respondents; 61% of all eligible), 2010 (Wave 3; 4,926 respondents; 58% of all eligible), and 2012 (Wave 4; 4,827 respondents; 57% of all eligible). In total, 3,340 individuals responded on all four occasions. Of these, the current study is based on the 2,017 participants who were working at least 30% in all four waves. Some characteristics of these participants are presented in Table 1. Compared to the nonrespondents and those excluded because they worked less than 30% in any of the waves, this population had a higher proportion of women, a slightly higher mean age, and a higher proportion with a university education. In 2006, ratings of high demands, low social support, disturbed sleep, and scores of depressive symptoms indicative of major depression were slightly more common among those who had responded on all occasions than among those who responded only to the first follow-up. The study was approved by the Regional Research Ethics Board in Stockholm and informed consent was obtained from all participants.

Measures

The SLOSH questionnaires for those working at least 30% included numerous questions about the psychosocial work environment, work organization, health, and health-related complaints. Demands, control, and support at work were measured in all four waves by the Swedish version of the Demand–Control Questionnaire (DCQ),³⁵ a standardized and widely used questionnaire for measuring these dimensions of the demand–control–support model with satisfactory psychometric properties.³⁶ Demands at work were measured with five questions (working fast, working intensively, too much effort, enough time, and conflicting demands) with four response options (1 = Never/almost never; 4 = Often), but the item ‘working intensively’ was excluded from the demand component because exclusion of this item has been shown to improve the factor structure and measurement invariance over time.³⁷ Decision authority was taken into consideration to represent job control, but was not used in the final analyses because it was made up of only two items, which caused nonconvergence in the models. Social support was measured with six questions (calm and pleasant atmosphere, good spirit of unity, colleagues are there for me, people understand a bad day, get on well with my colleagues, get on well with my superiors) with four response options (1 = Strongly disagree; 4 = Strongly agree). Disturbed sleep was assessed with four questions (difficulty falling asleep, repeated awakenings, early awakening, and disturbed sleep) from the Karolinska Sleep Questionnaire^{38–40} with six response options (1 = Never; 6 = Always/5 times a week or more). The items covering symptoms of difficulties with initiating or maintaining sleep have been validated and found to have good psychometric properties.^{13,38–41} Depressive symptoms were measured with a brief subscale from the Hopkins Symptom Checklist (SCL-90), the SCL-CD₆.⁴² The participants were asked how much on a five-point scale (0 = Not at all; 4 = Extremely) they experienced: feeling blue, feeling no interest in things, feeling lethargic or low in energy, worrying too much about things, blaming oneself for things, and feeling everything is an effort. The six items represent core symptoms, whose selection was based on principles of clinical validity. This scale has been validated and was found to have good psychometric properties. Previous results have also shown that the items are suitable to combine into a composite score that is indicative of depression severity.⁴² The Cronbach alphas were 0.70 for work demands, 0.85 for social support, 0.85 for disturbed sleep, and 0.91 for depressive symptoms.

Analytic Strategy

The current analysis evaluated the proposed mediated effect by using an autoregressive approach based on structural equation modeling (SEM) that allows the measures to be fitted as latent variables, which can reduce measurement error. This type of longitudinal mediation analysis was used because it also allows for paths opposite to the traditional direction to be estimated.³² Models were fitted separately for demands and social support. First, bivariate cross-lagged models and structural cross-lagged models were fitted, allowing correlations between all constructs and the errors of individual items over time to account for consistency in item-specific variance.⁴³ The cross-lagged paths estimated the effect of one variable on the other,

after controlling for the stability of the variables over time.⁴⁴ Next, we tested several structural autoregressive mediation models. The most parsimonious models justified by the data were determined by comparing models with and without constraints on loadings and thresholds for all the items in Wave 1 through Wave 4 as well as factor loadings and thresholds of the items for each of the constructs over time.⁴⁵ After choosing the most plausible autoregressive mediation model, the indirect effect (mediated effect) of the work characteristics on depressive symptoms through the mediator (i.e., disturbed sleep) was estimated by the product of coefficients method, and the statistical significance of the effect was evaluated using Monte Carlo Simulation confidence interval with 20,000 draws.⁴⁵ To estimate degree of mediation over the entire period from Wave 1 to Wave 4,⁴³ we first assessed the overall indirect effect, which is based on all paths that start with work characteristics in Wave 1 and end with depressive symptoms in Wave 4 and pass through disturbed sleep at least once in any intermediate wave. The overall direct effect is based on all paths from work characteristics in Wave 1 to depressive symptoms in Wave 4 that do not pass through disturbed sleep. We also assessed the total effect as the sum of the indirect and the direct effect (Figure 1). The analyses were conducted using the *lavaan* 5.13⁴⁶ package specifically developed for fitting latent variable structural equation models in *R* Statistical computing and graphics software.⁴⁷ To account for the ordinal nature of all the indicators measuring latent constructs, a robust weighted least squares estimator (WLSMV) was used.⁴⁸ Furthermore, to reduce the bias introduced by missing information we used the full-information maximum likelihood (FIML) estimation, which is better than conventional methods at dealing with missing data, such as listwise or pairwise deletion.^{49,50} Model fit was assessed by the comparative fit index (CFI) and the root mean square error of approximation (RMSEA), based on the recommendations of Hu and Bentler.⁵¹ For the final models standardized estimates were also calculated. Covariates such as age, sex, marital status (married/cohabiting or single), and education (compulsory, 2-y upper secondary/vocational training, 3- or 4-y upper secondary, university or equivalent < 3 y, university or equivalent ≥ 3 y) at baseline were finally included to test the robustness of the results, but time-varying covariates were left out of the equations to limit the number of parameters estimated.

RESULTS

All of the measures were found to be significantly correlated. Tables S1 and S2 (supplemental material) show the means, standard deviations, and correlations between the measures for both work demands and social support. The correlation coefficients varied between 0.26 and 0.31 for work demands–depressive symptoms, -0.31 and -0.37 for social support–depressive symptoms, 0.26 and 0.28 for work demands–disturbed sleep, -0.24 and -0.27 for social support–disturbed sleep, and 0.48 and 0.52 for disturbed sleep–depressive symptoms on the same measurement occasion. The coefficients generally decreased when the interval between measurements was longer.

The results of the comparison of measurement models concerning demands and depressive symptoms are presented in Table 2. The measurement models showed good fit, and the fit of Model 2 was not significantly different, as indicated by a

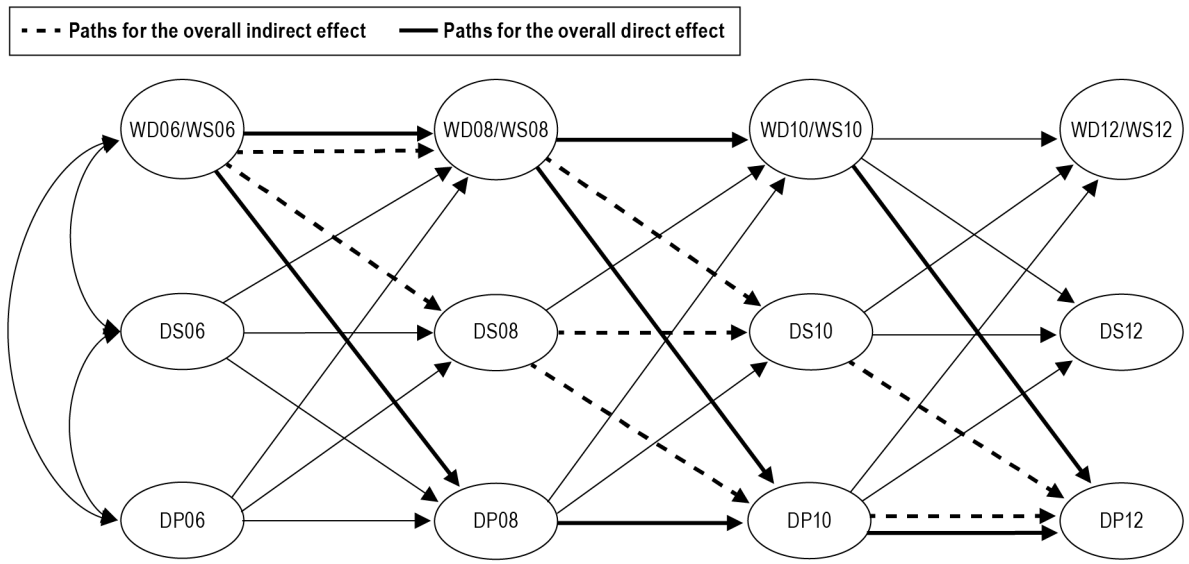


Figure 1—Longitudinal mediation models of work demands/workplace support, disturbed sleep, and depressive symptoms. WD, work demands; WS, workplace support; DS, disturbed sleep; DP, depressive symptoms.

Table 2—Summary of fit statistics for bivariate and mediation models for work demands, disturbed sleep, and depressive symptoms.

Competing Models	χ^2 ^a	df	CFI	Δ CFI	RMSEA [90% CI]
Bivariate models (work demands and depressive symptoms)					
Measurement models					
1. Free loadings and thresholds	2235*	652	0.979	—	0.035 [0.034, 0.037]
2. Longitudinal constraints on loadings and thresholds	2882*	784	0.977	-0.002	0.039 [0.037, 0.040]
Structural models					
3. Free structural paths	4326*	796	0.952	—	0.050 [0.049, 0.052]
4. Longitudinal constraints on structural paths	3999*	804	0.957	0.005	0.047 [0.046, 0.049]
Mediation models (work demands, disturbed sleep, and depressive symptoms)					
Measurement models					
5. Free loadings and thresholds	3432*	1334	0.979	—	0.031 [0.029, 0.032]
6. Longitudinal constraints on loadings and thresholds	4183*	1535	0.977	-0.002	0.032 [0.031, 0.033]
Structural models					
7. Free structural paths	5502*	1562	0.961	—	0.039 [0.038, 0.039]
8. Longitudinal constraints on structural paths	5252*	1580	0.964	0.003	0.037 [0.036, 0.038]

^a Satorra-Bentler scaled chi-square; * $P < 0.05$; CFI, comparative fit index; Δ CFI, change in CFI; CI, confidence interval; df, degrees of freedom; RMSEA, root mean square error of approximation.

small change in CFI. Therefore, from a parsimonious modeling point of view, we favored Model 2 and retained the constraints on factor loadings and thresholds of the items of each of the constructs in the subsequent analyses. On the same grounds, from among the structural cross-lagged models, we also favored Model 4, which used longitudinal constraints on structural paths, over Model 3.

Figure 2 shows the standardized structural coefficients obtained from the constrained bivariate model concerning work demands and depressive symptoms (i.e., Model 4). All stability coefficients were statistically significant ($P < 0.05$), ranging from 0.77 to 0.80 for demands and from 0.72 to 0.75 for depressive symptoms. All the first-order cross-lagged coefficients

from work demands to depressive symptoms were also significant ($P < 0.05$, β , 0.06), whereas none of the paths from depressive symptoms to work demands were significant. Separate models also showed significant and about equal coefficients for cross-lagged paths from demands to depressive symptoms two and three waves later (more information is available from the corresponding author on request). Similar bivariate models for social support and depressive symptoms are shown in Table 3 and Figure 3. Standardized structural stability coefficients for support ranged from 0.64 to 0.66 ($P < 0.05$) (Figure 3). Similarly, we found significant paths from support to depressive symptoms (β -0.07 and -0.08, $P < 0.05$), but also from depressive symptoms to support (β , -0.11, $P < 0.05$). Thus, the

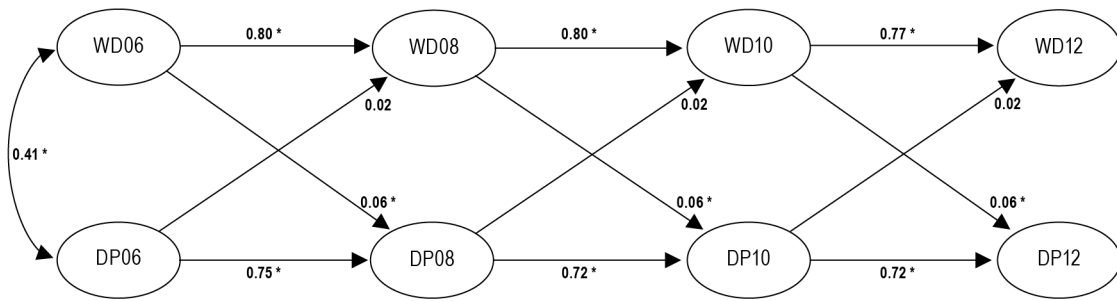


Figure 2—Standardized structural coefficients for the bivariate model of work demands and depressive symptoms (Model-4, Table 1). WD, work demands; DP, depressive symptoms.

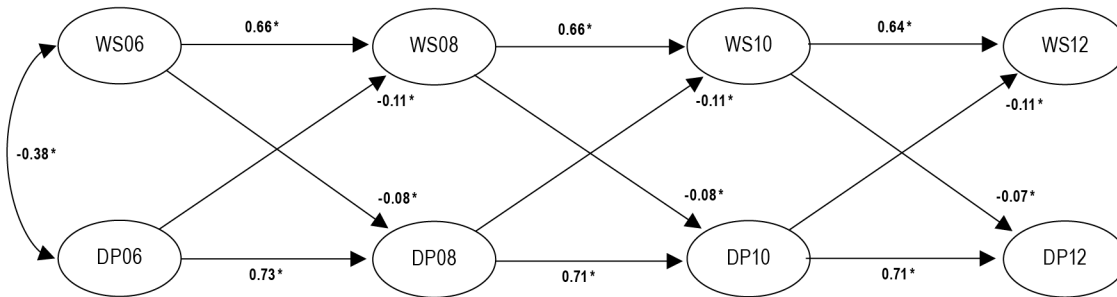


Figure 3—Standardized structural coefficients for the bivariate model of workplace support and depressive symptoms (Model-4, Table 2). WS, workplace support; DP, depressive symptoms.

Table 3—Summary of fit statistics for bivariate and mediation models for workplace support, disturbed sleep, and depressive symptoms.

Competing Models	χ^2 ^a	df	CFI	Δ CFI	RMSEA [90% CI]
Bivariate models (workplace support and depressive symptoms)					
Measurement models					
1. Free loadings and thresholds	3332*	980	0.973	–	0.037 [0.036, 0.039]
2. Longitudinal constraints on loadings and thresholds	3700*	1136	0.971	-0.002	0.036 [0.035, 0.037]
Structural models					
3. Free structural paths	5420*	1148	0.951	–	0.046 [0.045, 0.048]
4. Longitudinal constraints on structural paths	4882*	1156	0.958	0.007	0.043 [0.042, 0.044]
Mediation models (workplace support, disturbed sleep, and depressive symptoms)					
Measurement models					
5. Free loadings and thresholds	4682*	1790	0.974	–	0.031 [0.030, 0.032]
6. Longitudinal constraints on loadings and thresholds	5215*	2015	0.972	-0.002	0.031 [0.030, 0.032]
Structural models					
7. Free structural paths	6437*	1817	0.959	–	0.039 [0.038, 0.040]
8. Longitudinal constraints on structural paths	6791*	2042	0.958	-0.001	0.038 [0.037, 0.039]

^a Satorra-Bentler scaled chi-square; *P < 0.05; CFI, comparative fit index; Δ CFI, change in CFI; CI, confidence interval; df, degrees of freedom; RMSEA, root mean square error of approximation.

bivariate cross-lagged models indicated that both work demands and support predicted subsequent levels of depressive symptoms, but that depressive symptoms predicted subsequent levels of support but not demands.

Furthermore, demands were found to be significantly associated with future disturbed sleep, although the β was relatively low (0.03, $P < 0.05$), whereas disturbed sleep was not

prospectively associated with demands (Figure S1, supplemental material). Conversely, social support was not longitudinally associated with disturbed sleep, whereas the coefficients for paths from disturbed sleep to social support in the subsequent wave were -0.07–0.08 ($P < 0.05$) (Figure S2, supplemental material). Stability coefficients for disturbed sleep were 0.83–0.85 ($P < 0.05$).

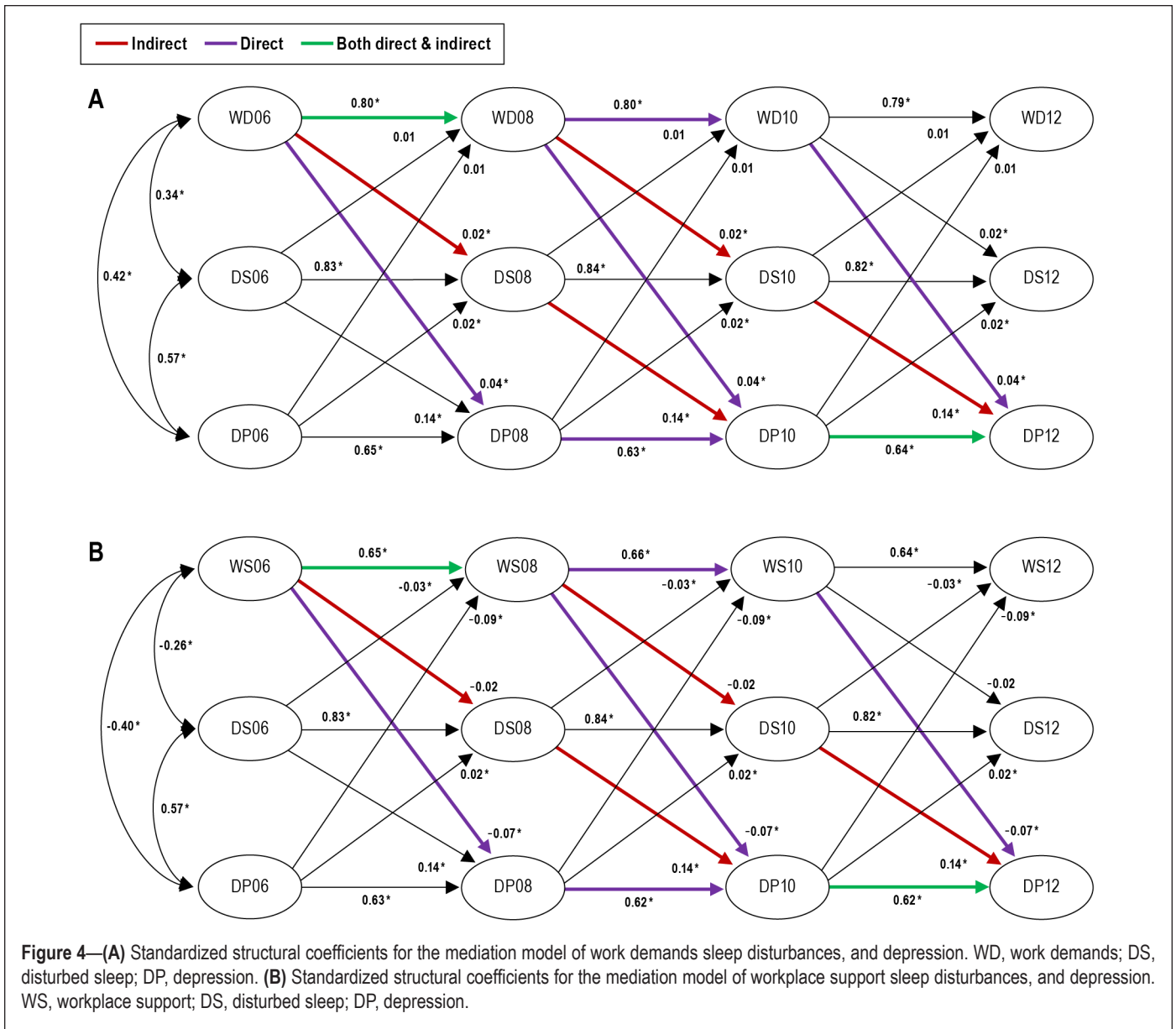


Table 4—Total and overall indirect effects of work demands and workplace support on depressive symptoms over 4 waves in the Swedish Longitudinal Occupational Survey of Health.

Work Characteristic	Total Effect		Overall Indirect Effect	
	Standardized estimate	Unstandardized estimate (95% CI)	Standardized estimate	Unstandardized estimate (95% CI)
Work demands	0.072*	0.114 (0.068, 0.160)	0.008*	0.013 (0.005, 0.020)
Workplace support	-0.096*	-0.103 (-0.125, -0.081)	-0.005	-0.006 (-0.014, 0.002)

* P < 0.05; CI, confidence interval.

(Figure 4B), which precludes any mediated effects of disturbed sleep in the support to depressive symptom relationship. This resulted in a non-significant total indirect effect of support on depressive symptoms (Table 4). The longitudinal mediation model supported a weak but statistically significant estimate of

Tables 2 and 3 also show that the constrained mediation models (i.e., Model 6 and 8) fitted equally well or better than the unconstrained models (i.e., Model 5 and 7). Therefore, we estimated the mediated effects based on Model 8. All the paths from work demands to disturbed sleep (β , 0.02, $P < 0.05$) and from disturbed sleep to depressive symptoms (β , 0.14, $P < 0.05$) were significant (Figure 4A). The mediation model also showed nonsignificant paths for workplace support to disturbed sleep

mediation by disturbed sleep of 0.008 ($P < 0.05$) in the work demands–depressive symptom relationship (Table 4). The total (indirect and direct) effect of demands on depressive symptoms was 0.07. This indicated that little more than 10% of the association between work demands and depressive symptoms was mediated by disturbed sleep. These estimates were essentially unchanged after the inclusion of baseline age, sex, marital status, and education.

Because we also found a significant reverse effect from depressive symptoms to disturbed sleep and a significant path from disturbed sleep to lower support in the earlier models (Figure 3, Figure S2, and Figure 4B), we further tested if the relationship between depressive symptoms and support was mediated by disturbed sleep. We found a very small indirect effect of depression on support through disturbed sleep (-0.002 ; $P < 0.05$), whereas the overall total effect was -0.119 ($P < 0.05$) (Table S3, supplemental material).

DISCUSSION

In this article we investigated the hypothesis that sleep problems are a mediator in the longitudinal relationships between both work demands and workplace social support and depressive symptoms. Our findings support that demands at work might cause increased depressive symptoms in part by increasing sleep problems. The analyses, however, supported only a weak longitudinal association, based on a 2-y time lag, between demands and disturbed sleep, and the mediated effect was relatively small compared to the total effect of work demands on depressive symptoms. No mediating role was indicated in the association between poor social support and depressive symptoms.

In accordance with previous literature, our analyses supported a longitudinal relationship between both work demands and social support and depressive symptoms.^{22,23} Disturbed sleep was also found to be highly associated with depressive symptoms while controlling for the work characteristics. Some of the criteria for establishing mediation, as proposed by Baron and Kenny, were thus fulfilled.⁵² Only demands were associated with disturbed sleep 2 y later, fulfilling the third criterion used to establish mediation. This association, however, was weak, which is also in accordance with previous work,¹³ and a weak mediation effect was indicated. Thus, disturbed sleep only seems to mediate the relationship between work demands and depressive symptoms to a relatively small extent. There are many possible explanations for these findings. It is possible that the main pathway is directly from work demands or from poor support to depressive symptoms (and accompanying physiological responses), but there may also be other pathways of relevance. A possible alternative pathway is via lifestyle factors such as exercise, diet, and alcohol habits but other unmeasured or unknown factors could also play a role. More knowledge is needed on whether these are effective preventive measures and on specific physiological pathways.⁸ The time frame is also most certainly of major importance for the size of the estimates of mediation. Whether or not the time frame used is optimal in relation to how quickly a true mediation effect would be likely to unfold is not obvious.⁴³ Some earlier research has been relatively consistent with respect to a predictive effect of insomnia or disturbed sleep on depressive disorders or symptoms 1 to 3 y later.⁴ The relevant time lag for the demands–disturbed sleep and social support–disturbed sleep associations are, however, more uncertain as there is little longitudinal data.¹³ It is likely that stronger longitudinal mediation effects would have been detected if the time lag had been shorter. Introducing contemporaneous paths in the models suggested a more sizable effect of mediation (results not presented), which may indicate that contemporaneous processes are of significance. However,

because it is unclear if these estimates reflect forward or reverse mediation, we base our main results and conclusions only on estimates of longitudinal mediation here. Work characteristics and disturbed sleep may even interact and result in more depressive symptoms, and thus moderate the relationship between, e.g., demands and depressive symptoms. Further research that examines whether disturbed sleep can act as a moderator and uses a shorter time frame is warranted.

The results of this study could also have been influenced by other methodological issues, including the particular longitudinal modeling strategy used. Measurement error, for example, can lead to an underestimation or overestimation of the parameters. Even though we used latent variables in this study, we cannot fully rule out measurement error. Work stress was operationalized by work demands and social support; however, these scales do not explicitly measure a stress reaction; not all people with high-demand scores react with a stress response. Moreover, a stress response may lead to sleep problems only under certain circumstances, e.g., in combination with ruminative thinking,⁵³ which would dilute the stress–sleep relationship. Measurement error may, however, be especially problematic if the mediator is measured with error.⁴³ It should be acknowledged that the sleep disturbance scale measures symptoms of sleep problems only, not the effects of sleep problems (daytime consequences of disturbed sleep, e.g., fatigue), which is required for the diagnosis of insomnia.⁵⁴ It might, however, have been problematic to include fatigue measures in the index of disturbed sleep because fatigue is also a symptom of depression. It has also been suggested that chronic rapid eye movement sleep fragmentation, in particular, is linked to mood regulation,⁵⁵ something that is not explicitly measured here. Although depression is usually accompanied by sleep problems, the scale for assessing depressive symptoms does not specifically measure sleep problems. This may be considered a strength, and that the measures seemed to represent different latent factors. Multicollinearity is thus not expected to significantly bias the estimates. The measure of depressive symptoms has also been demonstrated to have good properties as a dimensional measure of depression severity.⁴² A weakness of this particular analytic strategy is that SEM makes strong assumptions about the linearity between the variables, which may not be completely appropriate.⁵⁶ The baseline estimates of certain covariates were found not to influence the estimates of mediation (data not shown), but the adjustment for covariates was limited to time-invariant covariates. Too many estimated parameters may make it impossible to estimate the mediation effect. Time-varying covariates may, however, cause residual confounding, which is particularly problematic if a variable leads to a change in the mediator and the outcome.⁴³ A group of variables that may confound the mediator–outcome relationship is lifestyle factors, including diet and exercise, but it is difficult to assess to what extent or in which direction this may pose a problem.⁵⁷ Because lifestyle factors can also act as mediators in the relationship between work stress and depressive symptoms, adjusting for these kinds of factors was considered unsuitable here. Finally, attenuated estimates may have resulted from a self-selection because of dropout. However, the differences observed between the study sample and the other respondents from the 2006 survey were small. This leads us to believe that selection was not a major problem in the study and that the

results could be generalized to a broad range of occupations. A particular strength associated with the use of structural equation modeling was that the effects caused by using the same method of assessing different variables were removed by correlating the errors. Furthermore, with this particular autoregressive modeling strategy we could also separately estimate the reverse paths, which were considered important based on previous results. Further studies, based on alternative longitudinal modeling strategies such as latent growth modeling or a latent difference score approach, modeling individual differences in growth could help to increase our understanding of the interrelationships between these variables.

The hypothesis that sleep disturbances have a mediating role in the relationship between work characteristics and depression received some support with regard to work demands. However, the results imply that sleep is only a minor mediator in the pathway between work demands and depression when using a 2-y time lag between measurements. The search for mediators is clearly of theoretical as well as applied interest. Although interventions for improving sleep may not be the first choice for reducing work-related depression, it may be worth taking into greater consideration, given the findings that sleep problems are relatively good predictors of depression. These results, along with the somewhat unexpected finding of a much weaker pathway from depression to disturbed sleep, are in line with recent observations that sleep may be part of the causal pathway to depression rather than with the traditional view of depression being a cause of disturbed sleep. This could be expected to have practical implications in terms of treatment and prevention. Theoretically, however, the nature of the sleep–depression link needs further research. The potential for prevention through sleep also needs to be investigated further in relation to other medical conditions. It is biologically plausible that improved sleep could have a preventive role for other psychiatric disorders as well.⁵⁸

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SUPPLEMENTAL MATERIAL

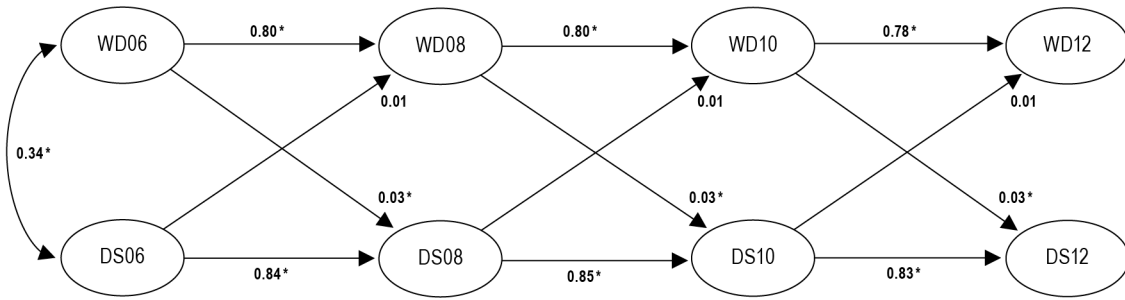


Figure S1—Standardized structural coefficients for the bivariate model of work demands and disturbed sleep. WD, work demands; DS, disturbed sleep.

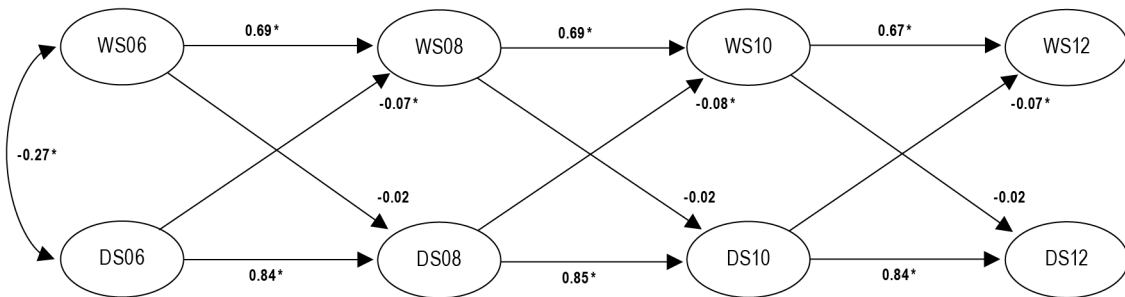


Figure S2—Standardized structural coefficients for the bivariate model of workplace support and disturbed sleep. WS, workplace support; DS, disturbed sleep.

Table S1—Means, standard deviations, and intercorrelations of work demands, disturbed sleep, and depressive symptoms 2006-2012.

Variables	Means	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. WD06	10.41	2.16	—											
2. WD08	10.53	2.08	0.62*	—										
3. WD10	10.32	2.14	0.55*	0.63*	—									
4. WD12	10.27	2.09	0.48*	0.53*	0.60*	—								
5. DS06	9.78	4.10	0.28*	0.20*	0.19*	0.16*	—							
6. DS08	9.92	4.07	0.23*	0.27*	0.23*	0.18*	0.70*	—						
7. DS10	10.54	4.29	0.23*	0.25*	0.28*	0.22*	0.65*	0.71*	—					
8. DS12	10.45	4.21	0.20*	0.23*	0.23*	0.26*	0.59*	0.68*	0.71*	—				
9. DP06	11.58	5.08	0.31*	0.24*	0.22*	0.18*	0.52*	0.41*	0.36*	0.34*	—			
10. DP08	11.43	5.14	0.25*	0.31*	0.25*	0.20*	0.37*	0.48*	0.36*	0.35*	0.53*	—		
11. DP10	11.14	5.02	0.27*	0.27*	0.32*	0.25*	0.36*	0.42*	0.48*	0.38*	0.57*	0.53*	—	
12. DP12	10.38	4.66	0.19*	0.19*	0.22*	0.26*	0.35*	0.40*	0.39*	0.49*	0.51*	0.48*	0.58*	—

*P < 0.05; DP, depressive symptoms; DS, disturbed sleep; SD, standard deviation; WD, work demands.

Table S2—Means, standard deviations, and inter-correlations of workplace support, disturbed sleep, and depressive symptoms 2006-2012.

Variables	Means	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. WS06	18.98	3.04	–											
2. WS08	18.71	3.07	0.54*	–										
3. WS10	18.73	3.12	0.47*	0.59*	–									
4. WS12	19.11	3.12	0.40*	0.44*	0.54*	–								
5. DS06	9.78	4.10	-0.24*	-0.21*	-0.20*	-0.19*	–							
6. DS08	9.92	4.07	-0.20*	-0.25*	-0.23*	-0.20*	0.70*	–						
7. DS10	10.54	4.29	-0.16*	-0.20*	-0.27*	-0.19*	0.65*	0.71*	–					
8. DS12	10.45	4.21	-0.18*	-0.20*	-0.19*	-0.25*	0.59*	0.68*	0.71*	–				
9. DP06	11.58	5.08	-0.37*	-0.28*	-0.28*	-0.22*	0.52*	0.41*	0.36*	0.34*	–			
10. DP08	11.43	5.14	-0.25*	-0.32*	-0.26*	-0.24*	0.37*	0.48*	0.36*	0.35*	0.53*	–		
11. DP10	11.14	5.02	-0.24*	-0.27*	-0.35*	-0.28*	0.36*	0.42*	0.48*	0.38*	0.57*	0.53*	–	
12. DP12	10.38	4.66	-0.22*	-0.23*	-0.24*	-0.31*	0.35*	0.40*	0.39*	0.49*	0.51*	0.48*	0.58*	–

* P < 0.05; DP, depressive symptoms; DS, disturbed sleep; SD, standard deviation; WS, workplace support.

Table S3—Total and overall indirect effects of depressive symptoms on work demands and workplace support over four waves of the Swedish Longitudinal Occupational Survey of Health.

Outcome	Total Effect		Overall Indirect Effect	
	Standardized estimate	Unstandardized estimate (95% CI)	Standardized estimate	Unstandardized estimate (95% CI)
Work demands	0.019	0.011 (-0.007, 0.029)	0.001	0.001 (-0.000, 0.001)
Workplace support	-0.119*	-0.109 (-0.130, -0.087)	-0.002*	-0.002 (-0.003, -0.001)

*P < 0.05; CI, confidence interval.