

# Reciprocal relations between work stress and insomnia symptoms: A prospective study

Johanna Garefelt<sup>1</sup>  | Loretta G. Platts<sup>1</sup>  | Martin Hyde<sup>2</sup>  |  
Linda L. Magnusson Hanson<sup>1</sup>  | Hugo Westerlund<sup>1,3</sup>  | Torbjörn Åkerstedt<sup>1,3</sup> 

<sup>1</sup>Stress Research Institute, Stockholm University, Stockholm, Sweden

<sup>2</sup>Centre for Innovative Ageing, Swansea University, Swansea, UK

<sup>3</sup>Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden

## Correspondence

Johanna Garefelt, Stress Research Institute, Stockholm University, SE-10691 Stockholm, Sweden.

Email: Johanna.garefelt@su.se

## Summary

Work stress and poor sleep are closely related in cross-sectional data, but evidence from prospective data is limited. We analysed how perceived stress and work stressors (work demands, decision authority and workplace social support) are related to key dimensions of insomnia over time, using structural equation modelling. Biennial measurements from a large sample of the working population in Sweden enabled us to analyse both the relationship from stress to sleep as well as that from sleep to stress. Overall, we found reciprocal relations between insomnia and all four stress measures. However, looking at the relation between each dimension of insomnia and each stress measure, there were some differences in direction of effects. In the direction from stress to sleep, all work stressors as well as perceived stress predicted both difficulties initiating sleep and difficulties maintaining sleep. The same was found for non-restorative sleep, with the exception for decision authority. In the opposite direction, difficulties maintaining sleep predicted increased levels of work demands and perceived stress. Difficulties initiating sleep stood out among the insomnia symptoms as not predicting any of the stress measures, while non-restorative sleep was the only symptom predicting all stress measures. The results advance the understanding of the stress–sleep relationship and indicate a potential vicious circle between insomnia and perceived stress as well as work stressors, suggesting that the workplace could be an arena for interventions to alleviate insomnia.

## KEYWORDS

job demands, longitudinal, nonrestorative sleep, occupational stress, psychological stress, sleep initiation and maintenance disorders

## 1 | INTRODUCTION

About one-third of the European population experiences one or more symptoms of insomnia, such as non-restorative sleep or difficulties initiating or maintaining sleep (Ohayon, 2002; Roth, 2007). Rising rates of insomnia symptoms have been observed in several countries, notably among people in paid work (Garland et al., 2018; Kronholm et al.,

2016). One potential explanatory factor could be stress at work, as there is a close relationship between psychosocial stress and insomnia symptoms (Åkerstedt, 2006). Studies have shown that stressful days tend to be followed by both difficulties initiating sleep as well as difficulties maintaining sleep, and that increased levels of stress (Åkerstedt, Orsini, et al., 2012) and high job strain (Halonen et al., 2017) are associated prospectively with increased levels of sleep disturbances. However, there is a lack of studies examining the relation

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2019 The Authors. *Journal of Sleep Research* published by John Wiley & Sons Ltd on behalf of European Sleep Research Society

between work-related stress and insomnia symptoms across a period of several years (Åkerstedt, 2006). The stress–sleep relationship might be bi-directional, as the experience of insomnia and sleep deprivation has been shown to be associated with emotional and physical impairment and higher stress levels (Schwarz et al., 2018; Zaslavsky, LaCroix, Hale, Tindle, & Shochat, 2015). Non-restorative sleep and sleep disturbances have each predicted subsequent high demands, low control and low social support at work, while sleep disturbances additionally predicted perceived stress (Åkerstedt et al., 2015; Magnusson Hanson et al., 2011). However, results from these studies, mostly using two measurement occasions, have not been entirely consistent; research with more waves of data may provide greater precision in order to clarify how stress and insomnia are associated over time.

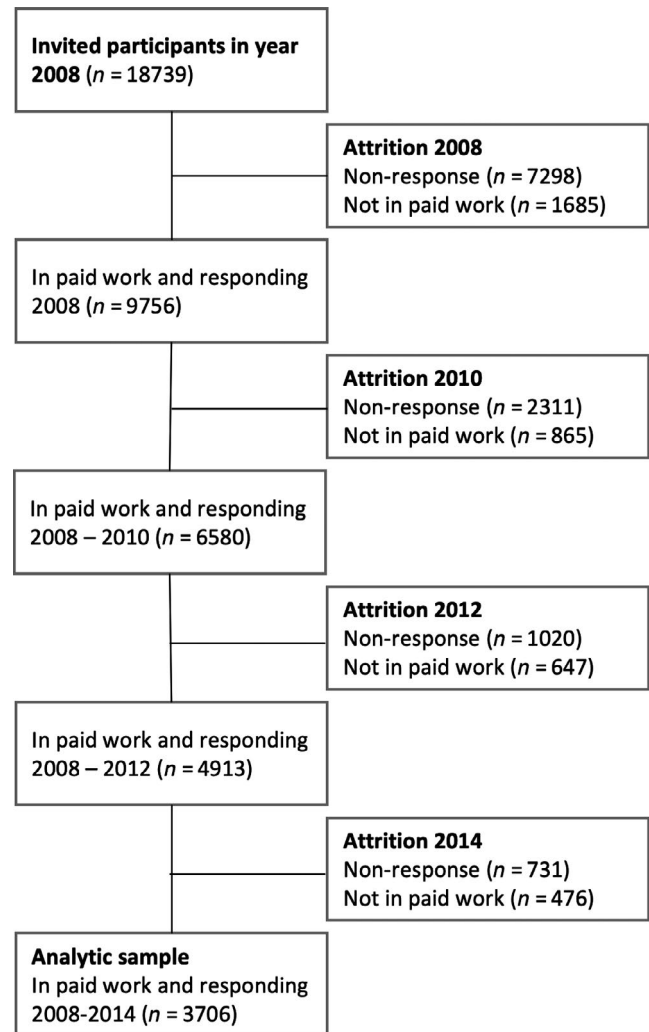
The nocturnal insomnia symptoms—difficulties initiating or maintaining sleep—are well studied (Roth et al., 2010; Zhang et al., 2013), while non-restorative sleep, which refers to the subjective feeling that sleep has not been sufficiently refreshing despite normal or longer than normal sleep duration, has gained less attention, despite its equally considerable daytime consequences (Ohayon, 2005; Roth et al., 2010). Even though non-restorative sleep is no longer a criterion for the clinical diagnosis of insomnia in the latest version of DSM (5), we believe that this aspect of insomnia is important to study in parallel with difficulties initiating and maintaining sleep. Several studies have suggested that non-restorative sleep might be a separate phenomenon that should be treated and analysed in its own right (Li et al., 2014; Roth et al., 2010; Wilkinson & Shapiro, 2012). By distinguishing the different insomnia symptoms: difficulties initiating sleep, difficulties maintaining sleep and non-restorative sleep, while also analysing them in parallel, we examine whether symptoms might relate differently to perceived stress and work stressors. Further, we distinguish measures of work stressors, referring to potentially stress-generating aspects of the work situation such as low social support or high work demands, from the experience of feeling stressed. This distinction is important as stressors, for example, high work demands can affect people differently: people's reactions may depend on their appraisal of the situation as well as vulnerability factors, such as exacerbation of the stress reaction by chronic sleep deprivation (Epel et al., 2018; Magnusson Hanson, Peristera, Chungkham, & Westerlund, 2017).

To our knowledge, no previous study has examined temporal relationships in a way that differentiates aspects of stress and the different symptoms of insomnia. The purpose of this study is to analyse whether a general measure of perceived stress and work stressors are differentially related to the main dimensions of insomnia in order to gain a more detailed understanding of how stress and sleep influence each other over time.

## 2 | METHODS

### 2.1 | Study sample

The sample ( $n = 3,706$ ) was derived from the Swedish Longitudinal Occupational Survey of Health, and comprises participants who



**FIGURE 1** Analytic sample ( $n = 3,706$ ) derived from the Swedish Longitudinal Occupational Survey of Health (SLOSH), consisting of participants who responded to the self-administered biennial postal questionnaire as working gainfully (30% of full time or more) at all four waves from 2008 to 2014. *Note: Causes of attrition due to non-response include death and emigration, in addition to individuals declining to participate in the study.*

responded to the self-administered biennial postal questionnaires stating that they participated in paid work for at least 30% at each of the four waves from 2008 to 2014 (see Figure 1 for details regarding eligibility and attrition). The SLOSH cohort is approximately representative of the working population in Sweden. More information about the SLOSH cohort including profile and non-response of participants is available elsewhere (Magnusson Hanson et al., 2018). Data collection was approved by the regional ethical review board in Stockholm.

### 2.2 | Measures and measurement models

All analyses were conducted using Stata SE 15.1. Factors with one or two measures were analysed as observed in the structural models, where indices are based on items with equal weight (Newsom,

2015). Factors with three or more items were analysed as latent factors, after testing for longitudinal metric invariance.

### 2.2.1 | Socio-demographic information

Information regarding sex (male/female), age (in years) and educational level (3 years or more at university, yes or no) was derived from administrative register data.

### 2.2.2 | Insomnia and sleep duration

We used the Karolinska Sleep Questionnaire (KSQ; Åkerstedt, Nordin, Alfredsson, Westerholm, & Kecklund, 2012) to measure different symptoms of insomnia. The question was phrased: "How often have you been troubled by the following in the last 3 months?": "Difficulties falling asleep", "Restless sleep", "Repeated awakenings", "Too early awakening", "Difficulties awakening" and "Not feeling refreshed at wake-up". The response options ranged from "never" to "most days of the week" (with values from 1 to 6 assigned). No previous studies have tested the longitudinal metric invariance of KSQ, but a two-factor structure has been established in cross-sectional data, in which non-restorative sleep is distinguished from sleep disturbances (Nordin, Åkerstedt, & Nordin, 2013). This structure was used as the starting point for longitudinal metric invariance testing. The sleep disturbances-factor was found not to be invariant across time (see Results), which was resolved by analysing the item "Difficulties falling asleep" separately. The KSQ was hence analysed as three separate factors in the structural models: *Difficulties initiating sleep* (one item, observed), *Difficulties maintaining sleep* (three items, latent) and *Non-restorative sleep* (two items, observed), and controlled for short sleep duration at each wave, in order to rule this out as the cause. Short sleep duration was calculated from self-declared regular bedtimes on nights before a working day and dichotomized to < 6 hr per night.

### 2.2.3 | Perceived stress

Global (non-specific) perceived stress (Åkerstedt et al., 2015) was measured with three questions asking how the participants felt during the three preceding months: "I have days when I feel wound up all the time", "I have days when I feel very pressured all the time" and "I have days when I feel stressed all the time". Answers ranged from 1 = not at all to 4 = all the time. A test of the longitudinal metric invariance of this factor (which has not previously been done), showed metric invariance across time (see Results).

### 2.2.4 | Stressors in the psychosocial work environment

To assess stressors in the psychosocial work environment, we used the Demand-Control-Support Questionnaire (DCSQ; Johnson, Hall,

& Theorell, 1989), an instrument that is validated longitudinally (Chungkham, Ingre, Karasek, Westerlund, & Theorell, 2013) showing that *work demands* is invariant across time (after elimination of the item "working very intensively") but *social support* is not. *Work demands* were assessed with four questions (e.g. "Do you have to work fast?", "Does your work often involve conflicting demands?"). The response alternatives ranged from 1 = yes, often, to 4 = hardly ever/never. *Decision authority* at work was measured with two questions ("Do you have a choice in deciding how you do your work?" and "Do you have a choice in deciding what you do at work?"). The response alternatives ranged from 1 = hardly ever/never to 4 = yes, often. *Social support* was measured by five questions (e.g. "There is a calm and pleasant atmosphere where I work" and "I get on well with my superiors"). Response alternatives ranged from 1 = strongly disagree, to 4 = strongly agree.

## 2.3 | Estimation of cross-lagged panel models

In order to investigate the relationships between perceived stress, stressors in the psychosocial work environment and insomnia over time, Structural Equation Modelling (SEM) was applied. Full-information maximum likelihood estimation was used to avoid bias due to item-level missing data. Kurtosis lower than 4 and skewness lower than 2 indicated that the data, with the exception of short sleep, were normally distributed. None of the variables was highly correlated ( $r > 0.85$ ), reducing the risk for multicollinearity (Kline, 2010). See Table 1 for the intercorrelation matrix and univariate statistics. To investigate the relationships across time, cross-lagged models were estimated. Each model contained all three insomnia factors, and one of perceived stress, work demands, decision authority or workplace social support. Four competing models were estimated to test the direction of the relations. First, a stability model with only the auto-regressions of all variables was estimated (Model 1). Second, a forward causal model where paths were added between hypothesized exposure (perceived stress/work stressors) and outcome (insomnia symptoms) in the subsequent wave (Model 2). The third model tested reverse causation, in addition to the auto-regressions, with causal paths from the hypothesized outcomes (insomnia symptoms) to the hypothesized exposure (perceived stress/work stressors) at the subsequent wave (Model 3). A fourth reciprocal model tested all the previous paths simultaneously (Model 4). Corresponding structural paths were constrained to be equal across all three pairs of years in all models, except for the analyses of social support due to variance in the social support construct. All factors were allowed to correlate at baseline, including the confounding factors sex, age and education. Item-specific measurement error was allowed to correlate across all waves. Chi-square tests were performed to compare the models. Due to large sample size, RMSEA, CFI and TLI were used as fit indices. A RMSEA value < 0.06 indicates good fit, while values above 0.10 indicate poor fit; TLI and CFI should be > 0.90 as good fit (Newsom, 2015).



**TABLE 2** Model fit and comparison for structural equation models between perceived stress, work demands, decision authority, social support and insomnia. Swedish Longitudinal Occupational Survey of Health (SLOSH),  $n = 3706$ 

	Chi <sup>2</sup> (versus saturated)	df	Prob > Chi <sup>2</sup>	Change Chi <sup>2</sup> (df), p-value	RMSEA	AIC	BIC	CFI	TLI	
<b>Perceived stress – Insomnia</b>										
1	Autoregression	7,813.830	654	$p < .001$	–	0.054	304,724.886	305,750.808	0.911	0.901
2	Forward causation	7,450.530	651	$p < .001$	versus 1 363.30(3), $p < .001$	0.053	304,367.586	305,412.161	0.916	0.906
3	Reverse causation	7,677.660	651	$p < .001$	versus 1 136.17(3), $p < .001$	0.054	304,594.721	305,639.296	0.913	0.903
4	Reciprocal	7,323.960	648	$p < .001$	versus 1 489.87(6), $p < .001$	0.053	304,247.016	305,310.244	0.917	0.907
				versus 2 126.57(3), $p < .001$						
				versus 3 353.70(3), $p < .001$						
<b>Work demands – Insomnia</b>										
1	Autoregression	7,433.670	809	$p < .001$	–	0.047	346,661.372	347,780.56	0.915	0.907
2	Forward causation	7,272.710	806	$p < .001$	versus 1 160.96(3), $p < .001$	0.047	346,506.412	347,644.253	0.918	0.909
3	Reverse causation	7,389.170	806	$p < .001$	versus 1 44.50(3), $p < .001$	0.047	346,622.873	347,760.713	0.916	0.907
4	Reciprocal	7,225.450	803	$p < .001$	versus 1 208.22(6), $p < .001$	0.046	346,465.155	347,621.649	0.918	0.909
				versus 2 47.26(3), $p < .001$						
				versus 3 163.72(3), $p < .001$						
<b>Decision authority – Insomnia</b>										
1	Autoregression	6,809.490	399	$p < .001$	–	0.066	280,529.803	281,325.669	0.898	0.886
2	Forward causation	6,799.510	396	$p < .001$	versus 1, 9.98(3), $p < .05$	0.066	280,525.826	281,340.346	0.898	0.885
3	Reverse causation	6,786.450	396	$p < .001$	versus 1 23.05(3), $p < .001$	0.066	280,512.757	281,327.277	0.898	0.886
4	Reciprocal	6,776.270	393	$p < .001$	versus 1 33.22(6), $p < .001$	0.066	280,508.578	281,341.751	0.898	0.885
				versus 2 23.25(3), $p < .001$						
				versus 3 10.18(3), $p < .05$						
<b>Social support – Insomnia</b>										
1	Autoregression	10,025.480	968	$p < .001$	–	0.050	350,500.59	351,787.656	0.903	0.893
2	Forward causation	9,950.560	959	$p < .001$	versus 1 74.93(9), $p < .001$	0.050	350,443.663	351,786.688	0.903	0.893
3	Reverse causation	9,891.530	959	$p < .001$	versus 1 133.96(9), $p < .001$	0.050	332,846.348	351,727.659	0.904	0.893
4	Reciprocal	9,816.290	950	$p < .001$	versus 1 209.20(18), $p < .001$	0.050	350,327.391	351,726.375	0.905	0.893
				versus 2 134.27(9), $p < .001$						
				versus 3 75.24(9), $p < .001$						

Full information maximum likelihood was used as the estimation method. Insomnia was measured by difficulties initiating sleep, difficulties maintaining sleep and nonrestorative sleep.

### 3 | RESULTS

#### 3.1 | Descriptive statistics and sociodemographic information

The mean age of the sample in 2008 was 47 years (range 20–69 years); 42% had three or more years of university education. More sociodemographic information and descriptive data on the variables and their intercorrelation are presented in Table 1. The insomnia measures had overall mean values between 2.33 and 2.66 (range 1–6), where 2 corresponds to “Occasionally” and 3 “Sometimes/a few times a month”.

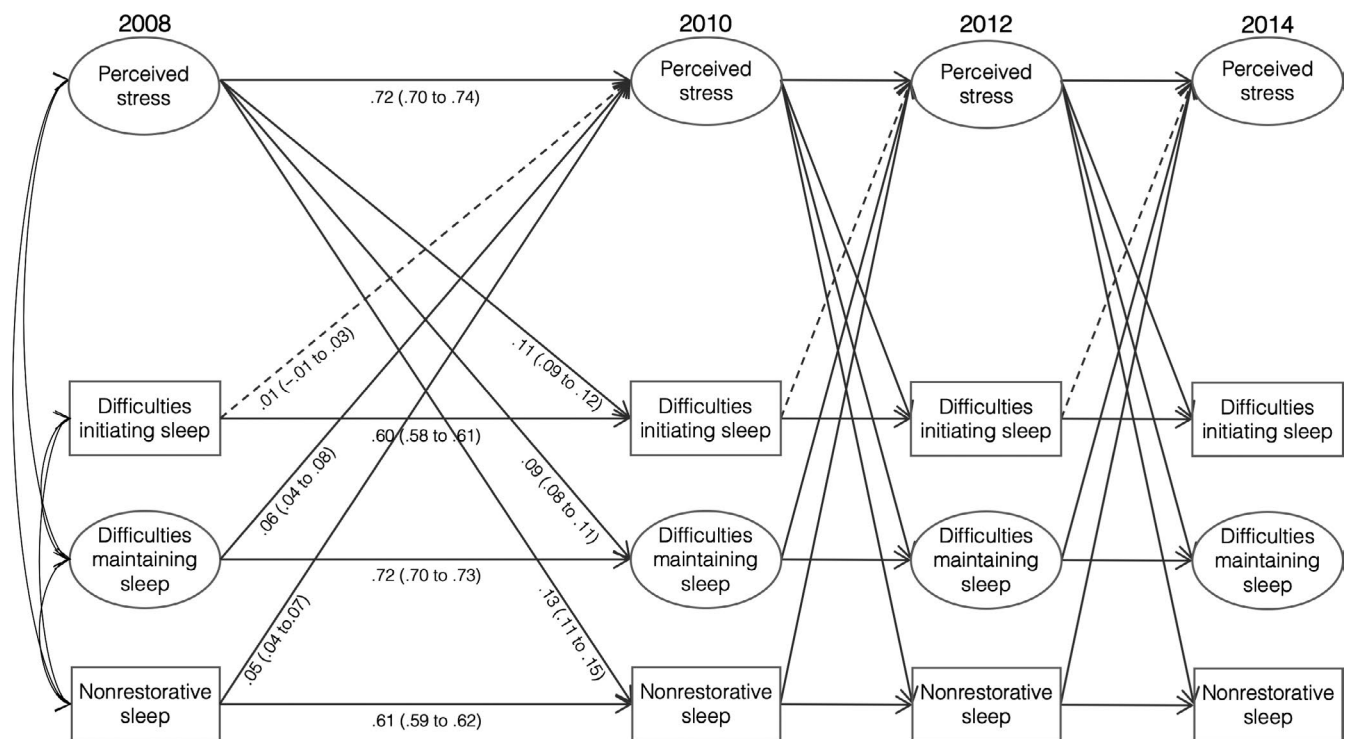
#### 3.2 | Longitudinal metric invariance test of the latent factors

The longitudinal metric invariance of the latent factors of insomnia symptoms and perceived stress was evaluated by comparing two nested longitudinal measurement models with a likelihood ratio test: one where item loadings were constrained to be equal across time and one where item loadings were allowed to vary across times. The latent factor of the KSQ for sleep disturbances, previously established from cross-sectional data (Nordin et al., 2013), was not invariant across time (probability  $> \chi^2 = 0.021$ , for  $\chi^2 = 19.53$  on 9

degrees of freedom). The three remaining items (in this paper named *Difficulties maintaining sleep*) were invariant across time (probability  $> \chi^2 = 0.807$ , for  $\chi^2 = 3$  at 6 df). Hence, insomnia symptoms were analysed as three factors: Difficulties initiating sleep, Difficulties maintaining sleep, and Non-restorative sleep. A likelihood ratio test between the constrained versus non-constrained longitudinal measurement model of *Perceived stress* was non-significant (probability  $> \chi^2 = 0.791$ , for  $\chi^2 = 3.14$  at 6 df), indicating metric invariance across time.

#### 3.3 | Structural relationships between perceived stress, psychosocial work environment stressors and insomnia

Fit statistics and comparisons of the cross-lagged SEM models are presented in Table 2. All models showed significant Chi-square test results due to large sample size, but other fit indices indicated acceptable to good fit for all structural models. The cross-lagged models were compared with likelihood ratio tests. In all comparisons, the reciprocal models fit the data best, compared with less complex models. Figures 2–5 show the best-fitting structural models, displaying path coefficients and associated confidence intervals. To simplify the figures, confounding factors, measurement models and errors are not shown.



**FIGURE 2** Best-fitting structural equation model of perceived stress and three components of insomnia: difficulties initiating sleep, difficulties maintaining sleep, and non-restorative sleep. Swedish Longitudinal Occupational Survey of Health (SLOSH),  $n = 3,706$ . Note: Solid lines depict paths that are significant at the 95% confidence level, and dotted lines depict non-significant paths. All factors were allowed to correlate at baseline, including the confounding factors (sex, age and education) not shown in the figure. Confidence intervals are shown for both significant and non-significant paths. Structural paths between the waves are constrained to be equal (standardized regression coefficients only shown once in the figure)

Overall, the results indicated a high degree of stability of all factors across the waves, with a stability of 0.72 for perceived stress (Figure 2), 0.75 for work demands (Figure 3), 0.62 for decision authority (Figure 4), and between 0.57 and 0.60 for social support (Figure 5). The structural paths were constrained to be equal in all structural models, except for social support due to variance in the construct. For the insomnia measures, the coefficients for the autoregressive paths across the analyses (Figures 2–5) ranged between 0.60 and 0.61 for difficulties initiating sleep, 0.73 and 0.77 for difficulties maintaining sleep and 0.60 and 0.69 for non-restorative sleep.

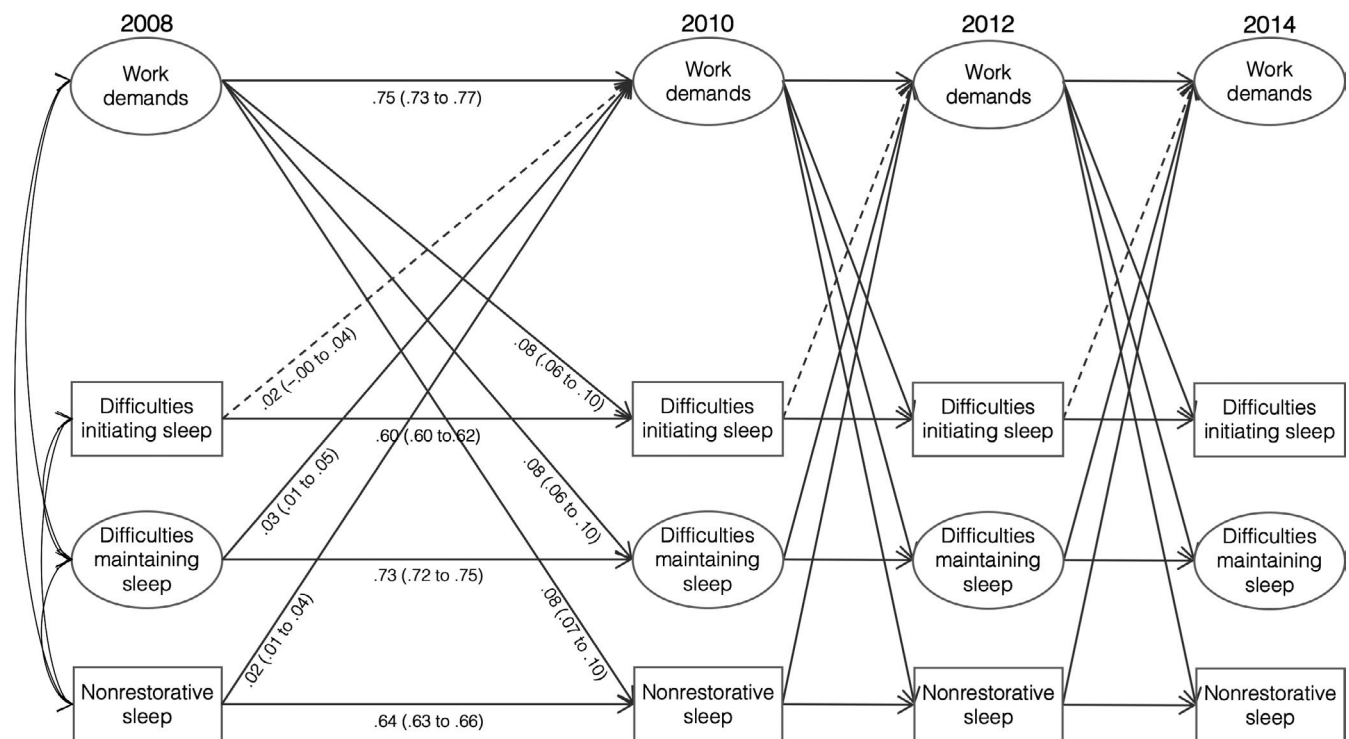
Figure 2 shows the best-fitting structural model of perceived stress and insomnia symptoms. In the forward direction, perceived stress was significantly related to increased levels of all factors of insomnia in the following waves. Although the coefficients were lower, the paths in the reverse direction were also significant going from difficulties maintaining sleep and non-restorative sleep, i.e. they predicted increased levels of perceived stress in the following waves. Difficulties initiating sleep was, however, not significantly predictive of increased levels of perceived stress in the following waves. In Figure 3, the same pattern could be seen between work demands and insomnia, with stronger paths in the forward direction than the reverse direction. Difficulties initiating sleep was not significantly related to increased levels of work demands in the following waves. Figure 4 shows that decision authority was related only

to difficulties initiating sleep and difficulties maintaining sleep in the forward direction, while the reverse paths were not significant. However, non-restorative sleep had a significant relation to decision authority in the following waves. In contrast to the other models, Figure 5 on the relation between social support and insomnia symptoms gives a more complex picture as both the loadings in the measurement model of social support as well as the structural paths across waves were allowed to vary. From social support, almost all paths in the forward direction were significant. In the reverse direction, the results were inconsistent (consult Figure 5 for more details).

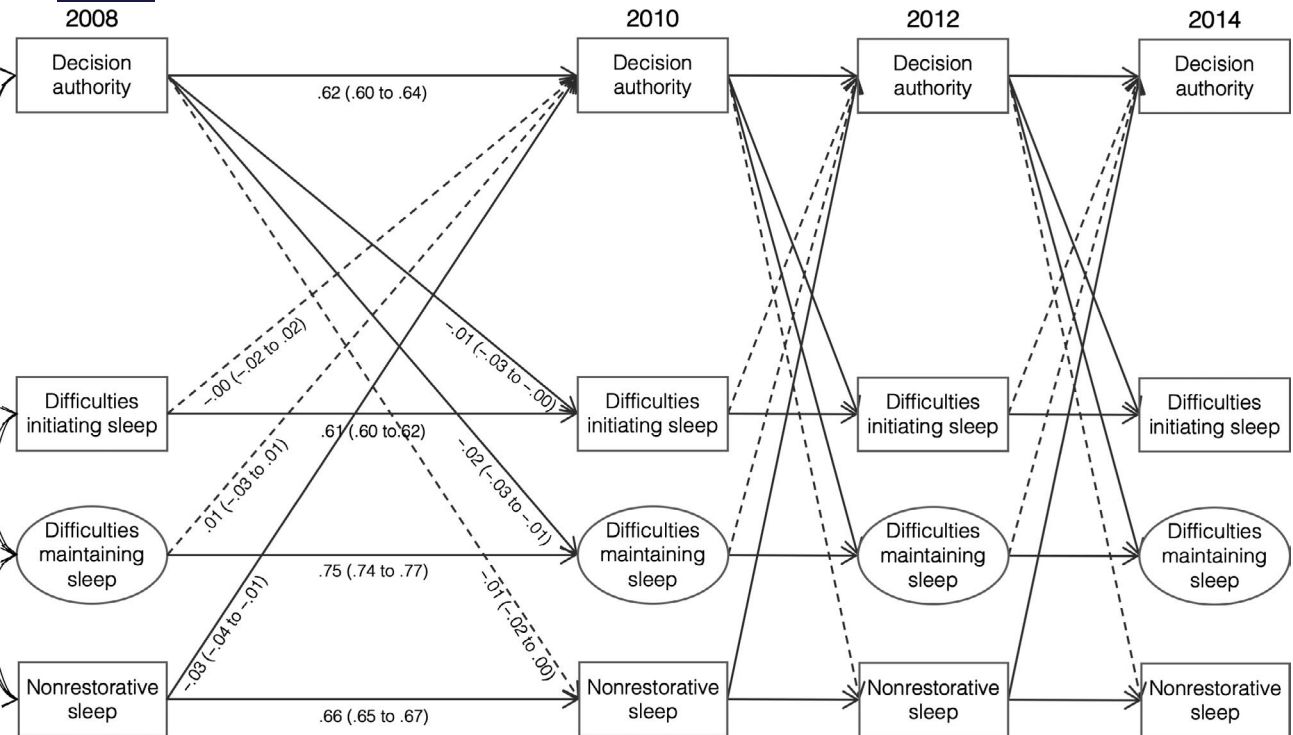
## 4 | DISCUSSION AND CONCLUSION

This paper demonstrates a reciprocal relationship between stress and insomnia, with stronger effects in the direction from stress to insomnia 2 years later than in the opposite direction. We will discuss the relationships in both directions, starting with the forward direction from perceived stress and each of the work stressors in relation to all insomnia symptoms, then discuss the relations from insomnia symptoms to perceived stress and each of the work stressors.

In the forward direction, perceived stress predicted all insomnia symptoms, indicating long-term consequences for all aspects of insomnia, in addition to the immediate effects found in previous studies (Åkerstedt, Orsini, et al., 2012; Hall et al., 2007). Similarly, work



**FIGURE 3** Best-fitting structural equation model of work demands and three components of insomnia: difficulties initiating sleep, difficulties maintaining sleep, and non-restorative sleep. Swedish Longitudinal Occupational Survey of Health (SLOSH),  $n = 3,706$ . Note: Solid lines depict paths that are significant at the 95% confidence level, and dotted lines depict non-significant paths. All factors were allowed to correlate at baseline, including the confounding factors (sex, age and education) not shown in the figure. Confidence intervals are shown for both significant and non-significant paths. Structural paths between the waves are constrained to be equal (standardized regression coefficients only shown once in the figure)



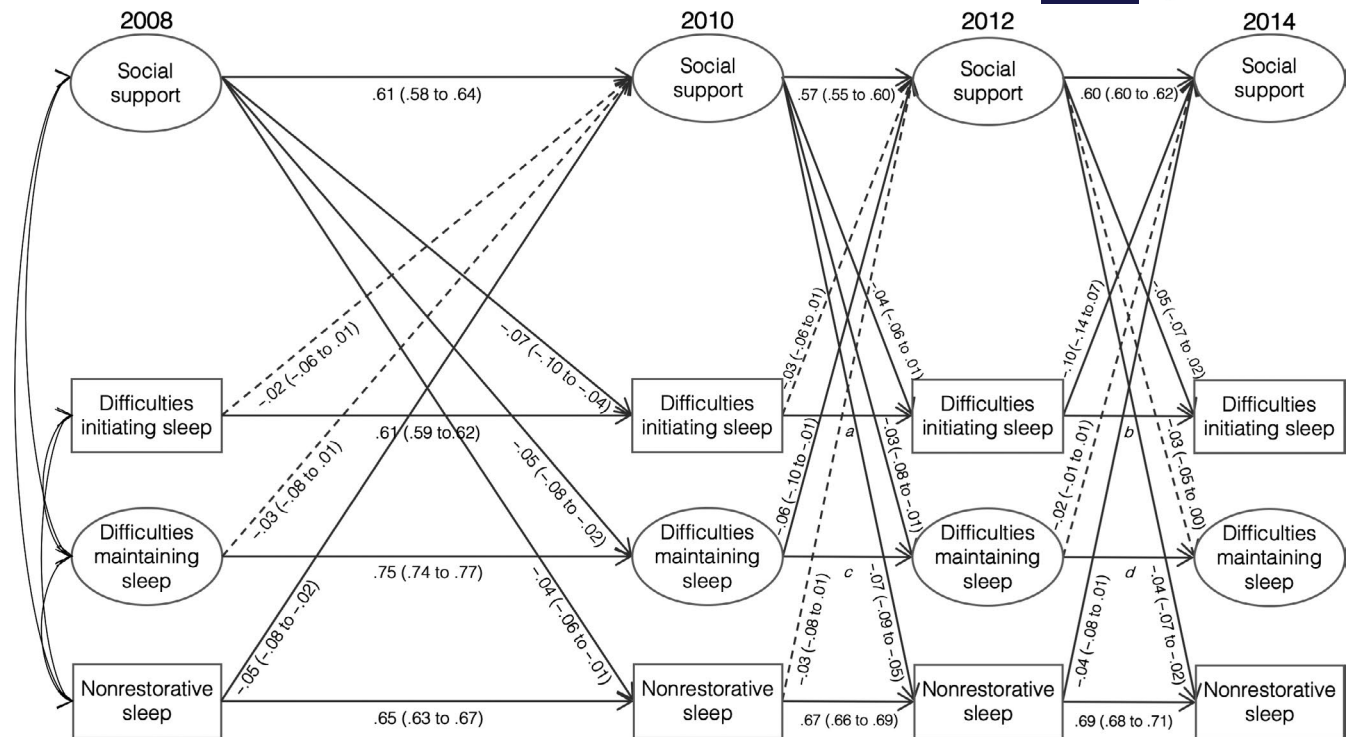
**FIGURE 4** Best-fitting structural equation model of decision authority and three components of insomnia: difficulties initiating sleep, difficulties maintaining sleep, and non-restorative sleep. Swedish Longitudinal Occupational Survey of Health (SLOSH),  $n = 3,706$ . Note: Solid lines depict paths that are significant at the 95% confidence level, and dotted lines depict non-significant paths. All factors were allowed to correlate at baseline, including the confounding factors (sex, age and education) not shown in the figure. Confidence intervals are shown for both significant and non-significant paths. Structural paths between the waves are constrained to be equal (standardized regression coefficients only shown once in the figure)

demands increased the risk of all insomnia symptoms, in accordance with the literature (Åkerstedt, Nordin, et al., 2012; Jansson & Linton, 2006; Statens beredning för medicinsk utvärdering, 2013). We found significant paths from decision authority to difficulties initiating and maintaining sleep but not to non-restorative sleep; however, regression coefficients were weak and model fit only borderline acceptable. Evidence from earlier studies is inconsistent, finding forward (de Lange et al., 2009), reverse (Åkerstedt et al., 2015) and no (Magnusson Hanson et al., 2011) associations. Social support was prospectively related to all insomnia symptoms, partly in line with Magnusson Hanson (2011) who found a relation to non-restorative sleep and a close to significant result for sleep disturbances.

In the opposite direction, difficulties initiating sleep stood out among the insomnia symptoms as neither predicting perceived stress nor any of the work stressors. This finding is, to our knowledge, new and strengthens the case for sleep-onset insomnia to be distinguished from sleep-maintenance insomnia – especially in longitudinal analyses – as we also found that they are not invariant across time if treated together as one factor. It could be that difficulties falling asleep do not reduce people's abilities to handle stress or social relationships, indicating that important mechanisms may be related to sleep quality and fragmentation rather than the partial sleep deprivation caused by delayed sleep onset. Poor sleep quality with a lot of fragmentation or premature awakenings may have more major

long-term consequences on the body's stress systems, such as the HPA-axis, than difficulties initiating sleep (van Dalsen & Markus, 2018). In our study, difficulties maintaining sleep and non-restorative sleep were reciprocally related to both work demands and perceived stress, only partly in line with the previous few longitudinal studies looking at reverse or reciprocal relations (Åkerstedt et al., 2015; de Lange et al., 2009; Magnusson Hanson et al., 2011; Van Laethem et al., 2018). Magnusson Hanson et al. (2011) found reciprocal relations between non-restorative sleep and work demands, but not with sleep disturbances (difficulties initiating and maintaining sleep). Neither did de Lange et al. (2009) find support for a reverse or reciprocal model between sleep problems (difficulties initiating, maintaining sleep and non-restorative sleep collapsed into one measure) and work demands. The disparities in results could be due to differences in statistical power or the treatment of insomnia symptoms as combined or separate. Our results imply that the relation from insomnia to stress may depend on which particular symptom is most dominant in the sample if insomnia is treated as one factor. Looking at our results from insomnia to decision authority, non-restorative sleep was the only significant predictor, in line with Magnusson Hanson et al. (2011). The paths from insomnia symptoms to social support were inconsistent across waves and should therefore be analysed with caution, but are partly supported by Magnusson Hanson et al. (2011) who found a relation from non-restorative sleep, but not from disturbed sleep.





**FIGURE 5** Best-fitting structural equation model of social support and three components of insomnia: difficulties initiating sleep, difficulties maintaining sleep, and non-restorative sleep. Swedish Longitudinal Occupational Survey of Health (SLOSH),  $n = 3,706$ . Note: Solid lines depict paths that are significant at the 95% confidence level and dotted lines depict non-significant paths. All factors were allowed to correlate at baseline, including the confounding factors (sex, age and education) not shown in the figure. Confidence intervals are shown for both significant and non-significant paths. Structural paths between the waves are allowed to vary. Standardized regression coefficients shown for all structural paths, except  $a = 0.61$  (0.59–0.62),  $b = 0.61$  (0.60–0.63),  $c = 0.77$  (0.75–0.78),  $d = 0.73$  (0.72–0.75)

Our study advances the understanding of the stress–sleep relationship across time, which can inform clinicians treating patients with long-lasting insomnia symptoms. The reciprocal relations indicate a vicious cycle of stress and insomnia that potentially could lead to emotional exhaustion or burnout (Grossi, Perski, Osika, & Savic, 2015). These results strengthen the case for the workplace being a potential area for interventions to break this cycle and reduce insomnia by either decreasing the demands, and/or to increasing workplace social support and decision authority. On the individual level, occupational health services could help identify and decrease exposure to these stressors as well as assist in the development of adequate stress coping strategies.

The main strengths of this study are that it uses a large sample with multiple repeated measures, and SEM, which enables analyses of reciprocal relationships at multiple points in time. Another strength is the parallel analysis of insomnia symptoms, which enables us to obtain the unique estimate related to each symptom. In addition, non-restorative sleep is adjusted for short sleep duration, which is measured by bedtime/getting up time, an approach that avoids the measure being confounded by participants' understandings of what a normal night's sleep entails. Limitations include the exclusive use of questionnaire data, which makes the results vulnerable to the risk of common method bias. This problem could be avoided if future studies are able to employ polysomnography

to measure sleep duration and disturbances as well controlling for snoring and apnea (which are known to affect both non-restorative sleep as well as difficulties maintaining sleep, but unfortunately no reliable data on this were available in the present study). The 2-year time interval might be too long, as potential effects of stress on sleep and vice versa may take place over substantially shorter time periods. Future studies with denser measurements of both exposures from work environment factors as well as insomnia symptoms are needed. Potential confounding factors not included in this study are factors in private life, such as taking care of a partner (Sacco, Leinweber, & Platts, 2017) or children (Estrela, Barker, Lantagne, & Gouin, 2018).

#### 4.1 | Conclusion

Difficulties initiating and maintaining sleep as well as non-restorative sleep should be analysed separately (at least in longitudinal studies), as these aspects of insomnia are differently related to factors in the psychosocial work environment across time. The reciprocal relation between work stress and insomnia indicates a potential vicious cycle, and also suggests that the work environment could be an area of interest for interventions to reduce difficulties both initiating and maintaining sleep as well as non-restorative sleep.

## DISCLOSURE

No conflicts of interest declared.

## ACKNOWLEDGEMENTS

This work was funded by The Swedish Council for Health, Working life and Welfare (FORTE) [grant no: 2012-1743] and by the Stockholm Stress Center, a FORTE Centre of Excellence for research on work related stress and health [grant no: 2009-1758].

## ORCID

Johanna Garefelt  <https://orcid.org/0000-0003-3658-6448>

Loretta G. Platts  <https://orcid.org/0000-0002-3243-0262>

Martin Hyde  <https://orcid.org/0000-0002-9955-8121>

Linda L. Magnusson Hanson  <https://orcid.org/0000-0002-2908-1903>

[org/0000-0002-2908-1903](https://orcid.org/0000-0002-2908-1903)

Hugo Westerlund  <https://orcid.org/0000-0002-8806-5698>

Torbjörn Åkerstedt  <https://orcid.org/0000-0001-8049-8504>

## REFERENCES

- Åkerstedt, T. (2006). Psychosocial stress and impaired sleep. *Scandinavian Journal of Work, Environment & Health*, 32(6), 493–501. <https://doi.org/10.5271/sjweh.1054>
- Åkerstedt, T., Garefelt, J., Richter, A., Westerlund, H., Magnusson Hanson, L. L., Sverke, M., & Kecklund, G. (2015). Work and sleep—a prospective study of psychosocial work factors, physical work factors, and work scheduling. *Sleep*, 38(7), 1129–1136. <https://doi.org/10.5665/sleep.4828>
- Åkerstedt, T., Nordin, M., Alfredsson, L., Westerholm, P., & Kecklund, G. (2012). Predicting changes in sleep complaints from baseline values and changes in work demands, work control, and work preoccupation—the WOLF-project. *Sleep Medicine*, 13(1), 73–80. <https://doi.org/10.1016/j.sleep.2011.04.015>
- Åkerstedt, T., Orsini, N., Petersen, H., Axelsson, J., Lekander, M., & Kecklund, G. (2012). Predicting sleep quality from stress and prior sleep—a study of day-to-day covariation across six weeks. *Sleep Medicine*, 13(6), 674–679. <https://doi.org/10.1016/j.sleep.2011.12.013>
- Chungkham, H. S., Ingre, M., Karasek, R., Westerlund, H., & Theorell, T. (2013). Factor structure and longitudinal measurement invariance of the demand control support model: An evidence from the Swedish Longitudinal Occupational Survey of Health (SLOSH). *PLoS ONE*, 8(8), e70541. <https://doi.org/10.1371/journal.pone.0070541>
- da Estrela, C., Barker, E. T., Lantagne, S., & Gouin, J.-P. (2018). Chronic parenting stress and mood reactivity: The role of sleep quality. *Stress and Health*, 34(2), 296–305. <https://doi.org/10.1002/smi.2790>
- de Lange, A. H., Kompier, M. A. J., Taris, T. W., Geurts, S. A. E., Beckers, D. G. J., Houtman, I. L. D., & Bongers, P. M. (2009). A hard day's night: A longitudinal study on the relationships among job demands and job control, sleep quality and fatigue. *Journal of Sleep Research*, 18(3), 374–383. <https://doi.org/10.1111/j.1365-2869.2009.00735.x>
- Epel, E. S., Crosswell, A. D., Mayer, S. E., Prather, A. A., Slavich, G. M., Puterman, E., & Mendes, W. B. (2018). More than a feeling: A unified view of stress measurement for population science. *Frontiers in Neuroendocrinology*, 49, 146–169. <https://doi.org/10.1016/j.yfrne.2018.03.001>
- Garland, S. N., Rowe, H., Repa, L. M., Fowler, K., Zhou, E. S., & Grandner, M. A. (2018). A decade's difference: 10-year change in insomnia symptom prevalence in Canada depends on sociodemographics and health status. *Sleep Health*, 4(2), 160–165. <https://doi.org/10.1016/j.sleh.2018.01.003>
- Grossi, G., Perski, A., Osika, W., & Savic, I. (2015). Stress-related exhaustion disorder – clinical manifestation of burnout? A review of assessment methods, sleep impairments, cognitive disturbances, and neuro-biological and physiological changes in clinical burnout. *Scandinavian Journal of Psychology*, 56(6), 626–636. <https://doi.org/10.1111/sjop.12251>
- Hall, M., Thayer, J. F., Germain, A., Moul, D., Vasko, R., Puhl, M., ... Buysse, D. J. (2007). Psychological stress is associated with heightened physiological arousal during NREM sleep in primary insomnia. *Behavioral Sleep Medicine*, 5(3), 178–193. <https://doi.org/10.1080/15402000701263221>
- Halonen, J. I., Lallukka, T., Pentti, J., Stenholm, S., Rod, N. H., Virtanen, M., ..., Vahtera, J. (2017). Change in job strain as a predictor of change in insomnia symptoms: analyzing observational data as a non-randomized pseudo-trial. *Sleep*, 40(1), zsw007. <https://doi.org/10.1093/sleep/zsw007>
- Jansson, M., & Linton, S. J. (2006). Psychosocial work stressors in the development and maintenance of insomnia: A prospective study. *Journal of Occupational Health Psychology*, 11(3), 241–248. <https://doi.org/10.1037/1076-8998.11.3.241>
- Johnson, J. V., Hall, E. M., & Theorell, T. (1989). Combined effects of job strain and social isolation on cardiovascular disease morbidity and mortality in a random sample of the Swedish male working population. *Scandinavian Journal of Work, Environment & Health*, 15(4), 271–279. <https://doi.org/10.5271/sjweh.1852>
- Kline, R. B. (2010). *Principles and Practice of Structural Equation Modeling [Elektronisk resurs]*. New York: Guilford Press.
- Kronholm, E., Partonen, T., Härmä, M., Hublin, C., Lallukka, T., Peltonen, M., & Laatikainen, T. (2016). Prevalence of insomnia-related symptoms continues to increase in the Finnish working-age population. *Journal of Sleep Research*, 25(4), 454–457. <https://doi.org/10.1111/jsr.12398>
- Li, Y., Zhang, X., Winkelmann, J. W., Redline, S., Hu, F. B., Stampfer, M., ..., Gao, X. (2014). Association between insomnia symptoms and mortality: A prospective study of U.S. men. *Circulation*, 129(7), 737–746. <https://doi.org/10.1161/CIRCULATIONAHA.113.004500>
- Magnusson Hanson, L. L., Åkerstedt, T., Näswall, K., Leineweber, C., Theorell, T., & Westerlund, H. (2011). Cross-lagged relationships between workplace demands, control, support, and sleep problems. *Sleep*, 34(10), 1403–1410. <https://doi.org/10.5665/SLEEP.1288>
- Magnusson Hanson, L. L., Leineweber, C., Persson, V., Hyde, M., Theorell, T., & Westerlund, H. (2018). Cohort profile: the Swedish longitudinal occupational survey of health (SLOSH). *International Journal of Epidemiology*, 47(3), 691–692i. <https://doi.org/10.1093/ije/dyx260>
- Magnusson Hanson, L. L., Peristera, P., Chungkham, H. S., & Westerlund, H. (2017). Psychosocial work characteristics, sleep disturbances and risk of subsequent depressive symptoms: A study of time-varying effect modification. *Journal of Sleep Research*, 26(3), 266–276. <https://doi.org/10.1111/jsr.12494>
- Newsom, J. T. (2015). *Longitudinal Structural Equation Modeling*, 1st edn. New York: Routledge.
- Nordin, M., Åkerstedt, T., & Nordin, S. (2013). Psychometric evaluation and normative data for the Karolinska Sleep Questionnaire: Evaluation of the KSQ. *Sleep and Biological Rhythms*, 11(4), 216–226. <https://doi.org/10.1111/sbr.12024>
- Ohayon, M. M. (2002). Epidemiology of insomnia: What we know and what we still need to learn. *Sleep Medicine Reviews*, 6(2), 97–111. <https://doi.org/10.1053/smr.2002.0186>
- Ohayon, M. M. (2005). Prevalence and correlates of nonrestorative sleep complaints. *Archives of Internal Medicine*, 165(1), 35–41. <https://doi.org/10.1001/archinte.165.1.35>
- Roth, T. (2007). Insomnia: definition, prevalence, etiology, and consequences. *Journal of Clinical Sleep Medicine*, 3(5 Suppl), S7–S10.
- Roth, T., Zammit, G., Lankford, A., Mayleben, D., Stern, T., Pitman, V., ..., Werth, J. L. (2010). Nonrestorative sleep as a distinct component

- of insomnia. *Sleep*, 33(4), 449–458. <https://doi.org/10.1093/sleep/33.4.449>
- Sacco, L. B., Leineweber, C., & Platts, L. G. (2017). Informal care and sleep disturbance among caregivers in paid work: longitudinal analyses from a large community-based Swedish cohort study. *Sleep*, 41(2), <https://doi.org/10.1093/sleep/zsx198>
- Schwarz, J., Gerhardsson, A., vanLeeuwen, W., Lekander, M., Ericson, M., Fischer, H., ..., Åkerstedt, T. (2018). Does sleep deprivation increase the vulnerability to acute psychosocial stress in young and older adults? *Psychoneuroendocrinology*, 96, 155–165. <https://doi.org/10.1016/j.psyneuen.2018.06.003>
- Statens beredning för medicinsk utvärdering (2013). *Arbetsmiljöns betydelse för sömnstörningar: En systematisk litteraturöversikt*. Stockholm: SBU, Statens beredning för medicinsk utvärdering.
- van Dalsen, J. H., & Markus, C. R. (2018). The influence of sleep on human hypothalamic–pituitary–adrenal (HPA) axis reactivity: A systematic review. *Sleep Medicine Reviews*, 39, 187–194. <https://doi.org/10.1016/j.smrv.2017.10.002>
- Van Laethem, M., Beckers, D. G. J., Geurts, S. A. E., Garefelt, J., Magnusson Hanson, L. L., & Leineweber, C. (2018). Perseverative cognition as an explanatory mechanism in the relation between job demands and sleep quality. *International Journal of Behavioral Medicine*, 25(2), 231–242. <https://doi.org/10.1007/s12529-017-9683-y>
- Wilkinson, K., & Shapiro, C. (2012). Nonrestorative sleep: Symptom or unique diagnostic entity? *Sleep Medicine*, 13(6), 561–569. <https://doi.org/10.1016/j.sleep.2012.02.002>
- Zaslavsky, O., LaCroix, A. Z., Hale, L., Tindle, H., & Shochat, T. (2015). Longitudinal changes in insomnia status and incidence of physical, emotional, or mixed impairment in postmenopausal women participating in the Women’s Health Initiative (WHI) study. *Sleep Medicine*, 16(3), 364–371. <https://doi.org/10.1016/j.sleep.2014.11.008>
- Zhang, J., Lamers, F., Hickie, I. B., He, J.-P., Feig, E., & Merikangas, K. R. (2013). Differentiating nonrestorative sleep from nocturnal insomnia symptoms: Demographic, clinical, inflammatory, and functional correlates. *Sleep*, 36(5), 671–679. <https://doi.org/10.5665/sleep.2624>

**How to cite this article:** Garefelt J, Platts LG, Hyde M, Magnusson Hanson LL, Westerlund H, Åkerstedt T. Reciprocal relations between work stress and insomnia symptoms: A prospective study. *J Sleep Res*. 2020;29:e12949. <https://doi.org/10.1111/jsr.12949>