Dear readers,

Since I am the first one out within this research school to have a half time seminar and since there are no formal (nor informal) guidelines on what to include in this document, I have tried my best to explain what I have done so far, what I am planning to do and how it all is suppose to go together.

The overall purpose of my thesis is to study how work and retirement affects subjectively and objectively assessed sleep. The plan is to conduct four studies on the relation between work and sleep - before, around and after retirement. The first two studies tries to answer the question how the work environment and sleep interrelate. Study I focuses on the relation between sleep disturbances and psychosocial and physical work environment. The second study will look deeper into the relation between psychosocial work environment, perceived stress and feelings of non-restorative sleep, that is, fatigue and tiredness upon awakening despite “a full night’s sleep” (a term/definition I will discuss more in my ‘kappa’). In study III, I will analyse trajectories of sleep (mid sleep, sleep length, sleep quality, sleep disturbances) around retirement related to previous work exposure. In study IV, I will look at objective sleep measures in a sub-sample (n=100) of people whom are about to retire. This group will be recruited from the cohort the three first studies are based upon: SLOSH, Swedish Longitudinal Occupational Survey of Health.

Manuscript I (attached) is based on my master thesis at CHESS, supervised by Torbjörn Åkerstedt. Since then, we have redone the study for submission to SLEEP, which is now finally accepted for publication.

Manuscript II is still “work in progress” and unfortunately not yet ready for submission (draft attached). After input from the commentators at my “higher seminar” Nov 26th 2014 I have redone many of the analyses and made a new mediational model with structural equation modelling.

Study III is still at the drawing board and no analyses has been done yet. The research question is if trajectories of sleep differ depending on previous exposures in their work environment. In this study, I will look at data from people who have retired during the data collection and use Generalized Estimating Equations to analyse their trajectories on sleep around retirement.
Study IV will differ somewhat from the first three, since I will have objective measures of sleep to analyse. During this year I have participated in the planning of the data collection, including development and pilot testing of a sleep diary and a questionnaire as well as different methods to objectively measure sleep and physical activity (actigraphy/accelerometers). The pilot study is now completed and sharp data collection just started. See more info about my studies in my PhD-plan.

Regarding courses, I have taken 53 credits (out of 75) so far, whereof 27 are credited from my two-year master program in population health at CHESS, Stockholm University (see Yearly follow-up, Year 1). None of the credited courses formed the basis for admission as a doctoral student.

Attached you will find my PhD plan, together with Study I and Study II.
To the half time committee I also attached
I) Individual study plan
II) Yearly follow-up
III) Ladok transcripts and other documentation regarding my progress so far

IV) PhD plan ......................................................................................................................................................... 3

V) Study I (Manuscript, accepted for publication in SLEEP 2015-01-10) ................................................. 6

VI) Study II (Manuscript, draft) ................................................................................................................................. 24

With kind regards,
Johanna Garefelt, PhD student
Stress Research Institute, Stockholm University
@: Johanna.garefelt@su.se
T: 0767788461
IV) PhD plan
Johanna Garefelt, updated 17\textsuperscript{th} Feb 2015

**Title:** Work, retirement and sleep: Prospective studies of how work environment and retirement influence subjectively and objectively assessed sleep.

**Purpose of the thesis:** Study how work and retirement affects subjectively and objectively assessed sleep.

**Manuscripts/Studies**

**MS I:** Work and sleep – a prospective study of psychosocial work factors, physical work factors and work scheduling

**Main research question:** How does the relation between sleep disturbances and the physical and psychosocial work environment look like?

**Data:** SLOSH, questionnaire data from 2008 and 2010.

**Method:** SEM.

**Status:** Submitted to SLEEP, September 2014. Accepted in January 2015. See attached manuscript.

**MS II:** Prospective relation between stress and nonrestorative sleep in the Swedish working population

**Main research question:** To what extent the psychosocial work environment affects the occurrence of nonrestorative sleep and if this relation is mediated by the stress reaction.


**Method:** SEM.

**Status:** On-going analyses and writing. See attached draft.

**MS III:** Trajectories of sleep length, mid sleep, and sleep quality around retirement

**Main research question:** How does retirement affect different aspects of sleep?


**Method:** Generalized Estimating Equations (GEE)/Latent Growth Curve modeling.

**Status:** Planned.

The basic idea to replicate the study of Vahtera et al., published in SLEEP 2009, who found that retirement was associated with decreased sleep problems, especially among those with poor work environment before retirement (see figure 1). The study is based upon the Gazel cohort (Gazel is a
French state owned gas and electricity company) where the retirement age is around 55 years, why the need for a replication study with higher de facto retirement age is needed. In the SLOSH cohort people have responded every second year between 2006 and 2014, where some of the respondents hopefully have retired between two of these waves. The disadvantage compared to the Gazel cohort is the number of observations is a lot smaller (5 vs 15) and timing of collection every second year (instead of every year). The advantage with the SLOSH, beside the higher retirement age, is that the cohort is approximately representative for the working population in Sweden, with a variety of people in different occupations and socioeconomic positions. However, power calculations needs to be done to evaluate if this study is possible to do with the SLOSH database (which will depend on the number of people who have retired and answered at least one questionnaire before and after). The advantage with GEE is that the method can handle missing data, since there will be more people with only two data points than three or four. If needed, there might be a possibility to merge several cohorts with the same retirement age and measures of sleep to enable the analyses. The study will add knowledge about what happens with the sleep when people retire, and if there are different trajectories between groups with different previous work exposure (e.g. high work demands and stress, or low control).

The study will also analyse differences in sleep trajectories related to gender and age of retirement, which differ also within the Swedish population.

Figure 1. Sleep disturbances in relationship to retirement. Annual prevalence (95% confidence interval [CI]) within ± 7 years to retirement derived from repeated-measures logistic-regression analyses with generalized estimating equations adjusted for time of data collection (1989-99 or 2000-07). (Vahtera et al. 2003, SLEEP)
MS IV: Job strain as predictor of objective sleep disturbances

Main research question: Is there a prospective relation between work stress and objective sleep measures before retirement?


Method: Multi-level analysis or growth curve modelling of day-to-day variations in sleep (objective and subjective measures) related to current and previous exposure from work.

Status: During the fall we have been pilot testing a questionnaire and a sleep and wakefulness diary that will be used for subjective day-to-day measures of sleep, work, health etc. We have also been piloting actigraphs for objective sleep measures and physical activity measures, which – after some adjustments - have worked out well. Sharp data collection just started last month, January 2015. We recruit respondents between 62-67 years (n=100) from the SLOSH cohort who are about to retire during 2015 to fill in sleep/wake diaries and wear the actigraphs during one week approximately 3-6 months before their retirement. Then we will follow them for two years with one week of data collection, during the same period every year to avoid confounding of season, sunlight exposure, holidays etcetera. To use as a comparison group, we plan to recruit a smaller group of younger working (35-50 years, n=60, 30 women and 30 men to enable simple gender stratified analyses) who will do one week of intensive data collection during this year. In other words, the collection of data will be constantly on going during three years from now. I wont have time (according to my PhD-plan) analyse the follow-ups, which are planned to be ready by the end of 2017. Instead, I will analyse the first measure, when they are all still working – and relate their objective sleep measures to current (questionnaire data) and previous (SLOSH-questionnaire) self-reported exposure of psychosocial work environment (e.g. demands, social support, stress). I will then compare the results of the future pensioners with the younger group, to see if there are differences – both in exposure of work environment as well as in the sleep measures. The study will add knowledge about the exposure from work on daily sleep measures. A comparison between objective and subjective measures of sleep will also be possible within this study.
V) Study I (Manuscript, accepted for publication in SLEEP 2015-01-10)

Work and sleep – a prospective study of psychosocial work factors, physical work factors and work scheduling

Torbjörn Åkerstedt1,3, Johanna Garefelt1, Anne Richter2,4, Hugo Westerlund1, Linda Magnusson-Hansson, Magnus Sverke2,5 & Göran Kecklund1,2

1 Stress Research Institute, Stockholm University
2 Department of psychology, Stockholm University
3 Clinical neuroscience, Karolinska Institutet, Stockholm, Sweden
4 Department of Learning, Informatics, Management and Ethics, Medical Management Centre (MMC), Karolinska Institutet, Stockholm, Sweden
5 WorkWell: Research Unit for Economic and Management Sciences, North-West University, South Africa

Study objectives: There is limited knowledge about the prospective relationship between major work characteristics (psychosocial, physical, scheduling) and disturbed sleep. The present study sought to provide such knowledge.

Design: Prospective cohort with two measurements (T1 and T2) across two years.

Setting: Naturalistic study.

Participants: 4827 persons in a representative sample of the working population.

Measurements and results: Questionnaire data on work factors obtained at two points in time was analysed with structural equation modelling. Competing models were compared in order to investigate temporal relationships, and a reciprocal model fitted the data best. Sleep disturbances at T2 were predicted by higher work demands at T1 and by lower perceived stress at T1. In addition, sleep disturbances at T1 predicted subsequent (higher) perceptions of stress, work demands, lack of control as well as lack of social support at work at T2. A cross-sectional mediation analysis showed that perceived stress mediated the relationship between work demands and sleep disturbances; however, no such association was found longitudinally.

Conclusions: Work demands, but not physical work characteristics, shift work or overtime work, predicted disturbed sleep. In addition, disturbed sleep predicted subsequent higher work demands, perceived stress, lack of social support and lack of control. The results suggest that remedial intervention against sleep disturbances should focus on psychosocial factors and that sleep interventions may improve the psychosocial work situation in the long run.

Key words: Sleep, demand, control, support, stress, physical work factors, longitudinal, cross-lagged, SEM
Introduction

Complaints of disturbed sleep are common, and a major factor is stress at work or in private life. Stress typically involves increased physiological and psychological arousal in response to external demands, and increased arousal is associated with disturbed sleep. Thus, a clear link can be expected between work stress and subsequent sleep disturbances, and has indeed been demonstrated in several prospective studies. Ribet et al were the first to show such a link, using the stress indicator “having to hurry”. Using a more established work stress indicator, the demand/control/support model, de Lange et al showed that a change from low to high job strain (i.e., going from high influence and low work demands to low influence and high work demands) was associated with increased sleep problems and fatigue between two measurement occasions. Two other studies have shown similar results regarding strain. In another study Magnusson Hanson et al used structural equation modeling and found no significant link between work demands and subsequent sleep problems. When studying changes in working conditions between two points in time, Akerstedt et al found that increased work demands, as well as preoccupation with work, predicted new cases of disturbed sleep. It should be noted that the focus of the studies cited above was external demands that could lead to a stress reaction, not the experience of stress itself. Social support at work may protect against stress and disturbed sleep, possibly because it provides a buffer to high work demands and/or low degree of control. However, no clear relation was observed between demands at work and sleep in an earlier prospective study.

Work schedules may also influence sleep. Sleep complaints have been found in several prospective studies of night shift workers. Some evidence of prospective negative effects on sleep has also been reported in association with overtime and long working weeks. Other aspects of work scheduling do not seem to have been addressed. Another work-related factor that may affect sleep is the physical demands of the work task, such as awkward work positions or heavy lifting or carrying. However, Ribet et al found no prospective evidence of this, and no other studies could be found in the literature. The direct physical environment at work, such as loud noise or extreme temperatures or lighting conditions, may also be assumed to affect sleep quality, but the only previous study on this issue revealed no effects of extreme temperatures or noise in the work place. It is clear that there is a need for more research into physical work factors and their effects on sleep.

Although the Ribet et al study revealed important information regarding work characteristics and sleep disturbances, the study had several limitations. For instance, it did not measure exposure at both
time points, nor did it control for sleep disturbances at the start. Furthermore, the sample only included individuals from 37 to 52 years of age and was not a representative national sample. The present study sought to improve on the Ribet et al approach by investigating the prospective relation between a variety of work environment factors (stress, demands, control, support, physical work load, physical work environment, and work scheduling) and disturbed sleep in a representative national sample with two waves of measurements. Since impaired sleep may affect emotional responses, also reverse relations were investigated, that is, how sleep disturbances relate to subsequent perceptions of work factors. In addition, the present study also introduces a measure of the perception of stress as a complement to work demands and as a possible mediator of a potential relation between work demands and sleep disturbances.

**Methods**

*Design and participants*

The study is based on the Swedish Longitudinal Occupational Survey of Health, SLOSH. This is a nationally representative longitudinal study with follow-ups every second year (from 2006). It has its origin in the Swedish Work Environment Survey (SWES, www.scb.se), which in turn is based on nationally representative samples of the working population. Earlier waves from this cohort have been studied by Magnusson Hansson et al regarding demands at work and their effects on sleep. The Regional Research Ethics Board in Stockholm approved the present study.

In the present study, we used data from the second wave in 2008 (T1) and the third wave in 2010 (T2). In the 2008 wave of SLOSH, all eligible participants from SWES 2003 or 2005 were invited to participate (N=15,147). A total of 11,441 individuals replied, of which 9756 were gainfully employed. In that group, 6580 people responded and were also gainfully employed in 2010 (Figure 1). As this study was focused on work characteristics, we used data only from those gainfully employed at both T1 and T2 (N=6580), thereby excluding individuals on sick leave or parental leave, or who were retired or unemployed at T1 or T2. The dropout rate between T1 and T2 was 28% (N = 2311). The number of respondents for which valid data were available for all variables investigated in this study at T1 was 5489, but 662 of these individuals had missing values at T2, resulting in an internal dropout rate of 12.1%. The final sample thus consisted of 4827 participants.

An analysis was conducted to investigate whether dropout (non-response) at T2 could be predicted by demographic, work environment or sleep disturbance variables at T1. Logistic regression analysis indicated that overall non-response dropout at T2 could be predicted ($\chi^2(12) = 276.35, p <.001$). Dropout was lower for women than for men (OR=0.74, p <.001), and among individuals with at least...
three years of education at university level, compared to the rest (OR 0.85, p<.001). Younger employees (age in years, OR=0.96, p < .001) and those having physically demanding work tasks (OR=1.08, p < .001) had a higher tendency to drop out at T2. Another logistic regression analysis was performed to investigate whether internal dropout at T2 (due to missing values) could be predicted by the same variables. The results showed that overall internal dropout at T2 could be predicted ($\chi^2$(12) = 64.48, p <.05). Further investigations of the results showed that the internal dropout rate was higher for women than for men (OR=1.24, p <.05). Older employees (OR=1.03, p <.001) and those with demanding physical work (OR=1.11, p <.01), as well as those working shifts (OR=1.29, p <.05) had a higher tendency for missing values at T2. Moreover, individuals reporting a higher degree of control at T1 were more likely to have missing values at T2 (OR=1.25, p <.05).

Figure 1 about here

Questionnaire

Information regarding sex, age, and socioeconomic position (SEP) were obtained from national register data at T1. SEP was defined by educational level (3 or more years of university education versus all other forms of education). For the other constructs investigated, items were selected as indicators based on reliability and confirmatory factor analyses. Items with a factor loading below 0.4 were removed in order to obtain a reasonable model fit. Table 1 shows the correlations between the variables at T1 and T2, and between T1 and T2.

Psychosocial variables

Four items representing disturbed sleep were selected from the 14-item Karolinska Sleep Questionnaire (KSQ) (Cronbach’s alpha > 0.70). The scale differentiates patients with insomnia from healthy individuals and correlates with perceived stress, anxiety, depression and burnout ($r >.40$). The items included are: difficulties falling asleep, restless sleep, repeated awakenings, and premature awakening. The responses range from “never” to “most days of the week” (values from 1-6 being assigned). Cronbach’s alpha was 0.84 at both T1 and T2 in the present study, and the correlation between time points was $r = .71$.

Work demands were measured using the Swedish version of the Demand-Control-Support Questionnaire. This scale has been extensively psychometrically investigated and used to predict health outcomes of psychosocial work factors. The three items that were selected (considering factor loadings) were: Do you have to work very intensively? Does your work demand too much effort? Do you have enough time to do everything? (reverse coded). The items excluded were: Do you have to work very fast? and Does your work often involve conflicting demands?. The response
alternatives range from 1: Hardly ever/never, to 4:Yes, often. Cronbach’s $\alpha$ was 0.67 at T1 and 0.66 at T2, and the test-retest reliability between T1 and T2 was $r = .56$. Higher values on this scale indicate higher perceived work demands.

Control at work was measured as an index of three questions (based on factor loadings from the Demand-Control-Support Questionnaire (Do you have to do the same thing over and over again?, Do you have a choice in deciding how you do your work?, Do you have a choice in deciding what you do at work?). The following items were excluded: Does your work require a high level of skill or expertise? Does your work require ingenuity? Do you have the possibility of learning new things through your work? High values indicate a high degree of control. The response alternatives were the same as for the work demands. Cronbach’s $\alpha$ was 0.62 at both T1 and T2 and the test-retest reliability between T1 and T2 was $r = .62$.

Social support at work was measured as an index of five statements (There is a calm and pleasant atmosphere where I work; There is a good spirit of unity; My colleagues are there for me; People understand that I can have a bad day; I get on well with my colleagues). The following item was removed: I get on well with my superiors. Response alternatives ranged from 1: Strongly disagree, to 4: Strongly agree. Cronbach’s $\alpha$ was 0.84 at T1 and 0.86 at T2 and the test-retest reliability between T1 and T2 was $r = .56$. It should be emphasized that this scale focuses only on support at work, in contrast to many other social support scales.

Physical work environment, scheduling and work hours

“Shift work” refers to any type of scheduling system that includes non-daytime work, that is, night work, three-shift work, two-shift work, day-oriented roster work, permanent morning work (starting before 0700h), or permanent afternoon work (starting after 1200h). “Long working hours” (overtime work) was defined as usually working $\geq 46$ hours per week (using 36-45 h/week as a reference).

Physically demanding work tasks were measured as an index of three questions (Is your work such that you have to use bent, twisted or otherwise unsuitable positions? Do you have to lift at least 15 kilos several times a day? Does your work sometimes involve heavy physical labor, that is, do you physically exert yourself more than when walking and standing and moving around in a normal way?). Response alternatives ranged from 1: No, not at all to 6: Almost all the time. Cronbach’s $\alpha$ was 0.89 for both T1 and T2 and the test-retest reliability between T1 and T2 was $r = .85$. 


Physically demanding work environment was measured using three questions on exposure to poor or excessively bright light, noise, and excessive heat, cold or draught. These questions have been constructed and used by Statistics Sweden since the late 1980's in their surveys of the working environment in Sweden. Validation and “calibration” against objectively measured work environment factors were carried out before using the questions in surveys. The six response alternatives range from 1: No, not at all to 6: Almost all the time. Cronbach’s $\alpha$ was 0.89 for both T1 and T2 and the test-retest correlation between T1 and T2 was $r=.71$.

Although the present study was focused on work factors, it was considered of interest to also investigate whether a more generic stress scale could serve as a complement to the traditional work demand scale. However, the available generic stress scales include items (for example, “angry”, “forgotten to do something”, “not in control”) that do not represent the original notion of an arousal response to demands, which constitutes the original concept of stress. Generic perceived stress, as measured in this study, was an index of three questions on feelings during the last three months, reasonably in line with the original concept (I have days when I feel wound up all the time; I have days when I feel very pressured all the time; I have days when I feel stressed all the time). Response alternatives ranged from 1: Not at all, to 4: Almost all the time. A three-month period was chosen since this should provide a better indication than “the present moment” or “the last few days”. Cronbach’s $\alpha$ was 0.80 at T1 and T2. As this was the first time this scale was used, we also computed correlations that may be useful psychometrically. It can be seen from Table 1 that the stress rating at T1 correlated ($r = 0.61$) with the same variable at T2, ($r = 0.47$; $p<.001$) with the work demand index at T1. The stress rating also correlated with “difficulties relaxing in the evening” at T1 ($r = 0.61$; $p<.001$), and with “often tense” at T1 ($r = 0.58$; $p<.001$). The latter two items were derived from other parts of the questionnaire (response range 1-5). The new stress index was called “Perceived Stress”.

Statistical analysis

In order to test the relationships, structural equation modeling was applied using IBM SPSS Amos 20.0. The maximum likelihood method was selected as the estimation procedure. In order to ensure that the data were normally distributed, they were screened for kurtosis and skewness; we found no kurtosis values greater than 10 or skewness values greater than 3. Moreover, none of the variables was highly correlated (defined as $r>0.85$) and $r$ did not exceed .70 in the present study (except for 4 variables for which the T1 and T2 variables were correlated), thus reducing the risk of
multicollinearity. In order to test the associations between sleep disturbances and the work environment indicators, four different cross-lagged models were fitted.

1. A stability model including the auto-regressions of all variables (Model 1).
2. A causal model including eight paths between the work environment indicators at T1 and sleep disturbance at T2, in addition to the auto-regressions (Model 2).
3. A reversed causal model including eight paths, between sleep disturbance at T1 and the work environment indicators at T2, in addition to the auto-regressions (Model 3).
4. A reciprocal model including all the paths in the previous models (Model 4).

To set the scale of the latent variables, one factor loading per latent variable was fixed. The model fit was evaluated using the comparative fit index (CFI), the non-formed fit index (NNFI), and the root mean square error of approximation (RMSEA) to complement the Chi-square fit statistic. The following approximate cut-off criteria were used to evaluate the model fit: for the CFI, values close to or above .97; for the NNFI, values greater than .95, and for the RMSEA, values below .06. The chi-square difference test was used to compare different nested models.

The four models were systematically evaluated by comparing the baseline model (Model 1) to the more complex models (Models 2, 3, 4) using the chi-square difference test. A lack of statistically significant difference in chi-square values would indicate that the baseline model explains the data as well as the more complex model with additional paths. The other fit indices were also used to choose the best-fitting model.

In order to correct for systematic method variance associated with each indicator, the item-specific measurement errors were allowed to correlate over time. Moreover, constructs were allowed to correlate within time points in all models in order to account for contemporary relations. Measurement-specific errors were allowed to correlate to improve the model fit. The effects of sex, age and SEP on the T1 variables under investigation were adjusted for in all models.

In order to further investigate the relation between sleep disturbances, demands at work and perceived stress, mediation analysis was applied. First, cross-sectional mediation was investigated, where the indirect effect of work demands, through perceived stress, on sleep disturbance was tested using Sobel’s test. The potential power problems associated with Sobel’s test were considered small due to the large sample size. In order to investigate longitudinal mediation with two waves, a procedure proposed by Taris and Kompier was employed. The cross-lagged relationship between T1 work demands and T2 perceived stress was investigated together with the cross-lagged relationship between T1 perceived stress and T2 sleep disturbance. Only conclusions on partial (as opposed to full) mediation can be drawn from studies with only two waves. In order to estimate
the magnitude of the indirect effects, the two cross-lagged relationships (i.e., T1 work demands → T2 perceived stress and T1 perceived stress → T2 sleep disturbance) were multiplied. Again, a Sobel test was conducted to formally investigate the indirect effect.

**Results**

Table 1 provides descriptive statistics, reliabilities, and intercorrelations between all the variables studied. In accordance with expectations, sleep disturbances were associated with perceived stress, work demands and support, within, as well as over, time. Overall, the variables were rather stable over the two-year time period, apart from working hours, which had a stability of .41 (see Figure 2).

Table 1 about here

Table 2 gives the fit statistics for the cross-lagged models. All models exhibited significant chi-square values, which could be expected due to the large sample size; however, the additional fit indices indicated acceptable fits to data for all four models. Comparisons between the stability model (Model 1) and the other three models revealed that Models 3 and 4 gave a significantly lower value of chi-square, thus indicating a better fit. The reciprocal model (Model 4), however, showed the greatest decrease in chi-square ($\Delta \chi^2=60.33$, df=14, $p<.05$) and this model was thus identified as the model giving the best fit.

Table 2 about here

Figure 2 shows the significant standardized path estimates for the reciprocal model, and it can be seen that higher work demands at T1 were related to higher levels of sleep disturbance at T2, while perceived stress at T1 was associated with lower levels of sleep disturbances at T2, after adjusting for sex, age and SEP. Moreover, sleep disturbances at T1 were related to higher perceived stress and work demands, as well as a lower degree of control and support at work at T2, after adjusting for sex, age, and SEP.

Since the negative beta coefficient for perceived stress and disturbed sleep was unexpected, we also carried out structural equation modeling using only perceived stress or work demands in combination with disturbed sleep. The results of this were as expected. Stress at T1 predicted subsequent sleep disturbances ($\beta=.06$, $p<.05$) and vice versa ($\beta=.13$, $p<.05$). A similar pattern was found with regard to demands at work. Demands at T1 predicted subsequent sleep disturbances ($\beta=.03$, $p<.05$), and vice versa ($\beta=.04$, $p<.05$).
Since perceived stress was seen as a complement to work demands, and assumed to be related to disturbed sleep, a mediation model (demands-stress-sleep disturbances) was applied. No mediation could be detected in the longitudinal analysis; demands were positively related to perceived stress ($\beta=.05, p<.05$), but perceived stress was not related to subsequent sleep disturbances ($\beta=.001, p>.05$). The indirect effect was not significant ($z = 0.057, p>.05$). However, mediation was found in the cross-sectional analysis. Demands were positively related to perceived stress ($\beta=.29, p<.05$) and perceived stress was positively related to sleep disturbances ($\beta=.60, p<.05$). The indirect effect was significant ($z = 15.1, p<.05$). In addition, work demands had an effect on sleep disturbance ($\beta=.27, p<.05$).

**Discussion**

The reciprocal model showed the best fit to the data. Our main hypothesis, of a forward “causal” pathway between work demands and sleep disturbances, was partly confirmed by the significant relationship between work demands at T1 and sleep disturbances at T2. Perceived stress showed an unexpected negative relation to disturbed sleep. No significant relationships were seen for control at work, social support, physical work factors, work schedules, or working hours. The reciprocal model also showed significant paths between sleep disturbances at T1 and work demands, stress, control at work, and social support at T2, indicating the presence of reversed causal paths.

The results regarding work demands are in line with those from several other prospective studies $^{8,10,13,14}$, although the effect found in the present study was modest. However, an important and new observation is that the prospective relation between work demands and disturbed sleep persisted in an analysis containing variables representing the physical aspects of work, shift work, overtime, and social support at work. It is important to take the two-year time lag into account when interpreting the results. It is possible that other time lags may have yielded stronger (or weaker) relationships. There is, however, no indication of the optimal time lag for the variables used in the present study, or for the variables used in most other observational studies. This is clearly an important topic for future research.

The unexpected negative association between perceived stress at T1 and sleep disturbances at T2 appeared despite a significant bivariate positive correlation between the two variables over time and a strong cross-sectional correlation. Both correlations were stronger than those between work demands and sleep disturbances. Furthermore, the cross-sectional mediation of perceived stress between
demands and sleep disturbance was significant. When the structural equation modeling was restricted
to perceived stress only, the path from T1 to T2 was significant and the coefficient positive (as was
that of work demands). These observations suggest that the negative coefficient for perceived stress
in the main analysis was due to suppression effects or, possibly, that stress at T1 might perhaps have
affected life style related to sleep. In terms of psychometrics, the perceived stress index showed high
internal consistency and test-retest reliability. It was also correlated with work demands, as well as
with the item “tension”, which suggests construct validity.

As in our previous studies \textsuperscript{13,14} control at work was not significantly related to subsequent sleep
disturbances. The dropout rate among those with a low degree of control was higher, but this cannot
explain the results since the correlation between control at T1 and disturbed sleep at T2 was \( r = .04 \),
and the cross-sectional correlations at T1 and T2 were \( r = .02 \) and \( r = .04 \), respectively. Thus, the
relation was very small at both points in time, and actually increased at T2, which would not have
been the case if dropout had affected the results (i.e., reduced the correlation). Possibly the reduced
reliability could have contributed to the lack of effects. The finding that (poor) social support failed to
predict later sleep disturbances was unexpected, considering previous findings, \textsuperscript{14,46,47} however, it is in
line with findings reported by Magnusson Hansson et al.\textsuperscript{13}. The cross-sectional correlation with
disturbed sleep was significant, and it may be that social support is important when support and sleep
are measured closer together in time.

Regarding the effects of work scheduling, the lack of a significant association between shift work and
disturbed sleep differs from our previous findings \textsuperscript{14}. However, we only adjusted for one physical
work environment variable – heavy work – in our previous study, while more aspects of the physical
working environment were included in the present study. Furthermore, in a previous prospective
study in a representative sample on the effects of starting or ending shift work we found that mainly
difficulties in falling asleep were influenced by these changes \textsuperscript{18}. It could thus be that the lack of effect
in the present study is the result of including other indicators of disturbed sleep in the index, such as
restless sleep, frequent awakenings and premature final awakening. Indeed, workers on the night shift
tend not to report more disturbed sleep than day workers \textsuperscript{25}. The reason for the lack of reports of
disturbed sleep could be that shift workers do not consider their sleep to be disturbed because there is
a clear external cause (the temporal displacement of sleep). The dropout frequency was also higher
among shift workers, but it is unlikely that this will have affected the results since the correlation
between shift work at T1 and disturbed sleep at T2 was low (\( r = .03 \)), and the cross-sectional
correlations between shift work and disturbed sleep were also low (\( r = .03 \) at T1 and \( r = .02 \) at T2).
The lack of any significant association between long hours of work and disturbed sleep is in contrast to the findings of previous studies, but very few individuals with long working weeks were included in the present study, compared to the studies cited. Thus, the range of variation may have been restricted. Also, as with shift workers, those with long working hours may not regard their sleep as being disturbed, rather curtailed by external factors. However, this requires further investigation.

The physical workload variables were not prospectively related to disturbed sleep. There is little data to compare our findings with, but we have previously found heavy physical work load to be associated with disturbed sleep in a cross-sectional study, but not in a longitudinal one. The dropout rate was higher among individuals with higher physical work load, but this is unlikely to have affected the results of the present study since the correlation between physical work load at T1 and disturbed sleep at T2 was low, as were the cross-sectional correlations (at T1 and T2, respectively). Furthermore, the analyses concerning physical working environment variables did not suggest a higher risk of subsequent sleep disturbances. Since this association has not been studied previously, caution should be exercised when drawing conclusions.

The second major finding of this study was that disturbed sleep at T1 predicted several psychosocial variables at T2. Both perceived stress and work demands were higher with prior sleep disturbance. Neither Magnusson Hanson et al. nor de Lange et al. found any similar reversed effects on demands. One reason for this, at least in the latter study, may have been that the sample was relatively young. Our findings with respect to stress agree with recent experimental results showing that disturbed sleep increases responses to stressors, and that sleep loss reduces the control of the prefrontal cortex over the amygdala, leading to increased emotional reactivity. It is also a common observation that sleep loss causes sleepiness/fatigue and impaired performance, and these may in turn lead to demands at work being seen as more difficult to handle than would otherwise be the case. It is also likely that a similar mechanism could apply to social support and control at work. Magnusson Hansson et al. also reported an association between sleep disturbances and later social support, whereas no significant paths were observed between disturbed sleep and control or work demands. These issues are important in understanding the relationship between sleep and working life, and there is a need for further research in these areas. Furthermore, it is noteworthy that disturbed sleep showed no reverse causality pattern with physical work factors.
A limitation of the present study is that more waves may be needed to gain a better understanding of the prospective links. Thus, the present results are merely suggestive. Another limitation is that no detailed information was available on changes in disturbed sleep (or in predictors) within the two-year interval studied. Major life events may occur such as divorce, bereavement, etc. There is also a moderate day-to-day co-variation between self-reported stress and sleep in normal sleepers, but no knowledge is available on the amount or duration of demands or stress exposure that causes more chronic sleep disturbances. Day-to-day variation in sleep quality seems to be relatively high in patients with insomnia, but considerably smaller in normal sleepers. Also, the correlation between sleep quality at T1 and T2 was high in the present study, suggesting considerable stability. Clearly, there is a need to study the relation between disturbed sleep and its causes, using shorter intervals between measurements. Another potential problem may be that the questions on work-related exposure asked about the respondents’ “work situation”, which was probably interpreted as meaning at the present time, in contrast to the questions on self-reported stress, which referred to the past three months. The reason for the latter was that there was a need for an anchor similar in time to what may be meant by the “present work” concept. This still resulted in some lack of clarity with respect to timing, which may have influenced the results.

A weakness of the study is the loss of some items with low factor loadings in order to improve model fit. The result may have been more unreliable scales, but Chronbach’s alpha values were still acceptable. There may also have been a reporting bias, that is, a dispositional tendency of an individual to report both psychosocial adversity and more health symptoms. This phenomenon is probably present in most studies on psychosocial factors and health, and may affect the associations between such variables. On the other hand, a certain amount of consistency across predictors would then be expected. In the present case control at work did not show any significant relation to disturbed sleep, which would have been expected had the subjectivity bias been strong. The “healthy worker effect” is another factor that must be taken into consideration since our sample only included gainfully employed individuals. Length of employment may have been of importance in the present context, but this information was not available for analysis.

In summary, the present study has shown that high work demands predict self-reporting of disturbed sleep two years later, but also that disturbed sleep predicts increased levels of perceived stress, work demands, (lack of) work control, and (lack of) social support two years later. Physical work factors and work scheduling seem to have no prospective relation to sleep disturbance. The results imply that remedial interventions to alleviate sleep disturbances should focus on psychosocial factors, and that
interventions to improve sleep may be important in reducing stress and negative views of work, and perhaps life in general.

References

47. Nordin M, Knutsson A, Sundbom E. Is disturbed sleep a mediator in the association between social support and myocardial infarction? Journal of Health Psychology 2008;13:55-64.
Table 1. Means, standard deviations, reliability (Cronbach's alpha in parentheses), and inter-correlations (N=4827).*
Table 2. Results of the test of the structural models: cross-lagged effects (N=4827)

<table>
<thead>
<tr>
<th>Model comparison</th>
<th>df</th>
<th>$\chi^2$</th>
<th>CFI</th>
<th>NNFI</th>
<th>RMSEA</th>
<th>$\Delta df$</th>
<th>$\Delta \chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. autoregression model (free)</td>
<td>1288</td>
<td>6654.80*</td>
<td>.960</td>
<td>.953</td>
<td>.029</td>
<td></td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>2. causal model</td>
<td>1280</td>
<td>6642.37*</td>
<td>.960</td>
<td>.953</td>
<td>.029</td>
<td>1 vs 2</td>
<td>8</td>
<td>.13</td>
</tr>
<tr>
<td>3. reversed causal model</td>
<td>1280</td>
<td>6604.72*</td>
<td>.960</td>
<td>.954</td>
<td>.029</td>
<td>1 vs 3</td>
<td>8</td>
<td>.00</td>
</tr>
<tr>
<td>4. reciprocal model</td>
<td>1272</td>
<td>6592.16*</td>
<td>.953</td>
<td>.955</td>
<td>.029</td>
<td>1 vs 4</td>
<td>16</td>
<td>.00</td>
</tr>
</tbody>
</table>

Notes: *<.05

Figures

Figure 1. Illustration of dropout. See text.
Figure 2. Structural model (reciprocal): Standardized Coefficients. Non significant paths represented by dotted lines, all coefficients in the model are significant (p<.05). Other models not presented.
VI) Study II (Manuscript, draft)

Prosp ective relation between work demands and nonrestorative sleep in the Swedish working population
Johanna Garefelt¹, Martin Hyde², Arne Lowden¹, Torbjörn Åkerstedt¹,³
¹ Stress Research Institute, Stockholm University, Sweden
² School of Social Science, University of Manchester, United Kingdom
³ Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden

Abstract
Nonrestorative sleep is part of the insomnia diagnosis and refers to the subjective feeling of sleep not being sufficiently refreshing, despite normal sleep duration. Factors associated with nonrestorative sleep are being young and being female. The purpose of the present study was to investigate the extent to which work environment factors would predict the subsequent occurrence of nonrestorative sleep, and if this relation was mediated by perceived feelings of stress. The respondents were gainfully employed across four waves of the Swedish Longitudinal Occupational Survey of Health (SLOSH) between year 2008 and 2014 (N=3706, 57.5% women, mean age: 47 years T1). Nonrestorative sleep was measured by the Karolinska Sleep Questionnaire (KSQ): “Difficulties awakening” or “Not feeling refreshed at wake-up”, controlling for short sleep duration (<6 h). Data on psychosocial work environment, stress, health and sleep obtained at four time points was analysed with structural equation modelling. Competing cross-lagged models were compared in order to investigate temporal relationships between demands, perceived stress and nonrestorative sleep, where the reciprocal models had the best fit to data. Stress mediated the reciprocal relation between work demands and nonrestorative sleep (in both directions) across the six years, which indicates a potential vicious circle.

Key words: Stress, demands, nonrestorative sleep, work environment.
Introduction

Recent research has shown that there is a reciprocal relation between stress, work demands and disturbed sleep across two years (Åkerstedt et al., 2015, in press). The concept of “disturbed sleep” usually refers to difficulties in initiating or maintaining sleep (AASM, 2005). However, lately researchers have identified the feeling of insufficiently refreshing, or nonrestorative, sleep as an important sleep problem and today the diagnosis of insomnia includes either or both disturbed- and nonrestorative sleep (Edinger et al., 2004; Roth, 2007).

Whilst there is no standardised definition of nonrestorative sleep, it is generally agreed that it refers to the subjective feeling that sleep has not been sufficiently refreshing despite normal or longer than normal sleep duration (Roth, 2007; Stone et al. 2008; Wilkinson & Shapiro, 2012). It has also been suggested that a “full night’s sleep” should be present to rule out insufficient sleep duration as a cause being unrefreshed (Stone et al., 2008). The duration or definition of “a full night’s sleep” is however not established, and is also likely to differ between with gender, age and genetic factors (TÅ-ref*).

Experimental studies with polysomnography (PSG), have found that being well rested upon awakening across 14 sleep periods with sleep diary ratings correlated with ease of awakening, but not with ratings of restlessness, sleep latency, early awakening and other indicators of sleep continuity or sleep quality (Åkerstedt & Kecklund, 1997). This indicates that there seem to be at least two dimensions of sleep problems, albeit the term “nonrestorative” was not explicitly used.

Estimates of the prevalence of nonrestorative sleep vary between countries, from 2.5 % in Spain to 15 % in Germany and 16 % in the UK (Ohayon, 2005). These differences could be due to differences in definition and a lack of population-based studies (Roth, 2007; Wilkinson & Shapiro, 2012). The prevalence in Sweden has been estimated to 18 %, when considering respondents with nonrestorative sleep at least four times per week (Ohayon & Bader, 2010). In a review by Stone et al. (2008) it was recommended that unrefreshing or nonrestorative sleep should be present at least three times per week, during at least one month, to be labelled as such. For a more chronic state, duration is set to three months or more has been recommended (Stone et al., 2008; Wilkinson & Shapiro, 2012).

With respect to mental health, Ohayon and Bader (2010) showed that anxiety and depression was associated with problems initiating and maintaining sleep, but not with nonrestorative sleep. Nonrestorative sleep appears to be the second most important factor for predicting daytime consequences, such as fatigue, memory and cognitive performance (Ohayon, 2012; Sarsour et al.,
Factors associated with non-restorative sleep are: younger age and female gender (Ohayon & Bader, 2010; Stone et al., 2008), living in an urban area, alcohol consumption at bedtime (Ohayon, 2005) and traffic noise during the night (Halonen et al., 2012). The association between total sleep duration and sleep quality has been shown to be weaker among respondents suffering from nonrestorative sleep, compared to respondents without nonrestorative sleep (Sarsour et al., 2010). In addition, being a morning type is associated with early rising and ease of rising (Horne & Östberg, 1976). Yet, possible links to the particular concept of nonrestorative sleep does not seem to have been studied. A twin study (Barclay et al., 2010) showed that diurnal preference was associated to sleep quality (evening preference and poor sleep quality, r=0.27) and that both were influenced by the same genetic profile.

Socioeconomic position or work environment factors have not been studied in relation to non-restorative sleep, although it seems likely that sleep disturbing factors like stress should be of interest.

A commonly used measure of the psychosocial work environment is the Demand-Control-Support Questionnaire (DCSQ) (Johnson, Hall, & Theorell, 1989; Theorell et al., 1988). The DCSQ measures the demands faced at work, such as having to work fast, and the degree of control that employees can exercise over their working situation. Work demands have been used as a proxy of work stress (ref), particularly in combination with low control or support. High work demands have been shown to be a predictor of poor health (ref TÅ) and disturbed sleep (Åkerstedt et al, 2015, in press), where the relation was reciprocal.

The purpose of the present study was to investigate if the work demands predicts the subsequent occurrence of nonrestorative sleep and if this relation is mediated by the perceived stress reaction. This paper adds knowledge about the impact of work demands and perceived stress on nonrestorative sleep. To the best of our knowledge, this is the first prospective study on this issue.

Method
Respondents
The respondents were drawn from four waves of the Swedish Longitudinal Occupational Survey of Health (SLOSH). This is a nationally representative longitudinal cohort survey with biennial follow-ups. In the present paper we use data from the second wave in 2008 as baseline (T1) and data from the third to fifth waves in 2010, 2012 and 2014 as follow up (T2 to T5).
SLOSH is drawn from the Swedish Work Environment Survey (SWES), which is in turn drawn from the Labour Force Survey (LFS). The SWES is a cross-sectional, biennial survey of work environment conditions. It is based on a random stratified sample of those gainfully employed people aged 16–64 years who responded to the Labour Force Survey in the same year. The first wave of SLOSH in 2006 was based on a random stratified sample of respondents to the 2003 SWES. The response rate was 65% and yielded an initial sample of 9214 respondents. At wave 2 in 2008 (baseline in the present paper), the sample was increased by adding new respondents from the 2005 SWES. Thus wave 2 is composed of a subsample with previous measures from wave 1 (N = 9095; response rate 61.1%) and a subsample of new entrants (N = 9639; response rate 61.0%). This gives an overall sample size of 18739 and overall response rate of 61.1%. This sample was then followed again in 2010 (N = 17738; response rate 56.8%) and in 2012 (N = 17409; response rate 56.8%) and 2014 (N=******; response rate XX.X%). Thus SLOSH is representative of the working population in Sweden in 2003 and 2005 and, although the response rate has fallen over the study period, it remains broadly so today. However, analyses performed by Statistics Sweden show that non-responders are more likely to be male and of younger age.

SLOSH is a postal survey. Respondents are invited to complete one of two self-completion questionnaires. One is intended for those who are ‘gainfully employed’, defined as those who are in paid work for at least 30% of full time and the other is for those who are ‘not gainfully employed’, i.e. those working less than 30% or who are outside of the labour force, such as retirees. Given the focus on work characteristics, we only included respondents who were gainfully employed at all four waves (N=3706, 57.5 % women). All data collection has been approved by national ethics boards.

**Questionnaire**

Information regarding gender, age and educational level were derived from register data. Educational level was entered as the highest completed level of: 3 years or more at university, less than 3 years at university; maximum of 12 years of education and maximum of 9 years of education.

The Karolinska Sleep Questionnaire (KSQ) was used to assess sleep (Akerstedt et al., 2008). An exploratory factor analysis of the items in KSQ resulted in a two-factor solution of the KSQ. “Difficulties awakening” and “Not feeling refreshed at wake-up” formed their own factor, in this paper is called “nonrestorative sleep”. The responses range from “never” to “most days of the week” (with values from 1-6 assigned). Answers from the two questions were summed giving a score between 2-12. The second factor “Sleep disturbances” measures problems initiating or maintaining
sleep with the remaining items: ‘difficulties falling asleep’, ‘restless sleep’ and ‘repeated awakenings’ and ‘too early awakening’.

Total sleep time (during work days) was calculated from the following two questions: “At what time do you normally go to sleep (turn the lights out)? During work days” and “At what time do you normally wake up? During work days”.

Work demands (Theorell et al., 1988) were measured as a latent factor of five questions (Do you have to work fast? Do you have to work very intensively? Does your work demand too much effort? Do you have enough time to do everything (reverse coded)? Does your work often involve conflicting demands?). The response alternatives ranged from 1 = Yes, often, to 4 = Hardly ever/Never. Cronbach’s α was 0.71 at T1 and 0.72 at T2.

Control at work (Theorell et al., 1988) was measured by two latent factors, Skill discretion (Does your work demand a high level of skill or expertise? Does your work require ingenuity?) and Decision authority (Do you have the possibility of learning new things through your work? Do you have to do the same thing over and over again? Do you have a choice in deciding how you do your work? Do you have a choice in deciding what you do at work?). The response alternatives were the same as for work demands, but reversed so that high values indicate low control.

Social support (Johnson, Hall, & Theorell, 1989) was measured as an latent factor of six questions (There is a calm and pleasant atmosphere where I work, There is a good spirit of unity, My colleagues are there for me, People understand that I can have a bad day, I get on well with my superiors, I get on well with my colleagues). Response alternatives ranged from 1=Strongly disagree, to 4=Strongly agree but then reversed so that high values indicate low social support. Cronbach’s α was 0.84 at T1 and 0.86 at T2.

Stress was measured as a latent factor of three questions on feelings the last three months (I have days when I feel wound up all the time. I have days when I feel very pressured all the time on the border of what I can manage, I have days when I feel stressed all the time). Response alternatives ranged from 1=Not at all, to 4=Almost all the time. Cronbach’s α was 0.80 at T1 and 0.79 at T2.
Statistical analysis

In order to test the relationships between the work demands, stress and nonrestorative sleep, Structural Equation Modelling (SEM) will be applied, using Stata SE version 13.1. The maximum likelihood method was selected as the estimation procedure. In order to ensure that the data was normally distributed, it was screened for kurtosis and skewness; we did not find kurtosis values greater than 6 or skewness values greater than 3 (ref AR). Moreover, none of the variables were highly correlated ($r > .85$) reducing the risk for multicollinarity.

The following relations (see figure 1) were assessed in the following separate (non-nested) models:

2. $c'$ - The relation between work demands (hypothesized exposure, $X$) and nonrestorative sleep (hypothesized outcome, $Y$) – the unmediated model
3. $a/a'$ - The relation between work demands (hypothesized exposure, $X$) and perceived stress (hypothesized mediator, $M$)
4. $b/b'$ - The relation between perceived stress ($M$) and nonrestorative sleep ($Y$)
5. Model 2, figure 1 - In the last step, a full mediation model tested if the relation between work demands and nonrestorative stress was mediated by the perceived stress reaction across four years (with the mediator two years in between the exposure and the outcome).

All models were controlled for age, gender and education.

For each relation, we fitted with four different cross-lagged models to test the direction of the relations (see figure 2):

![Figure 1. Path diagrams of cross-sectional (Model 1) and longitudinal (Model 2) models of mediation.](image1)

![Figure 2. Competing cross-lagged SEM-models between exposure and dependent variables. (Solid lines represent main analysis and dotted lines the analyses of long-term effects).](image2)
1. First, a stability model with only the auto-regressions of all variables was estimated.
2. A forward causal model, that in addition to the auto-regressions, paths were added between hypothesized exposure and outcome in the subsequent wave.
3. A reversed causal model, that in addition to the auto-regressions, paths were added between hypothesized outcome and hypothesized exposure the subsequent wave.
4. A last step with a reciprocal model that included all paths from the previous models.

To test for long-term effects from work demands on nonrestorative sleep, additional paths were added from work demands to nonrestorative sleep to all subsequent waves in a complementary analysis.

**Results**

Over half of the sample (57.5%) are women. The mean age was 47 years at T1 (53 years at T4). The mean value of nonrestorative sleep was stable across the four time points, but differ somewhat by gender (see figure 3) and age (see figure 4).

![Figure 3. Box-plot of nonrestorative sleep from T1 to T2 by gender.](image-url)
Figure 4. Two-way scatterplot of nonrestorative sleep and age. The solid line represents fitted values.

The measurement model of the latent variables stress and work demands, where all latent constructs were allowed to correlate, showed good fit to data (RMSEA=0.032, SRMR=0.039, CFI=0.973). In both measurement and structural models, item-level specific errors were correlated in the latent constructs (stress and work demands) (ref AR). Nonrestorative sleep, which consisted of only two questions, was treated as an observed variable with values between 2-12. At T1, work demands, stress and nonrestorative sleep were correlated with each other and with female gender, age and university education ≥3 years (dichotomous) to control for confounding. Short sleep (<6 hours per night) was controlled for by each wave.

Table 1 shows the fit indices of the competing cross-lagged models for each relation hypothesized exposure, mediator and outcome as well as the full mediation model, whereof all showed acceptable fit to data (RMSEA <=0.6 & CFI >=0.90). The reciprocal models showed the best fit to data in all competing cross-lagged analyses. The full model with the mediation across 4 years, with reciprocal relations between X and M as well as M and Y had the following fit indices RMSEA=0.046, CFI=0.909, and SRMR=0.051 and is presented in more detail, with beta coefficients of all paths, in Figure 5.
Table 1. Fit indicies of cross-lagged SEM models testing the relations between hypothesized exposure X (work demands), mediator M (stress) and outcome Y (nonrestorative sleep).

<table>
<thead>
<tr>
<th>XY</th>
<th>Demands - Sleep</th>
<th>$\chi^2$</th>
<th>df</th>
<th>Prob &gt; $\chi^2$</th>
<th>$\Delta\chi^2(\Delta df)$, p-value</th>
<th>RMSEA</th>
<th>AIC</th>
<th>BIC</th>
<th>CFI</th>
<th>TLI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Autoregression</td>
<td>2566</td>
<td>386</td>
<td>p&lt;0.001</td>
<td>-</td>
<td>0.044</td>
<td>172557.643</td>
<td>173399.274</td>
<td>0.933</td>
<td>0.921</td>
<td>0.056</td>
</tr>
<tr>
<td>2</td>
<td>Forward causation</td>
<td>2537</td>
<td>383</td>
<td>p&lt;0.001</td>
<td>vs 1) 27(3) p&lt;0.001</td>
<td>0.044</td>
<td>172534.879</td>
<td>173394.416</td>
<td>0.934</td>
<td>0.921</td>
<td>0.053</td>
</tr>
<tr>
<td>3</td>
<td>Reverse causation</td>
<td>2545</td>
<td>383</td>
<td>p&lt;0.001</td>
<td>vs 1) 20(3) p&lt;0.001</td>
<td>0.044</td>
<td>172542.751</td>
<td>173402.288</td>
<td>0.933</td>
<td>0.921</td>
<td>0.053</td>
</tr>
<tr>
<td>4</td>
<td>Reciprocal</td>
<td>2516</td>
<td>380</td>
<td>p&lt;0.001</td>
<td>vs 1) 49(6) p&lt;0.001</td>
<td>0.044</td>
<td>172520.370</td>
<td>173397.815</td>
<td>0.934</td>
<td>0.921</td>
<td>0.051</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>XM</th>
<th>Demands - Stress</th>
<th>$\chi^2$</th>
<th>df</th>
<th>Prob &gt; $\chi^2$</th>
<th>$\Delta\chi^2(\Delta df)$, p-value</th>
<th>RMSEA</th>
<th>AIC</th>
<th>BIC</th>
<th>CFI</th>
<th>TLI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Autoregression</td>
<td>4208</td>
<td>499</td>
<td>p&lt;0.001</td>
<td>-</td>
<td>0.047</td>
<td>224567.317</td>
<td>225581.498</td>
<td>0.925</td>
<td>0.911</td>
<td>0.043</td>
</tr>
<tr>
<td>2</td>
<td>Forward causation</td>
<td>4014</td>
<td>496</td>
<td>p&lt;0.001</td>
<td>vs 1) 194(3) p&lt;0.001</td>
<td>0.046</td>
<td>224379.129</td>
<td>225411.638</td>
<td>0.929</td>
<td>0.915</td>
<td>0.064</td>
</tr>
<tr>
<td>3</td>
<td>Reverse causation</td>
<td>3977</td>
<td>496</td>
<td>p&lt;0.001</td>
<td>vs 1) 231(3) p&lt;0.001</td>
<td>0.046</td>
<td>224342.088</td>
<td>225374.598</td>
<td>0.930</td>
<td>0.918</td>
<td>0.062</td>
</tr>
<tr>
<td>4</td>
<td>Reciprocal</td>
<td>3834</td>
<td>493</td>
<td>p&lt;0.001</td>
<td>vs 1) 374(6) p&lt;0.001</td>
<td>0.045</td>
<td>224204.581</td>
<td>225256.420</td>
<td>0.933</td>
<td>0.919</td>
<td>0.053</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MY</th>
<th>Stress - Sleep</th>
<th>$\chi^2$</th>
<th>df</th>
<th>Prob &gt; $\chi^2$</th>
<th>$\Delta\chi^2(\Delta df)$, p-value</th>
<th>RMSEA</th>
<th>AIC</th>
<th>BIC</th>
<th>CFI</th>
<th>TLI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Autoregression</td>
<td>2562</td>
<td>196</td>
<td>p&lt;0.001</td>
<td>-</td>
<td>0.063</td>
<td>123623.015</td>
<td>124241.911</td>
<td>0.916</td>
<td>0.895</td>
<td>0.076</td>
</tr>
<tr>
<td>2</td>
<td>Forward causation</td>
<td>2307</td>
<td>193</td>
<td>p&lt;0.001</td>
<td>vs 1) 255(3) p&lt;0.001</td>
<td>0.060</td>
<td>123373.294</td>
<td>124010.216</td>
<td>0.925</td>
<td>0.905</td>
<td>0.049</td>
</tr>
<tr>
<td>3</td>
<td>Reverse causation</td>
<td>2500</td>
<td>193</td>
<td>p&lt;0.001</td>
<td>vs 1) 62(3) p&lt;0.001</td>
<td>0.063</td>
<td>123566.641</td>
<td>124203.863</td>
<td>0.918</td>
<td>0.896</td>
<td>0.067</td>
</tr>
<tr>
<td>4</td>
<td>Reciprocal</td>
<td>2245</td>
<td>190</td>
<td>p&lt;0.001</td>
<td>vs 1) 371(6) p&lt;0.001</td>
<td>0.060</td>
<td>123317.812</td>
<td>123972.761</td>
<td>0.927</td>
<td>0.906</td>
<td>0.044</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>XMY</th>
<th>Demands - Stress - Sleep</th>
<th>$\chi^2$</th>
<th>df</th>
<th>Prob &gt; $\chi^2$</th>
<th>$\Delta\chi^2(\Delta df)$, p-value</th>
<th>RMSEA</th>
<th>AIC</th>
<th>BIC</th>
<th>CFI</th>
<th>TLI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Autoregression</td>
<td>6009</td>
<td>787</td>
<td>p&lt;0.001</td>
<td>-</td>
<td>0.049</td>
<td>222706.939</td>
<td>223907.439</td>
<td>0.898</td>
<td>0.885</td>
<td>0.082</td>
</tr>
<tr>
<td>2</td>
<td>Forward causation</td>
<td>5648</td>
<td>781</td>
<td>p&lt;0.001</td>
<td>vs 1) 361(6) p&lt;0.001</td>
<td>0.047</td>
<td>222357.953</td>
<td>223594.112</td>
<td>0.905</td>
<td>0.892</td>
<td>0.062</td>
</tr>
<tr>
<td>3</td>
<td>Reverse causation</td>
<td>5780</td>
<td>781</td>
<td>p&lt;0.001</td>
<td>vs 1) 589(6) p&lt;0.001</td>
<td>0.048</td>
<td>222489.323</td>
<td>223725.482</td>
<td>0.903</td>
<td>0.889</td>
<td>0.068</td>
</tr>
<tr>
<td>4</td>
<td>Reciprocal</td>
<td>5429</td>
<td>775</td>
<td>p&lt;0.001</td>
<td>vs 1) 580(12) p&lt;0.001</td>
<td>0.046</td>
<td>222150.923</td>
<td>223422.741</td>
<td>0.909</td>
<td>0.895</td>
<td>0.051</td>
</tr>
</tbody>
</table>
Figure 5. Structural model (reciprocal) with demands, stress and nonrestorative sleep across four waves controlled for age, gender and education at T1 and short sleep (<6 h) for each wave. Number of observations=2816 (866 observations with missing values excluded). Estimation method: maximum likelihood. Log likelihood value -110861.46. RMSEA=0.046, CFI=0.909, SRMR=0.051. Solid lines represent significant (p<0.05) \( \beta \) coefficients (standardized) and dotted lines represent non-significant coefficients (\( \beta \) coefficients for relations with and between the cofounders are not shown in figure).

In figure 5 the final structural model with reciprocal relationship is presented. All solid lines are significant (p<0.05) and the beta coefficients are standardized to enable comparison of magnitude in different directions.

The total effect from demands at T1 to nonrestorative sleep T4 is the indirect effect… (HW ref) The size of the mediation is between 20-25 % in both directions when comparing the beta coefficients in the two models (Not yet ready, and calculations I have made has to be confirmed with a statistician…).

Discussion
The results from the analyses show that there is a reciprocal relationship between work demands and nonrestorative sleep and that this relationship is mediated (in both directions) of the perceived stress reaction.

The relative sizes of the standardized beta coefficients in the reciprocal mediational model suggest that the perceived stress has the strongest effect on both work demands and nonrestorative sleep. The size of the mediational process through the stress reaction compared to the effect of demands on
nonrestorative sleep across two measures is hard to compare, since the effect is expected to decrease with time from exposure (Cole & Maxwell 2003). The SLOSH cohort is collected every second year, why no more detailed analyses on the relations between the work environment and sleep is possible. Even though that the stability in nonrestorative sleep (around .67 across two years in the present study) suggest that the measure is relatively “chronic” – or maybe that the exposure (stress and work environment) causing nonrestorative sleep are constant (and that the relation rather is almost cross-sectional). The mechanisms are still unknown. How short/long time spans should be to be appropriate to use in this type of research is however still unknown. Only a study with month-to-month (or even day-to-day) variations in both sleep and work exposure over a longer period (>1-2 years) would yield an answer to that question.

Since previous research on nonrestorative sleep mainly focus on the diagnostics and consequences of nonrestorative sleep, the prediction of the same has gained less attention and no other prospective study on the relation to the work environment is available. So despite the long time lag between waves, this study is important to establish that there is a relation between work demands, stress and nonrestorative sleep and that this relation is reciprocal in both directions, which indicates a potential vicious circle where high demands precedes feeling of being stress, which in turn precedes nonrestorative sleep, which in turn might increase the feelings of stress and a feeling of being too high at work.
References


Wilkinson, K., & Shapiro, C. (2012). Nonrestorative sleep: symptom or unique diagnostic entity? Sleep Medicine, 13(6), 561-569.