Title:

Shift work with and without night work as a risk factor for fatigue and changes in sleep length: A cohort study with linkage to records on daily working hours

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SUMMARY

We examined shift work with or without night work as a risk factor for fatigue and short or long sleep. In a prospective cohort study with 4- and 6-year follow-ups (the Finnish Public Sector study), we linked survey responses of 3 679 full-time hospital employees on sleep duration and fatigue to records on daily working hours in 2008 (baseline), 2012 and 2014. We used logistic regression to estimate risk ratios (RRs) and their confidence intervals (CIs) to examine whether continuous exposure to shift work or changes between shift work and day work were associated with short (<6.5 h) or long (9.0> h) sleep over 24 hours and fatigue at work and during free time. Compared to continuous day work and adjusting for age, gender, education and fatigue/sleep duration at baseline, continuous shift work with night shifts was associated with increased fatigue during free time (RR=1.38, 95% CI 1.17-1.63) and long sleep (RR=8.04, 95% CI 2.88-22.5, without adjustment for education) after 6 year follow-up. Exposure to shift work without night shifts increased only long sleep after 6 years (RR 5.87, 95% CI 1.94-17.8). A change from day work to shift work with or without night shifts was associated with an increased risk for long sleep, and a change from shift work to day work with a decreased risk for long sleep and fatigue. This study suggests that irregular shift work is a modifiable risk factor for long sleep and increased fatigue probably reflecting higher need for recovery.

KEYWORDS

working hours, night work, sleepiness, tiredness, exhaustion

INTRODUCTION

Shift work is common in modern societies; 21% of the wage earners in the European Union and 20% in Finland worked shifts in 2015 (Eurofound, 2016). Prospective studies have linked shift work to increased risk of occupational accidents (Wagstaff and Sigstad Lie, 2011), cardiovascular disease (Vyas et al., 2012, Vetter et al., 2016) and type 2 diabetes (Knutsson and Kempe, 2014). Sleep deprivation is similarly associated with increased risk of cardiometabolic diseases and accidents (Härmä, 2006, Kecklund and Axelsson, 2016) suggesting insufficient sleep may be a plausible pathway from shift work to worse health.

A systematic review of cross-sectional studies suggested that permanent night shifts and rotating work shifts are related to shorter main sleep length (Pilcher et al., 2000). However, the few prospective studies published on shift work with night shifts and sleep show mixed results (Niedhammer et al., 1994, Ribet and Derriennic, 1999, Åkerstedt et al., 2015, Thun et al., 2016) with some studies suggesting shift work to be associated with deteriorating sleep quality and other reporting no such association. Similarly, evidence on change between shift work and day work is inconsistent. While leaving shift work was associated with improvement of sleepiness and improvements in sleep quality in some studies (Linton, 2004, Åkerstedt et al., 2010, Thun et al., 2016), entering shift work showed an increase in difficulties to fall asleep only in the Swedish cohort study (Åkerstedt et al., 2008) but no effect on sleepiness or sleep quality in the Norwegian cohort study of hospital workers (Thun et al., 2016).

There are several limitations to the existing evidence. Since the decision to leave shift work or change the work schedule may be associated with disturbed sleep and health, cross-sectional studies on shift work and sleep are especially vulnerable to selection bias, potentially diluting the association between shift work, sleep and fatigue. As ageing workers typically represent a more selected population than their younger counterparts, stratifying analysis by age would allow to evaluate selection bias, but few studies to date have reported such analyses. Most longitudinal studies (Åkerstedt et al., 2015, Thun et al., 2016) have relied on questionnaires while the use of objective data, such as records of daily working hours over an extended period, would provide a more reliable method to ascertain long-term shift work exposure. No longitudinal studies are available on shift work in relation to changes in sleep length, although increased sleep duration, when combined with day-time fatigue, may indicate cumulative sleep loss and reduced sleep sufficiency. The role of napping outside the main sleep is insufficiently addressed as most follow-up studies have assessed sleep duration during the nights only rather than over 24 hours. Finally, little is known about the reversibility of shift work-induced sleep problems because of the lack of follow-up studies on change from shift work to day work.

In this longitudinal study of shift work, sleep and fatigue, we used day-to-day objective records of working hours to assess whether continuous exposure to shift work would be associated with the risk for increased fatigue and changes in sleep length over 24 hours. Since there is an U-shaped association between sleep duration and health (Cappuccio et al., 2010, Kronholm et al., 2006), we hypothesised that both short and long sleep duration would reflect higher need for recovery. We distinguished between shift work with and without night work as in particular night work has been suggested to lead to changes in sleep and fatigue. In addition to the main effects, the interactions of age and gender with exposure to shift work were studied. It was hypothesized that older employees and women could be more sensitive to the long-term effects of shift work on sleep.

MATERIAL AND METHODS

Study sample

This study is part of the ongoing Finnish Public Sector (FPS) study. The data available for this study is based on survey data of 11 072 hospital workers in 2008 (baseline) and follow-up surveys in 2012 (4-year follow-up) and 2014 (6-year follow-up). The individual survey data (response rates 72%, 71% and 67% in 2008, 2012 and 2014) were linked to the payroll data of daily work shifts from the 91 days prior to answering each questionnaire. To be included in the final sample, the employees had to have at least 31 work shifts of any type during the 91 preceding days of each of the three surveys. Part-time workers and physicians (due to on-call work not registered in the database) were excluded.

Fig. 1

The final sample for the 4-year follow-up included 3679 participants (Table 1) with both exposure data (payroll data of working hours), and outcome data (surveys) from 2008 and 2012. For the 6-year follow-up, 2546 participants were available (from 2008 to 2014, Appendix 1).

The participants were hospital workers with various job titles. The main occupational titles in 2008 were nurse (37%), department secretary (9%), practical nurse (6%), laboratory nurse (5%), assistant nurse/ hospital ward assistant (4%) and x-ray nurse (3%). The excluded part-time workers (n=367) included more younger employees and women, but the distribution of occupational titles was mostly the same as among the full-time workers.

The Finnish Public Sector Study has been approved by the ethics committee of the Hospital District of Helsinki and Uusimaa (HUS) (HUS 1210/2016). Answering to the FPS survey was voluntary and therefore completed questionnaire acted as an informed consent (Ministry of Justice, Finland 1999).

Working hour data

Payroll-based realized rosters were retrieved from the shift scheduling program (Titania®, CGI Finland Ltd, Helsinki, Finland) as described before (Härmä et al., 2015). Working hours in the Finnish public sector's health care and social services are characterized by varying and partly irregular shift combinations. The starting and ending times of the daily working hours were used to define work shifts. Night (N) shifts were defined as ≥3 hours between 23:00–06:00 hours; evening (E) shifts as shifts with any time between 18:00 and 23:00 and not categorized to a night shifts; morning (M) shifts as work starting not before 03:00 and ending no later than 18:00. Based on the frequency of the different shifts during the 3 months preceding each of the survey, the employees were categorized to three groups of work schedule: *Day work (* ≥ 1 M, < 1 E and < 1 N shifts /month), *Shift work without N shifts (* ≥ 1 M, ≥ 1 E and < 1 N shifts /month) and *Shift work with N shifts (* ≥ 1 M, ≥ 1 E and ≥ 1 N shifts/month) (Härmä et al., 2017). Since the number of employees who changed work schedule during the follow-up was small (Table 1), we combined the groups of shift work with and without night shifts when analyzing changes in work schedules.

Survey variables

Information on age, gender and education (1=primary education, 2=secondary education, 3= high school) was obtained from the questionnaire. Fatigue/tiredness during work shifts and fatigue/tiredness during free time during the last four weeks were asked according to the following options: 1=”not at all”, 2=”1-3 days a month”, 3=”about during one day in a week”, 4=”during 2-4 days a week”, 5=”during 5-6 days a week, 6=”every day” (Jenkins et al., 1988). 24-hour sleep length was asked with half an hour intervals by a question “How many hours do you normally sleep during 24 hours?”.

Statistical methods

The statistical analyses were conducted with SAS 9.4 (SAS Institute Inc., Cary, North Carolina, USA). The differences in the descriptive characteristics between the work schedules were tested with Chi-square test.

To study the association of shift work with fatigue, criteria for the dichotomized outcome variables, the occurrence of fatigue at work and during free-time, was set to at least two times a week. The explanatory variables were the work schedule (day work / shift work without N shifts / shift work with N shifts), the change from day work 2008 to any shift work 2012 in 4-year follow-up and both 2012 and 2014 in 6-year follow-up, and the change from any shift work 2008 to day work 2012 in 4- year follow-up and both 2012 and 2014 in 6-year follow-up.

Logistic regression was used to estimate risk ratios (RRs) and their confidence intervals (CIs) for the longitudinal association between shift work, sleep, and fatigue. First, we used crude logistic regression adjusted for the outcome at baseline and logistic regression adjusted for age (≤39, 40-49, ≥50), gender, education, and the outcome at baseline to examine whether continuous exposure to shift work with or without night shifts was associated with a change in fatigue during and after work, and short and long 24-hour sleep after 4 and 6 years. We used the same statistical model to test whether a change from day work to shift work (shift work with and without nights shifts combined) or a change from shift work to day work was associated with changes in the same four outcomes. In the adjusted models, interactions between explanatory variables and both age and gender were tested with a Wald statistic. Based on interactions with $p<0.10$ (Greenland and Rothman, 1998, Dijkman et al. 2009), a stratified analysis of age and gender was conducted.

Fatigue during work and during free time were classified as fatigue 0-3 times per month/1 time per week and 2 or more times per week. Fatigue 0-3 times a month was regarded as reference for studying the risk having fatigue two or more times per week. In order to study the association of shift work to shorter and longer sleeping, 24-hour sleep length was classified as short (≤ 6.5 hours), normal (7.0-8.5) or long (≥ 9.0 hours). Sleep length of 7.0–8.5 hours was regarded as reference for studying changes in the length of 24-hour sleep. The criteria for short sleep was 6.5 hours instead of the traditional 6 hours (see e.g. Kronholm et al., 2006) since we measured 24-hour sleep length instead of only the night sleep. In a separate sensitivity analysis the results were also analysed using a lower limit (≥ 8.0 hours) as the criteria for longer 24-hour sleep.

RESULTS

Baseline

Descriptive characteristics and baseline information of fatigue and 24-hour sleep length according to the work schedules are shown in Table 1. Shift workers with night shifts were on average younger (age group 50- years: 30.0%) compared to shift workers without night shifts or day workers (43.7% and 43.2%, respectively). Shift workers with night shifts were also more often men and had higher education than the other groups. Based on the unadjusted baseline data, fatigue during work at least twice a week (28.4%), fatigue during free time (19.6%) and sleeping 9 hours or more during 24 hours (7.2%) was most frequent in shift work with night shifts compared to day work (22.4%, 9.4% and 1.4%) or shift work without night shifts (25.3%, 14.9% and 2.5%, respectively).

The longitudinal association of shift work with fatigue and sleep length during 4 and 6 years

Table 2 shows the longitudinal associations of shift work with fatigue and sleep length during the 24 hours for participants who continued in the same work schedule through the 4- and 6-year follow-ups. Shift work with night shifts was associated with an increased risk for fatigue during free time both in the crude model adjusting only for the baseline, as well as in the fully adjusted model (RR 1.35, 95% CI 1.16-1.56) after 4 years compared to day work. After 6 years, shift work with night shifts was associated with the increase of fatigue during free time (RR 1.38, 95% CI 1.17-1.63) and long sleep (RR 8.04, 95% CI 2.88-22.5) in the adjusted models. After 6 years, exposure to shift work without night shifts was associated with the increase of long sleep (RR 5.87, 95% CI 1.94-17.8; adjusted model) compared to day work but not with fatigue during work or free-time.

In a sensitivity analysis with the criteria of longest sleep length category being only 8 hours during the 24 hours, shift work with night shifts was similarly associated with an increase of longer sleeping in the crude and adjusted models after 4- and 6- years of follow-up (RR 1.17, 95% CI 1.05-1.30 and RR 1.20, 95% CI 1.04-1.37) and controlling for age, gender, education and sleep duration at baseline compared to day workers. However, exposure to shift work without night shifts was not significantly associated with the increased risk for short or longer sleep of 8 hours or more compared to day work (data not shown).

The longitudinal association of a change in work schedule to fatigue and sleep length

Changing from day work to any shift work (shift work with or without night shifts combined, n=218) was associated with an increased risk for long sleep after 6 years (RR 4.74, 95% CI 2.03-11.1; adjusted model) when compared to those staying in day work (Table 3). On the other hand, changing from shift work to day work was associated with a decrease of the risk for long sleeping (RR 0.23, 95% CI 0.08-0.71; adjusted model), as well as fatigue during work (RR 0.84, 95% CI 0.71-0.98, adjusted model) at the 4 year follow-up. A change from shift work to day work was also associated with a decrease in fatigue during free time after both 4 and 6 years (RR 0.75, 95% CI 0.59-0.96 and RR 0.68, 95% CI 0.50-0.94; adjusted models).

Interactions according to age and gender

There data showed only few significant interactions according to age and gender. The decrease of fatigue during free time after changing from shift work to day work during the 6 years was most pronounced among the 50 years or older workers (RR 0.48, 95% CI 0.26-0.88) and among women (RR 0.66, 95% CI 0.47-0.91) compared to men (see details in Tables 2 and 3). None of the 50-year or older shift workers changing from shift work to day work were long sleepers while being in shift work (no observations available). However, a significant ($p < 0.001$) interaction according to age suggests that the decrease of long sleeping among those shifting from shift work to day work was most evident among the youngest age group (39 years: RR 0.22, 95% CI 0.03-1.49) even not significant in the stratified analysis.

DISCUSSION

This study shows that long-term exposure to shift work with night shifts is associated with an increase of fatigue during free time and long sleep adjusting for several confounders and the baseline differences in fatigue and sleep. Shift work without night shifts was only associated with the increased risk for long sleep but not with fatigue during or after work. A change from day work to shift work was associated with an increase of long sleeping, while a change from shift work to day work was associated with a decrease of long sleeping as well as fatigue both during and after work. After changing to day work, the decrease of fatigue during free time was most evident among workers of 50 years or older.

The studied shift work schedules were mostly irregular having a varying number of consecutive night shifts and occasional quick returns with less than 11 hours between the shifts, and a variation in weekly working hours (Härmä et al., 2015). Earlier research on irregular shift systems suggest that occasional sleep deprivation may lead to cumulative sleep loss over time (Sallinen and Kecklund, 2010). For example, in a field study of train drivers in an irregular shift system, quick returns related to the evening-morning shift combinations were associated with shortened sleep between the shifts but also to a significantly increased sleep need (Sallinen et al., 2003). In a subsample of the current sample at baseline (n=95), sleep length after night shifts was on average under 4.5 hours and between the evening and morning shifts from 5 to 6 hours based on actigraphy recording (Karhula et al., 2013). At the same time, 93% of the studied nurses took at least one nap in a week.

Our findings are consistent with the hypothesis that irregular shift work is a risk factor for increased fatigue outside work and that long sleeping possibly reflects higher need for recovery. Shift work and ageing have both been associated with increased need for recovery in earlier studies (Jansen et al., 2003, Gommans et al., 2014), and increased need for recovery, in turn, is a strong predictor of subsequent cardiovascular disease (van Amelsvoort et al., 2003) and even cardiovascular death (Kivimaki et al., 2006). Both shortened and extended objective sleep durations have been reported to be linked to cardiovascular diseases and its early indicators (Cappuccio et al., 2010, Aziz et al., 2017).

We are not aware of previous longitudinal studies on the association between shift work and sleep length. We found a significant association between shift work and long sleep not only at baseline and in the follow-up, but sleep length also changed as a response to entering or exiting shift work. Even though the number of long sleepers was limited in some data-points, the results of the crude and adjusted models were consistent, as well as the main results with the sensitivity analysis using a lower 8h cut-off criteria for longer sleep. Long sleeping has earlier been shown to be related to sociodemographic and lifestyle factors in cross-sectional studies (Kronholm et al. 2006). The current study shows that long sleeping can also be a consequence of exposure to shift work.

There are few longitudinal studies that have studied the association of extended exposure to shift work with sleepiness or fatigue (Thun et al., 2016, Akerstedt et al., 2015). Unlike in our study, continuous exposure to night shift work or rotating shift work was not associated with increased trajectories of sleepiness during the follow-up of 4 years among Norwegian hospital workers (Thun et al., 2016). That study was, however, based on a smaller sample of night shift workers (n=218) and possible selection due to low response rate (38%) at baseline. In addition, shift workers without night work were combined to the control group of day workers.

Our result of significantly decreasing fatigue during work and free time after changing from shift work to day work suggest the adverse effects of shift work on fatigue are reversible. These findings are in line with earlier findings suggesting that leaving shift work is related to a decrease in sleepiness or disturbed sleep (Linton, 2004, Akerstedt et al., 2015, Waage et al., 2014, Thun et al., 2016). Entering shift work from day work was similarly associated with an increased risk for long sleeping. In an earlier Swedish study entering shift work was associated with an increased risk in falling asleep at work (Akerstedt et al., 2015). In Finland, newly graduated nurses mostly start their career from a shift working ward. In our study, those changing from shift work to day work were thus older and outnumbered those shifting from day work to shift work, which may explain the non-significant association for increased risk of fatigue after changing to shift work.

We found only few age and gender interactions for the association of shift work with fatigue and sleep. The decrease of fatigue during free time after changing from shift work to day work was most pronounced among the oldest workers. Among employees of 50 years or more, insomnia symptoms are generally more common (Marquiae et al., 2012) and the possible age-related changes in sleep and diurnal type can make it more difficult to sleep after night shifts (Härmä et al., 1994, Blok and de Looze, 2011).

The strengths of our study are the large and representative sample, a prospective study design with long follow-up, and the use of objective registry data of working hours. The use of objective exposure information has several advantages. It provides precise information without memory bias, attrition or selection based on exposure (Härmä et al., 2015). Such data are particularly useful when analysing complicate and changing working time arrangements since self-reported shift work assessment can contribute to bias in epidemiological studies (Härmä et al., 2017).

There are also some limitations that need to be regarded when interpreting the results. The study was focused on hospital workers who often had irregular shift systems and the proportion of men was small. We excluded physicians due to lack of information on on-call hours, a small number of permanent night workers as a specific and probably a highly selected group, and part-time workers to make the sample more homogenous for the comparison of work schedules. However, there were no differences in the distribution of job titles among the final sample and the excluded part-timers. The results should be interpreted cautiously for regular rotating night shift work, men and part-time workers. The subgroup of long sleepers was small to detect significant interactions. Also the number of individuals who changed their work schedule from day to shift work was small reducing statistical power to establish reliable effects. It should also be notified that subjective fatigue and subjective sleepiness are interrelated, but distinct phenomena. Both are multidimensional and have many causes (Shen et al., 2006).

In conclusion, the results of this longitudinal cohort study show that long-term exposure to shift work with night shifts is associated with increased fatigue during free time and long 24-hour sleep. The results support the hypothesis that irregular working hours can lead to increased fatigue during free time and higher need for recovery sleep.

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Table 1. Descriptive statistics and base-line information on fatigue during work, fatigue during free time and 24-hour sleep according to work schedule at baseline (2008) of the participants with the 4-year follow-up (n=3679). Probability for the statistical difference between the work schedules.

		Day work		Shift work without night shifts		Shift work with night shifts		Sig.	From day work to any shift work		From any shift work to day work	
		n	%	n	%	n	%		n	%	n	%
No of participants		1476	100.0	895	100.0	1308	100.0		218	100.0	322	100.0
Age	-39	275	18.6	196	21.9	475	36.3	<.0001	60	27.5	88	27.3
	40-49	563	38.1	308	34.4	441	33.7		85	39.0	105	32.6
	50-	638	43.2	391	43.7	392	30.0		73	33.5	129	40.1
Gender	men	90	6.1	56	6.3	129	9.9	<.0002	21	9.6	14	4.4
	women	1386	93.9	839	93.7	1179	90.1		197	90.4	308	95.7
Education	primary	158	10.7	141	15.8	85	6.5	<.0001	23	10.6	22	6.8
	secondary	492	33.3	308	34.4	417	31.9		71	32.6	110	34.2
	high school	813	55.1	438	48.7	795	60.8		121	55.5	188	58.4
	missing	13	0.9	10	1.1	11	0.8		3	1.4	2	0.6
Fatigue during work	0-3/month	791	53.6	471	52.6	604	46.2	0.0008	103	47.3	161	50.0
	1/week	340	23.0	185	20.7	319	24.4		59	27.1	84	26.1
	2-/week	330	22.4	226	25.3	372	28.4		51	23.4	74	23.0
	missing	15	1.0	13	1.5	13	1.0		5	2.3	3	0.9
Fatigue during free time	0-3/month	1011	68.5	564	63.0	734	56.1	<.0001	139	63.8	205	63.7
	1/week	300	20.3	178	19.9	309	23.6		50	22.9	63	21.1
	2-/week	138	9.4	133	14.9	256	19.6		22	10.1	45	14.0
	missing	27	1.8	20	2.2	9	0.7		7	3.2	4	1.2
Sleep length	$\leq$ 6.5h	404	27.4	244	27.3	289	22.1	<.0001	55	25.2	84	26.1
	7.0-8.5h	1043	70.7	619	69.2	918	70.2		152	69.7	221	68.6
	$\geq$9.0 h	20	1,4	23	2.5	94	7.2		10	4.6	13	4.0
	missing	9	0.6	9	1.0	7	0.5		1	0.5	4	1.2

Table 2. The association of exposure to shift work (SW) from 2008 to 2012 (4-year follow-up) and from 2008 to 2014 (6-year follow-up) to fatigue during and after work, short (-6.5 hours) and long (9- hours) 24-hour sleep compared to day work. Logistic regression model. No significant interactions according to age or gender.

		Minimally adjusted model (adjusted for baseline fatigue/sleep length)				Adjusted model (adjusted for age, gender, education and fatigue/sleep length at baseline)			
		2008-2012 (4 years)		**2008-2014 (6 years)**		**2008-2012 (4 years)**		**2008-2014 (6 years)**	
		n	**RR (95% CI)**	**n**	**RR (95% CI)**	**n**	**RR (95% CI)**	**n**	**RR (95% CI)**
Fatigue during work	Day work	1124	1	792	1	1116	1	786	1
	SW without N shifts	685	1.02 (0.94-1.12)	398	1.05 (0.94-1.18)	675	1.03 (0.79-1.13)	394	1.04 (0.93-1.17)
	SW with N shifts	973	1.02 (0.94-1.10)	727	1.04 (0.95-1.14)	964	0.99 (0.91-1.07)	722	1.02 (0.93-1.12)
Fatigue during free time	Day work	1141	1	804	1	1134	1	799	1
	SW without N shifts	686	1.17 (0.99-1.39)	398	1.29 (1.06-1.57)	676	1.15 (0.97-1.37)	394	1.27 (1.04-1.55)
	SW with N shifts	969	1.39 (1.20-1.61)	678	1.39 (1.18-1.63)	962	1.35 (1.16-1.56)	672	1.38 (1.17-1.63)
Short 24-hour sleep	Day work	1448	1	1058	1	1435	1	1049	1
	SW without N shifts	856	1.03 (0.94-1.13)	505	0.91 (0.79-1.04)	848	1.05 (0.95-1.15)	500	0.91 (0.79-1.04)
	SW with N shifts	1218	0.99 (0.90-1.08)	894	0.90 (0.81-1.01)	1208	1.02 (0.93-1.12)	887	0.92 (0.83-1.03)
Long 24-hour sleep	Day work	999	1	710	1		- [1]	705	1 [2]
	SW without N shifts	620	2.19 (1.19-4.02)	375	6.06 (2.00-18.3)		-	371	5.87 (1.94-17.8)
	SW with N shifts	952	3.09 (1.80-5.32)	692	8.34 (2.99-23.3)		-	686	8.04 (2.88-22.5)

[1] insufficient number of observations for all covariates

[2] education excluded from the model

Table 3. The association of a change from day work 2008 to any shift work (SW) (SW with and without night shifts combined) in 2012 or 2014 and a change from any shift work 2008 to day work in 2012 or 2014. Fatigue during and after work, short (-6.5 hours) and long (9- hours) 24-hour sleep. Logistic regression model. Significant interactions according to age or gender.

		Minimally adjusted model (adjusted for baseline fatigue/sleep length)				**Adjusted model** (adjusted and for age, gender, education level and fatigue/sleep length at baseline)			
		From 2008 to 2012		**From 2008 to 2014**		**From 2008 to 2012**		**From 2008 to 2014**	
		n	**RR (95% CI)**	**n**	**RR (95% CI)**	**n**	**RR (95% CI)**	**n**	**RR (95% CI)**
Fatigue during work	Ever day work	1124	1	721	1	1116	1	715	1
	From day work to SW	164	0.96 (0.81-1.13)	58	0.81 (0.56-1.17)	161	0.96 (0.80-1.14)	57	0.82 (0.57-1.19)
	Ever SW	1658	1	1125	1	1639	1	1116	1
	From SW to day work	247	0.83 (0.71-0.97)	134	0.85 (0.69-1.04)	245	0.84 (0.71-0.98)	133	0.84 (0.68-1.03)
Fatigue during free time	Ever day work	1141	1	731	1	1134	1	726	1
	From day work to SW	159	1.15 (0.86-1.54)	60	0.97 (0.57-1.64)	156	1.09 (0.81-1.48)	59	0.98 (0.58-1.67)
	Ever SW	1655	1	1076	1	1638	1	1066	1 [1, 2]
	From SW to day work	257	0.74 (0.58-0.94)	144	0.71 (0.52-0.97)	255	0.75 (0.59-0.96)	143	0.68 (0.50-0.94)
Short 24-hour sleep	Ever day work	1448	1	960	1	1435	1	951	1
	From day work to SW	211	0.86 (0.70-1.06)	70	0.84 (0.59-1.18)	208	0.87 (0.71-1.07)	69	0.81 (0.58-1.13)
	Ever SW	2074	1	1399	1	2056	1	1387	1
	From SW to day work	314	0.88 (0.76-1.02)	182	1.10 (0.91-1.34)	312	0.90 (0.78-1.05)	181	1.10 (0.91-1.34)
Long 24-hour sleep	Ever day work	999	1	646	1		- [3]	646	1 [4]
	From day work to SW	163	1.38 (0.57-3.37)	56	6.55 (2.62-6.33)		-	56	4.74 (2.03-11.10)
	Ever SW	1572	1	1067	1	1572	1 [5]	1067	1 [4]
	From SW to day work	231	0.23 (0.08-0.71)	130	0.16 (0.02-1.13)	231	0.23 (0.08-0.71)	130	0.16 (0.02-1.15)

[1] Interaction by age (p< 0.0823): -39 years: from shift work to day work RR 1.09 (95% CI 0.73-1.63); 40-49 years: from shift work to day work RR 0.64 (95% CI 0.36-1.15); 50- years: from shift work to day work RR 0.48 (95% CI 0.26-0.88)

[2] Interaction by gender (p< 0.090): men: from shift work to day work RR 1.75 (95% CI 0.47-6.47); women: from shift work to day work RR 0.66 (95% CI 0.47-0.91)

[3] insufficient number of observations for all covariates

[4] education excluded from the model

[5] Interaction by age (p<0.0001): -39 years: from shift work to day work RR 0.22 (95% CI 0.03-1.49); 40-49 years: from shift work to day work RR 0.47 (95% CI 0.12-1.85); 50- years: - (no cases)

Appendix 1. Descriptive statistics and base-line information on fatigue during work, fatigue during free time and 24-hour sleep according to work schedule at baseline (2008) of the participants with the 6-year follow-up (n=2546). Probability for the statistical difference between the work schedules.

		Day work		**Shift work without night shifts**		**Shift work with night shifts**		**Sig.**	**From day work to any shift work**		**From any shift work to day work**	
		n	%	n	%	n	%		n	%	n	%
No of participants		1072	100.0	526	100.0	948	100.0		76	100.0	185	100.0
Age	-39	181	16.9	117	22.2	315	33.2	<.0001	19	25.0	44	23.8
	40-49	443	41.3	211	40.1	359	37.9		36	47.4	69	37.3
	50-	448	41.8	198	37.6	274	28.9		21	27.6	72	38.9
Gender	men	70	6.5	30	5.7	93	9.8	<.0004	2	2.6	9	4.9
	women	1002	93.5	496	94.3	855	90.2		74	97.4	176	95.1
Education	primary	102	9.5	62	11.8	46	4.9	<.0001	9	11.8	9	4.9
	secondary	62	34.1	186	35.4	311	32.8		26	34.2	62	33.5
	high	46	55.6	273	51.9	584	61.6		40	52.6	113	61.1
	school	9	0.8	5	1.0	7	0.7		1	1.3	1	0.5
	missing											
Fatigue during work	0-3/month	577	53.8	283	53.8	447	47.2	0.0345	43	56.6	92	49.7
	1/week	246	23.0	116	22.1	232	24.5		15	19.7	51	27.6
	2-/week	235	21.9	120	22.8	260	27.4		17	22.4	41	22.2
	missing	14	1.3	9	1.3	9	0.9		1	1.3	1	0.5
Fatigue during free time	0-3/month	735	68.6	339	64.5	518	54.6	<.0001	52	68.4	110	59.5
	1/week	216	20.2	107	20.3	235	24.8		16	21.1	48	26.0
	2-/week	101	9.4	68	12.9	186	19.6		6	7.9	25	13.5
	missing	20	1.9	12	2.3	9	1.0		2	2.6	2	1.1
Sleep length	≤6.5h	305	28.5	136	25.9	216	22.8	<.0001	19	25.0	44	23.8
	7.0-8.5h	743	69.3	370	70.3	657	69.3		54	71.1	134	72.4
	≥9.0 h	16	1,5	14	2.7	70	7.4		2	2.6	5	2.7
	missing	8	1.1	6	1.1	5	0.5		1	1.3	2	1.1