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Shift work schedule and night work load: Effects on body mass index – a four-year longitudinal study

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There are few prospective studies exploring the effects of different shift schedules and night work exposure on weight gain. In this study, we found that night workers gained significantly more weight than day workers over a four-year period. Night workers seem to be a subgroup of shift workers who need special attention due to higher risk of weight.

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Key terms: BMI; body mass index; body mass index; cardiovascular disease; CVD; longitudinal study; night shift; night work; night work load; night worker; obesity; shift work; shift work schedule; shift worker

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Shift work schedule and night work load: Effects on body mass index – a four-year longitudinal study

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Objectives The aim of this study was to investigate changes in body mass index (BMI) between different work schedules and different average number of yearly night shifts over a four-year follow-up period.

Methods A prospective study of Norwegian nurses (N=2965) with different work schedules was conducted: day only, two-shift rotation (day and evening shifts), three-shift rotation (day, evening and night shifts), night only, those who changed towards night shifts, and those who changed away from schedules containing night shifts. Paired student's t-tests were used to evaluate within subgroup changes in BMI. Multiple linear regression analysis was used to evaluate between groups effects on BMI when adjusting for BMI at baseline, sex, age, marital status, children living at home, and years since graduation. The same regression model was used to evaluate the effect of average number of yearly night shifts on BMI change.

Results We found that night workers [mean difference (MD) 1.30 (95% CI 0.70–1.90)], two shift workers [MD 0.48 (95% CI 0.20–0.75)], three shift workers [MD 0.46 (95% CI 0.30–0.62)], and those who changed work schedule away from [MD 0.57 (95% CI 0.17–0.84)] or towards night work [MD 0.63 (95% CI 0.20–1.05)] all had significant BMI gain ($P<0.01$) during the follow-up period. However, day workers had a non-significant BMI gain. Using adjusted multiple linear regressions, we found that night workers had significantly larger BMI gain compared to day workers [$B=0.89$ (95% CI 0.06–1.72), $P<0.05$]. We did not find any significant association between average number of yearly night shifts and BMI change using our multiple linear regression model.

Conclusions After adjusting for possible confounders, we found that BMI increased significantly more among night workers compared to day workers.

Key terms BMI; cardiovascular disease; CVD; night shift; night worker; obesity; shift worker.

Shift work has been shown to be associated with many different health consequences such as sleep difficulties, gastrointestinal disease, cancer, metabolic disease, and increased risk of cardiovascular disease (CVD) (1–5). According to the last European Working Conditions Survey, 21% of the workforce participates in some type of shift work (6). Accordingly, the health of the shift worker is a major public health concern.

Lately, much attention has been directed towards the possible increased risk of metabolic and cardiovascular disease among shift workers, as well as the pathways and mechanisms that may mediate the effects of shift work on CVD (2, 7, 8). Obesity is a well-recognized cardiovascular risk factor. Notably, increased prevalence of body weight related outcomes, such as increased body mass index (BMI) and obesity has been found among shift workers (8, 9). In addition to constituting a metabolic and cardiovascular risk factor, obesity has also been identified as a risk factor for several types of cancer, musculoskeletal disorders and poor health in general. In addition, obesity is also linked to increased mortality (10–14). As the prevalence of obesity is rising worldwide, both the Organization for Economic Co-operation and Development and the World Health Organization have expressed concern about obesity reaching global epidemic proportions (15, 16).

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Several cross-sectional studies have shown that shift workers are at increased risk of having higher BMI compared to day workers (17–21). A few longitudinal studies have also reported larger weight gain among shift and night workers compared to day workers (22–24). However, several systematic reviews have consistently pointed to several major methodological limitations in the majority of previous studies within this field of research, such as lack of large prospective studies and heterogeneities in study designs, especially related to different work schedules and exposure variables (3, 8, 9, 25, 26).

Taking these issues into account, the aim of this study was to investigate how different work schedules and average number of yearly night shifts were associated with changes in BMI over a four-year follow-up period in a large sample of nurses.

Methods

Design

The data stemmed from an ongoing project "The Survey of Shiftwork, Sleep and Health" (SUSSH). The project was initiated in December 2008. In the present study, we analyzed data from the first five annual waves. The population consisted of registered members of the Norwegian Nurses Organisation (NNO), which include most of the working nurses in Norway. The survey population (N=6000) comprised a total of five strata, each containing 1200 nurses holding at least a 50% work position, and was randomly drawn from the member registry of the NNO. The criteria for the different strata were time elapsed since graduation: <12 months (stratum 1), 1–3 years (stratum 2), >3–6 years (stratum 3), >6–9 years (stratum 4) and >9–12 years (stratum 5). The stratification towards a young cohort was done in order to ensure that the cohort could be followed for the planned ten-year period. However, nurses were not excluded based on age. Figure 1 provides an overview of the selection process for the nurses involved in this SUSSH sub cohort.

Data

Data used in this study were extracted from (i) baseline: sex, age, body weight, height, marital status, and whether the responders had children living at home, years since graduation, and work schedule, (ii) wave 2–5: number of night shifts previous year, and (iii) wave 5: body weight and work schedule. BMI was calculated conventionally using weight (kg) over the square of height in meters.

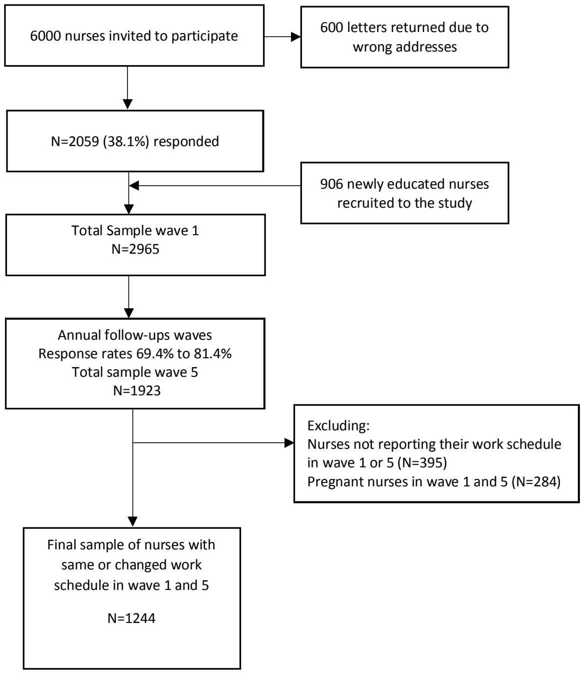

Figure 1. Flow chart visualizing the selection process for the analysis of the nurses in this study.

Work schedule

Responders were asked about their work schedule: day only, evening only, two-shift rotation (day and evening), three-shift rotation (day, evening and night), night only, or another schedule including night work. We studied workers who reported working the same schedule in wave 1 and wave 5 and included those involved in the most frequently reported work schedules: Day only (N=65), two-shift rotation (N=300), three-shift rotation (N=445), and night only (N=43). We also included those who in the follow-up period had stopped working night shifts (N=302), and those who had started working night shifts (N=89). Thus, we had a total of six subgroups. The most common work hours in rotational work schedules are 07:00–15:00 (day shifts), 14:30–22:00 (evening shifts), and 22:00–07:00 (night shifts). There may be local variations, especially among day-only workers working in outpatient clinics, where for example 08:00–16:00 shifts are quite frequent. Shift workers in full position have a 35.5 hours work-week, while day-only workers have a 37.5 hours-work week.

Average number of yearly night shifts

In each wave, the nurses were asked to report the number of night shifts they had worked last year. Thus, in wave 2 this reflected the number of nights worked the year after the first BMI measurement. As a result of this, we calculated a sum score from wave 2–5 which comprised the years with night work between the two BMI measurements. By dividing the sum score by number of waves we created a continuous exposure which represented the average number of night shifts per year. Only those who answered the question in all 4 waves were included. The nurses who reported working day only throughout the follow-up period were included with 0 night shifts in the sum score. We further categorized this continuous variable into three subgroups with respect to average number of yearly night shifts: <1, 1–20, and >20. Regarding average number of yearly night shifts, we did a subgroup analysis including only day and night workers (night and three shift workers combined). We analyzed the latter subgroup with respect to the categorized average number of yearly night shifts variable. In addition, for the night workers (night and three-shift workers), we also conducted a sub-categorization with respect to average number of yearly night shifts reflecting their night shift exposure: <20, 20–40, and >40.

Statistical analysis

SPSS version 24 (IBM, Armonk, NY, USA) was used for the analyses. Continuous variables were expressed as means (±SD) and categorical variables as proportions (%). For demographic data and different work schedules, ANOVA analyses were used to compare means and chi-square tests were used to compare proportions. To evaluate within-subgroup differences (BMI change from wave 1 to 5) for work schedule, we used paired t-tests. Further, we used hierarchical linear regression analyses to adjust for the following confounders when evaluating the outcome variable (BMI in wave 5): BMI at baseline, sex, age, children living at home (baseline), marital status (baseline), and years since graduation (baseline). When adjusting for BMI at baseline in our model and using BMI in wave 5 as our outcome variable, we used the residual change scores to evaluate changes in BMI in the follow-up period (27). Children living at home and marital status were chosen as confounders because of their potential for non-work related disruption of life balance and sleep. Years since graduation was included as a possible confounder to adjust for potential work related effects (eg, experience) beyond our follow-up period. Regarding the choice of confounders, we did not include exercise habits and lifestyle behaviors. We will argue that lifestyle factors might entail one of the mechanisms driving the larger weight gain among shift workers due to disruption of work-life balance. Adjusting for these factors could thus lead to an underestimation of the effects of night work on BMI change. Work schedule was dummy coded using day workers as contrast in the model. For average number of yearly night shifts, we used those workers with lowest average number of yearly night shifts as contrasts. For both work schedule and average number of yearly night shifts, we used the same linear regression model with BMI in wave 5 as the outcome variable. The unstandardized regression coefficients (B) reflect the magnitude of change observed in the dependent variable (in this case change in BMI) when the predictor/independent variable changes with one unit when controlling for the influence of the other predictors/independent variables included in the regression analysis. Significance level was set to $P<0.05$.

Ethics

The Regional Committee for Medical and Health Research of Western Norway (REK-WEST) (NO. 088.88) approved the project.

Results

Demographics

In this sub-cohort of the SUSSH, the mean age of the study population at baseline was 32.9 (SD 8.6) years, range 21–63 years. In wave 1, the nurses worked on average 33.7 (SD 6.9) hours per week and 51.6% reported working a position exceeding 90%. At baseline, three-shift rotation was most common (57.0%, N=709), followed by two-shift rotation (30.7%, N=379), night only (6.5%, N=81), and lastly day only (6.0%, N=75). Mean BMI in wave 1 was 24.6 (SD 4.2) kg/m^2 and 25.1 (SD 4.7) kg/m^2 in wave 5. Prevalence of obesity was 11.0% (N=134) and 13.0% (N=159) in wave 1 and 5, respectively (table 1).

Work schedule

Day workers did not change BMI significantly during the follow-up period. However, all the other groups – two-shift rotation, three-shift rotation, night only, and those who stopped and started with night work in the four year period – increased in BMI (table 2). The linear regression models showed that night workers had significantly larger BMI gain compared to day only workers, even when adjusting for all confounders (table 2).

Average number of yearly night shifts.

A total of 810 nurses reported yearly number of night

Table 1. Demographics at baseline for the shift work population consisting of Norwegian nurses. **BOLD indicates significance (P<0.05).**

	Day workers (N=65)				2-shift workers (N=300)				3-shift workers (N=445)				Night-only workers (N=43)				Stopped working nights (N=302)				Started working nights (N=89)				P-value
	N	%	Mean	SD	N	%	Mean	SD	N	%	Mean	SD	N	%	Mean	SD	N	%	Mean	SD	N	%	Mean	SD	
Female	57	89.1			273	91.3			393	88.7			36	85.7			273	91.1			82	92.1			0.65 [a]
Age [b]	65		37.6	7.8	298		34.6	9.8	445		31.5	7.8	43		35.9	8.7	301		32.3	8.1	89		30.3	8.0	**<0.0001** [c]
Children living at home [b]	44	71.0			135	46.7			171	39.5			27	64.3			144	49.3			20	35.7			**<0.0001** [a]
In relationship [a]	55	84.6			208	69.6			287	64.9			35	81.4			206	68.2			54	60.7			**0.006** [a]
Average work hours per week [a]	63		35.7	5.7	300		33.8	6.1	430		34.1	6.3	42		27.9	10.4	294		33.0	7.2	84		33.3	7.9	**<0.001** [c]
Years since graduation [b]	64		8.2	3.1	299		2.8	3.7	444		3.9	3.9	43		5.9	5.0	301		3.9	3.8	89		2.6	3.9	**<0.0001** [c]
BMI [b]	64		24.3	3.6	293		24.8	4.6	441		24.2	3.8	43		25.9	3.9	300		24.8	4.6	89		24.9	4.3	**0.0497** [c]
Obese	4	6.3			35	12.0			37	8.4			6	14.0			40	13.3			13	14.6			0.133 [d]
Average yearly night shifts [e]									249		33.3	18.5	26		116.1	36.3	163		15.9	12.7	34		34.4	40.5	**<0.0001** [c]

[a] Evaluated using Pearson Chi-square.
[b] Data recorded at baseline.
[c] Evaluated using one-way ANOVA.
[d] Evaluated using Fisher's exact test due to expected cell count <5.
[e] Average number of yearly night shifts in the follow-up period.

shifts in each wave. The mean was 24.6 night shifts/year (range 0–195, SD 30.9). Using the same hierarchical regression model, we did not find any significant relationship between night shift exposure (average number of yearly night shifts) and BMI change (table 2). In our subgroup analysis of only day and night workers with respect to average number of yearly night shifts, we did not find any significant differences between groups in terms of BMI (data not shown). Similarly, in the subgroup analyses of nurses working nights (<20, 20–40, >40) higher number of night shifts was not significantly related to BMI change (table 2).

Discussion

In the present study, we found that those working nights only gained more weight (higher BMI gain) during the four-year follow-up period compared to day-only workers, even when adjusting for relevant confounders. However, the average number of yearly night shifts in the follow-up period was not significantly associated with BMI gain.

Increased attention has recently been directed towards the possible causal relationship between shift work and weight increase. There is however large heterogeneity across studies within this field when it comes to study design, choice of exposure variable (type of shift work schedule and total night work exposure) and choice of outcome variables (BMI increase, weight increase, prevalence of overweight or obesity). Two systematic reviews on this topic emphasize the need for more longitudinal studies including analyses of different shift schedules and cumulative night work exposure (8, 9). Van Drongelen et al (9) concluded in 2011 that there was strong evidence for a crude association between shift work exposure and weight increase, but also noted that there was insufficient evidence for a confounder-adjusted relationship between shift work and weight increase. However, in a more recent systematic review, Proper et al (8) concluded that there was a strong evidence for a relation between shift work and increased body weight.

The present study addressed some of the methodological concerns that have been raised in previous reviews. We investigated both work schedules and average number of yearly night shifts using a prospective design (3, 8, 9). In our study, night only workers had the largest BMI gain in the follow-up period, which also turned out to be significantly larger compared to day workers, even after adjusting for possible confounders. This result is consistent with other longitudinal studies (22–24). A few studies have looked at BMI and shift work with respect to metabolic syndrome (a cluster of independent risk factors for CVD: central obesity, dyslipidemia, hypertension, and glucose intolerance) (28). In a 20-year follow-up study on night workers (working 210–230 nights per year), Biggi et al found that night workers, compared to day workers, had elevated BMI and obesity rates, which is in line with our findings (29). Zhao et al found in a two year follow-up study of nurses and midwives that shift work maintainers and those who changed from day to shift work significantly increased

Table 2. Paired t-test evaluating within group effects and linear regression model analyzing respective body mass index (BMI, kg/m²) changes in the follow-up period. [CI=confidence interval; SD=standard deviation]

	Paired t-test						Linear regression model (BMI at year four as dependent variable)			
	N	BMI at baseline		BMI at year four		Mean difference (95% CI)	Model 1 [a] (N=1225/ N=792/N=271) [c]		Model 2 [b] (N=1172/ N=754/N=260) [c]	
		Mean	SD	Mean	SD		BMI_{diff} [d]	95% CI	BMI_{diff} [d]	95% CI
Work schedule										
Day only (contrast)	64	24.25	3.52	24.59	3.66	0.33 (-0.17–0.84)				
2-shift rotation	288	24.88	4.53	25.36	4.79	0.48 (0.20–0.75) [e]	0.11	-0.43–0.66	0.15	-0.43–0.73
3-shift rotation	436	24.17	3.72	24.63	3.94	0.46 (0.30–0.62) [e]	0.08	-0.45–0.60	0.03	-0.52–0.58
Night only	43	25.95	3.87	27.25	4.52	1.30 (0.70–1.90) [e]	0.95	0.15–1.76 [f]	0.89	0.06–1.72 [f]
Stopped working nights	296	24.82	4.57	25.40	5.39	0.57 (0.17–0.84) [e]	0.20	-0.47–0.75	0.14	-0.43–0.71
Started working nights	87	24.69	4.14	25.32	4.96	0.63 (0.20–1.05) [e]	0.26	-0.45–0.40	0.22	-0.49–0.92
Average number yearly night shifts, whole cohort										
<1(contrast)	189	24.29	3.40	24.63	3.78	0.34 (0.54–0.63) [f]				
1–20	277	24.68	4.49	25.24	5.30	0.56 (0.27–0.85) [e]	0.22	-0.19–0.63	0.17	-0.26–0.60
>20	326	24.88	4.07	25.44	4.34	0.57 (0.34–0.79) [e]	0.23	-0.16–0.63	0.27	-0.15–0.68
Average number yearly night shifts, night workers										
<20 (contrast)	64	24.25	3.91	24.69	4.36	0.44 (0.02–0.86) [f]				
20–40	109	24.45	3.89	24.79	4.89	0.34 (-0.03–0.71)	0.10	-0.64–0.44	0.09	-0.49–0.66
>40	98	24.76	3.68	25.56	3.88	0.80 (0.50–1.11) [e]	0.37	-0.18–0.92	0.56	-0.03–1.15

[a] Model 1: Adjusted for BMI_{year1}.
[b] Model 2: Adjusted for BMI_{year1}, sex, age, children living at home, marital status, and years since graduation at baseline. BMI at baseline was significant among the adjusting variables in both models. Children living at home was significant in the adjusted model with night only workers.
[c] Number on individuals included in the linear regression models (n=) for work schedule and average number of yearly night shifts, respectively.
[d] Unstandardized coefficients (B) values (units BMI change/units change in predictor variable).
[e] P<0.001.
[f] P<0.05.

BMI, while those who changed from shift work to day work did not (24). When analyzing data of those who changed schedule during the follow-up period in the present study, we found that they had significant within-group BMI gain, but compared to day workers they did not have a significant larger BMI gain. The interpretation of this finding is difficult because we do not have information on why they changed work schedule. However, it is interesting that so many nurses stopped working nights. One may speculate that there is a "healthy worker effect" or a "survivor effect", meaning that only those with a tolerance for night work tend to maintain this kind of work schedule (30). This could potentially underestimate the effect of shift and night work on BMI in the present study. One could also argue that increased salary may attract some nurses to work nights, and night work may be less physically demanding than day and evening work. Thus, there may also be a selection into shift and night work. We did not find a significant difference between the three shift rotation workers and day workers with regards to BMI. This could possibly reflect that the average exposure to night work in this group might not have been large enough, or that the follow-up period might not have been sufficiently long. In our subgroup analysis of the night workers (night-only workers and three-shift workers), we found that those with highest number of night shifts had the largest BMI gain (table 2). Interestingly the group with a medium number of yearly night shifts (20–40 night shift/year) did not have a significant BMI gain in the follow-up period. One may speculate that even though no linear relationship between night work and BMI gain was detected, a very heavy night work load (above a certain number of night shifts) may lead to increased BMI gain at a group level. This might be the result of both failure to adapt biologically and increased social constraints and restricted opportunities to adhere to a healthy lifestyle. In a study of Korean nurses, Kim et al (20) found a higher prevalence of obesity and overweight (odds ratio 1.63) among those with the longest exposure to shift work when adjusting for confounders. However, that study was based on a cross-sectional design, thus conclusions regarding overweight and obesity trajectories based on that are not possible.

As previously stated, different exposure variables regarding shift work schedules have been used in different studies making comparisons difficult. Some studies have reported that those changing from day to night shifts and permanent night shift workers are those at highest risk of weight gain (17, 31). A few studies have investigated if there is a graded effect of cumulative night work exposure on weight gain in addition to the effects of years exposed to shift work. Peplonska et al (19) concluded that there was a graded association both between cumulative night shifts and cumulative night shift hours and obesity. Similarly, Ramin et al (32) found for example that higher levels of night shifts per month were associated with increased risk of obesity. The risk was graded with respect to the number of night shifts. They also found that the risk of obesity was higher among those who had night work as their primary schedule compared to those with rotating shift work as their primary schedule. We did not find a dose–response relationship with respect to average number of yearly night shifts and BMI change, but overall our data also suggested that those with the largest night shift exposure were most at risk.

In terms of limitations, it should be noted that we did not control for the "healthy worker effect" or the "survivor effect". Our study had a low response rate at baseline, which is an increasing problem in epidemiological research. A review by Baruch et al (33) suggests that most study populations have response rates around 53% ± 20% (1 SD from the mean response rate in that review) (34). Our initial response rate was within this range, and the follow-up waves in our study had high and stable response rates around 70–80%. Unfortunately, we have no information about the non-responders at wave 1, preventing us from conducting attrition analyses. Also, as with all studies based on self-report there will be uncertainties in terms of how well the data reflect objective realities. There is for example a tendency for respondents to overestimate height and underestimate weight compared to objectively collected data (34). An important, albeit subjectively assessed, parameter in this study was the number of night shifts worked the last year. Most Norwegian nurses work regular schedules and are thus likely to provide good estimates of this variable. In line with this, Brisson et al (35) found that self-reported data collected close to specific events are highly accurate ensuring high validity. Another limitation was that we did not exclude nurses who were pregnant and gave birth in-between the two BMI measurements. This may have confounded the relationship between night work and BMI gain. However, we did exclude nurses who were pregnant at the time of BMI measurements.

Strengths of the present study entail its homogenous population and clearly defined exposure variables. Data were collected annually and thus increasing the validity and minimizing recall bias (35). With our prospective study design, we have addressed several issues that systematic reviews have emphasized as important (8, 9).

Concluding remarks

We found that night only workers had significantly larger BMI gain than day-only workers in the four-year follow-up period, also after adjusting for relevant confounders. Our findings add to the growing evidence attesting to the negative effects of night work on body weight development. We did not find a dose–response relationship with respect to average number of yearly night shifts. It is concluded that night work might be one parameter to consider as an occupational and societal hazard in terms of weight gain. Relevant countermeasures such as dietary advice and exercise opportunities should accordingly be emphasized for night workers.

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