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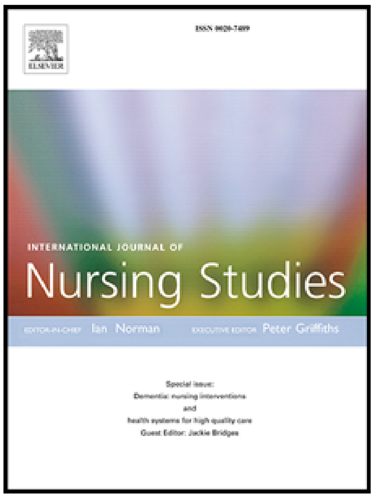

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The effects of using participatory working time scheduling software on working hour characteristics and wellbeing: A quasi-experimental study of irregular shift work

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Abstract

Background: Studies in the health care sector indicate that good work time control is associated with better perceived wellbeing but also with non-ergonomic work schedules, such as compressed work schedules. Participatory working time scheduling is a collaborative approach to scheduling shift work. Currently, there is a lack of information on whether working hour characteristics and employees' wellbeing in irregular shift work change after implementing participatory working time scheduling.

Objective: To investigate the effects of using digital participatory working time scheduling software on working hour characteristics and well-being among Finnish hospital employees.

Participants and methods: We compared changes in objective working hour characteristics and wellbeing between 2015 and 2017 among employees (n= 677, mainly nurses and practical nurses) when using participatory working time scheduling software (participatory scheduling, n= 283) and traditional shift scheduling (traditional scheduling, n= 394). The statistical analyses were conducted using the repeated measures general linear model and the generalized logit model for binomial and multinomial variables adjusted for age, sex, education, shift work experience, control over scheduling of shifts at baseline (where applicable) and hospital district.

Results: The proportion of long work shifts (≥12h) increased to a greater extent (F= 4.642, p= 0.032) with the participatory scheduling than with the traditional scheduling. In comparison to traditional scheduling, the perceived control over scheduling of shifts increased significantly with participatory scheduling (OR 3.24, 95% CI 1.73–6.06). None of the other wellbeing variables showed statistically significant changes in the adjusted models.

Conclusions: The proportion of long work shifts and perceived control over scheduling of shifts increased more among employees using participatory working time scheduling than among those using traditional scheduling. Otherwise, using participatory working time scheduling software had little effect on both objectively measured working hour characteristics and perceived wellbeing in comparison to traditional scheduling. The results merit confirmation in a larger sample with a longer follow-up.

This study was registered to ClinicalTrials.gov (NCT02775331) before starting the intervention phase.

Key words

shift work, work time control, working time autonomy, self-rostering, hospital employees, health care, nursing

Tweetable abstract

Participatory working time scheduling combines individual flexibility and staffing requirements in shift work.

What is already known about the topic?

- Previous research shows that good work time control associates positively with wellbeing at work, but may result in poorer ergonomics, for example compressed work schedules.
- Among nursing staff, good work time control can even increase staff retention.
- As a new, collaborative form of working time arrangement, participatory working time scheduling can combine individual flexibility and staffing requirements in shift work.

What this paper adds

- Data on objective working hour characteristics show that working hour characteristics change only slightly after the implementation of participatory working time scheduling.
- Long work shifts increased among employees who used participatory working time scheduling software compared to employees who continued in traditional scheduling.
- Using participatory working time scheduling software had a positive effect on employees´ perceived control over scheduling of shifts compared to traditional scheduling.

1. Introduction

Shift workers comprise more than one fifth of the workforce (Eurofound 2016). In many countries, health care workers have the largest proportion of shift workers, e.g., 60% of nurses work shifts in the National Health Service in the UK (Ball *et al.* 2015). Shift work has many negative impacts on employees´ health and wellbeing, including insufficient sleep (Kecklund and Axelsson 2016), increased risk of occupational injuries (Nielsen *et al.* 2018), type 2 diabetes (Gao *et al.* 2020), breast cancer (Pahwa *et al.* 2018), and coronary heart disease (Torquati *et al.* 2018). Actions that promote shift workers' health, recovery, and wellbeing at work are thus needed.

Earlier research on work time control in shift work has mainly used the concepts self-rostering or self-scheduling, referring to a method that allows employees a certain amount of flexibility in choosing their shift patterns, which management can augment in terms of coping with operational requirements (Bailyn *et al.* 2007). Whereas self-rostering can be understood as individual entitlement (Barrett and Holme 2018), participatory working time scheduling is a collaborative approach in which working time legislation, operation of the ward, and employees´ equality and fairness are all taken into account (Hakola *et al.* 2007) in cycles of negotiations and adjustments of schedules. Participatory working time scheduling is both an opportunity and an obligation for the employee to participate in their own scheduling and their ward's scheduling, which in turn affects the consistency of scheduling at the ward level.

As previous studies have mainly investigated good work time control in shift work either using surveys on work time control or studied the effects of self-rostering instead of participatory working time scheduling, we cite these studies here. Good opportunities to influence working hours have many positive effects on day and shift workers´ wellbeing, including improved sleep quality (Takahashi *et al.* 2011, Tucker *et al.* 2015), work-life balance (Keeton *et al.* 2007, Nijp *et al.* 2012), job/career satisfaction (Lowden and Åkerstedt 2000, Pryce *et al.* 2006, Clem *et al.* 2008), as well as decreased depressive symptoms (Takahashi *et al.* 2011), sickness absence (Nätti *et al.* 2015) and burnout (Keeton *et al.* 2007). In one cohort study, good work time control was even related to later retirement beyond the pensionable age (Virtanen *et al.* 2014). Among nursing staff, providing good opportunities to influence working hours seems to be a promising measure for increasing staff retention (Leineweber *et al.* 2016). Cohort studies have linked low control over working hours with psychological distress (Ala-Mursula *et al.* 2002, Vahtera *et al.* 2010), an increased risk of sleep disturbances (Salo *et al.* 2014), and poor perceived health (Ala-Mursula *et al.* 2002, Vahtera *et al.* 2010). Thus, employee-oriented flexibility is beneficial for employees and indeed, workplaces have increasingly implemented flexible work time arrangements (Beckers *et al.* 2012).

However, in shift work, the introduction of self-rostering may result in poorer ergonomic work schedules. Research shows that employees may prioritize longer continuous free time at the cost of sufficient sleep and recovery (Kecklund *et al.* 2008, Beckers *et al.* 2012) as well as at the cost of the functionality of the operations of the unit or workplace (Barrett and Holme 2018). The few previous studies on this area show none or minor negative changes in working hour ergonomics after the implementation of self-rostering. In a Danish study, self-rostering increased both short and long shift durations, but did not compromise most recommendations for ergonomic shift work schedules (Garde *et al.* 2012) that restrict circadian disruption and promote sufficient sleep and recovery. On the other hand, self-rostering among nursing staff has been reported to result in significantly improved work-life balance (Wortley and Grierson-Hill 2003), which may, in turn, lead to increased staff retention (Barrett and Holme 2018).

As most of the earlier studies on work-time control are not experimental, we lack information on how working hour characteristics change after increasing employees' control over working hours. Our previous cross-sectional study (Karhula *et al.* 2019) utilized objective working hour data and showed that high perceived control over scheduling of shifts was associated with slightly more weekend work and more variability in shift length. Nevertheless, no association was found between most of the working hour characteristics studied, including short shift intervals and number of consecutive night shifts, and level of control over scheduling of shifts. Importantly, there is a further lack of studies on participatory working time scheduling and the implementation of participatory working time scheduling at workplaces.

In this study, we were able to observe the implementation of participatory working time scheduling software and utilize extensive objective working hour data to study the changes in the exact proportions of different working hour characteristics. The aim of the study was to investigate the effects of the implementation of software for participatory working time scheduling on realized working hour characteristics and changes in several wellbeing outcomes. These outcomes included self-reported sleep length, shift-specific insomnia and excessive sleepiness, work-life conflict, control over scheduling of shifts, and perceived health. We expected that the implementation of participatory working time scheduling software would decrease work-life conflict and increase perceived control over the scheduling of shifts, but also result in more irregularity in shift schedules, which might weaken shift ergonomics within the boundaries set in the studied shift scheduling software.

2. Methods

2.1 Study sample and participants

The study participants were hospital employees from three hospital districts that participated in the Finnish Public Sector (FPS) study survey in 2015 (n=11 274, response rate 69%) and 2017 (n=9 030, response rate 74%) and who had objective working hour data from Titania® (CGI Finland Ltd, Helsinki, Finland) shift scheduling software for 91 days preceding both survey waves. To be included in the quasi-experimental intervention, all three hospital districts needed to have wards that were included in the intervention as well as wards that acted as controls. The employees had to be shift workers (with a minimum of three evening and three night shifts during the past 91 days) and to have had at least 31 work shifts during the past 91 days. All the employees worked on a period-based work contract (114:45h/3 weeks) and had a monthly salary. Day workers were excluded due to the lack of most of the studied working hour characteristics, and physicians were excluded due to on-call work not being registered in the database. The employees worked in wards that either started to use the new participatory working time scheduling software (from here on participatory scheduling) or remained in traditional shift scheduling (from here on traditional scheduling) (Figure 1.).

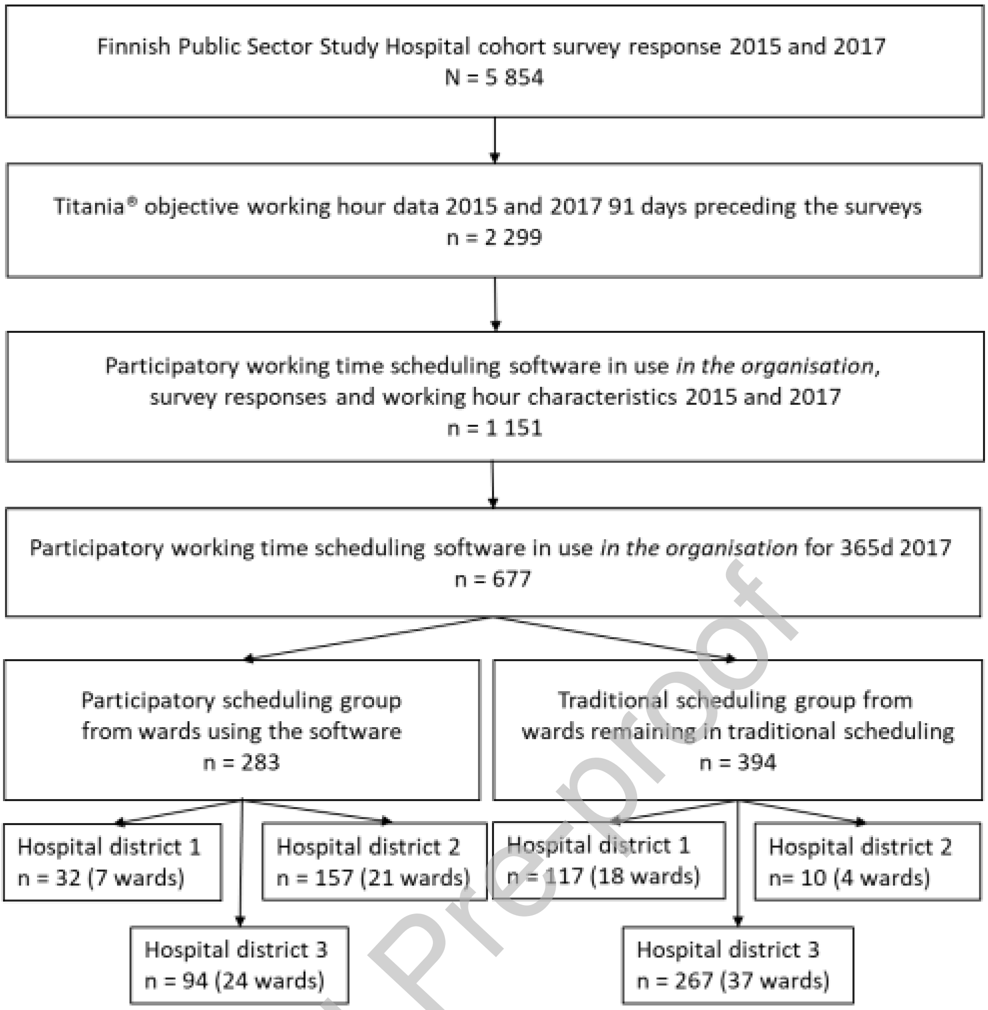

Figure 1. Flow chart of study's inclusion criteria.

2.2 Objective working hour data

The objective working hour data were retrieved from the shift scheduling program Titania®. Based these data we formed the following working hour characteristics: long (>40h) and very long (>48h) weekly working hours, long (≥12h) work shifts, quick returns (<11h shift interval), single days off, evening shifts (starts after 12:00 and is not categorized as night shift) and night shifts (≥3 hours between 23:00 and 06:00 according to the Finnish Working Time Act) and weekend work. The methodology of retrieving and analysing the daily payroll working hour data has been described earlier (Härmä *et al.* 2015).

2.3 Survey variables

We used the survey variables of age, sex, level of education, shift work experience and perceived control over scheduling of shifts at baseline (where applicable) as covariates in the statistical models, which are described later. Education was categorized into three levels: basic, vocational and applied university- or university-level education. Duration of shift work experience was elicited by asking 'How long have you worked shifts altogether?'. The response was the total number of years in shift work.

The wellbeing outcomes of interest included work-life conflict, perceived health, perceived control over scheduling of shifts, sleep duration, and shift-specific insomnia and excessive sleepiness symptoms. Work-life conflict was elicited by asking '*How often do you feel that your work takes too much time or energy from your family-life or life*?' adapted from Mårdberg *et al.* (1991). The response options were on a five-point Likert-type scale from never to very often, and they were dichotomized: 'never' to 'sometimes' as not having work-life conflict, and 'often' and 'very often' as having work-life conflict. Perceived health was measured using a five-point Likert-type scale from good to poor (Blaxter 1987). When dichotomized, poor perceived health included the alternatives 'poor' and 'rather poor', and good perceived health the three alternatives 'intermediate', 'rather good' and 'good'. Perceived control over scheduling of shifts was elicited by asking 'How much control do you have over the scheduling of work shifts?' (Ala-Mursula *et al.* 2002). The responses 'very much' and 'much' were classified as good control, 'some' as intermediate control, and 'little' and 'very little' as low control. The baseline answers were used as covariates where applicable.

Average 24h sleep duration was elicited with the question 'How many hours do you normally sleep during a 24-hour period?' with options from five hours or less to ten hours or more in 30-minute intervals (Vahtera *et al.* 2006). The responses were categorized into three classes; short sleep (≤6 hours), normal sleep (6.5–8.5h) and long sleep (≥9h). Insomnia and excessive sleepiness were elicited separately using shift-specific questions 'How often have you experienced insomnia/excessive sleepiness in connection with morning/evening/night shifts or on days off during the past three months?'. The response options were on a six-point Likert-type scale from 'not at all' to 'every day' (Vanttola *et al.* 2020). The answers were classified as having sleep difficulties if the frequency was at least two times per week.

2.4 Quasi-experimental participatory working time scheduling intervention

In this quasi-experimental intervention, the researchers had no influence on the implementation process of the working time scheduling software in the hospital districts. The hospital districts followed internal processes to decide which units started to use the digital participatory working time scheduling software and when. The introduction period, training and negotiations regarding the rules that outlined the shift scheduling (for example, minimum number of night shifts or weekend shifts per employee in each three-week period) were also organized internally. Based on the ward-level rules, each employee recorded their schedules in three-week periods in the software in a view that showed current staffing requirements in the ward and the ergonomics of their planned schedule in traffic light colour coding (i.e. green = good, yellow = moderate, orange = should be avoided and red = forbidden). The employees were able to check the ergonomic criteria for each colour in a separate view. The shift ergonomics tool consisted of working time dimensions and characteristics that are described in detail in Härmä *et al.* (2015).

To ensure enough experience in using the participatory working time scheduling software, only the employees from the wards that had been using the Titania® software for at least the whole of 2017 (365 days) were included in the participatory scheduling group.

The traditional scheduling group was selected from among the employees who worked in the wards that continued using traditionally scheduled rosters in the same hospital districts. In our study, traditional scheduling meant that in these units, a head nurse or a shift planner made the plans for three-week periods at least two weeks before the start of a new period. The employees had the opportunity to express their wish for single shifts (i.e., due to personal needs or preferences). After the person responsible for planning agreed, the final version of the three-week roster was made available to the employees at least one week before the beginning of the three-week period. A head nurse or shift planner used the shift scheduling program and may have had access to the information in the shift ergonomics view, depending on the software version. Employees who had used the new working time scheduling software for only part of 2017 (n= 669) were excluded.

2.5 Ethical issues

All the hospital districts gave the Finnish Institute of Occupational Health their written permission to use the employers' working time registries for its research. All data were anonymized, and international ethical standards were conformed to. The coordinating ethics committee of the Hospital District of Helsinki and Uusimaa (HUS) approved this study as part of the Finnish Public Sector study ethical approval (HUS 1210/2016). As required by The International Committee of Medical Journal Editors (Zarin *et al.* 2011), the intervention was registered to ClinicalTrials.gov (NCT02775331) before the intervention phase began. The primary outcome of the intervention, sickness absence, is reported in a manuscript submitted by Turunen et al. (2020).

2.6 Statistical methods

The statistical analyses were conducted using IBM SPSS Statistics 25 (IBM Corp., Armonk, NY, USA) and SAS 9.4 (SAS Institute Inc., Cary, North Carolina, USA) software.

Changes in the continuous objective working hour characteristics between 2015 and 2017 were analysed using repeated measures GLM (general linear model). The within-subject GLM models were run to calculate the F- and p-values for both the unadjusted and adjusted models. Maulchy´s test of sphericity showed no violation of sphericity and therefore no corrections were used. The fully adjusted model included age, sex, level of education, shift work experience, perceived control over scheduling of shifts at baseline (where applicable) and finally, hospital district, to control for possible differences between the three hospital districts studied. Changes in the categorical wellbeing outcomes (work-life conflict, control over scheduling of shifts, perceived health and shift-specific insomnia and excessive sleepiness) between 2015 and 2017 were analysed using a generalized logit model for binomial and multinomial variables. The fully adjusted model included age, sex, level of education, shift work experience, perceived control over scheduling of shifts at baseline (where applicable) and hospital district.

3. Results

3.1 Characteristics of participants

The participants' (n= 677) mean age was 40.8 years, and 84% were females and 87% full-time workers. The participants' descriptive characteristics are shown in Table 1. At baseline, the proportion of participants with at least a bachelor´s degree and part-time work as well as the proportion of females was larger in the participatory scheduling group than in the traditional scheduling group. There were no differences between the groups in terms of mean age, shift work experience and job title. The most common occupational titles were registered nurse, practical nurse, psychiatric nurse, and X-ray nurse.

Table 1. Descriptive statistics of participants.

	All n= 677		Participatory scheduling n= 283		Traditional scheduling n= 394		Group difference
	Mean	SD	Mean	SD	Mean	SD	Sig.[1]
Age (years)	40.8	(10.95)	39.9	(11.71)	41.3	(10.39)	0.150
Shift work experience (years)	13.6	(9.64)	13.6	(10.57)	13.6	(8.99)	0.461
	%	(n)	%	(n)	%	(n)	Sig.
Sex							<0.001[2]
Female	79.2	(536)	93.8	(166)	72.0	(193)	
Male	20.8	(141)	6.2	(11)	28.0	(75)	
Level of education							<0.001[3]
Basic	5.2	(23)	0.6	(1)	8.3	(22)	
Vocational	43.1	(190)	41.5	(73)	44.2	(117)	
Bachelor or higher	51.7	(228)	58.0	(102)	47.5	(126)	
Full-time work							<0.001[2]
Yes	87.0	(589)	74.9	(212)	95.7	(377)	
No	13.0	(88)	25.1	(71)	4.3	(17)	
Job title							0.268[1]
Registered nurse	64.4	(436)	73.9	(209)	57.6	(227)	
Psychiatric nurse	7.4	(50)	2.8	(8)	10.7	(42)	
X-ray nurse	4.3	(29)	1.4	(4)	6.3	(25)	
Practical nurse	8.4	(57)	9.9	(28)	7.4	(29)	
Other[4]	15.5	(105)	12.0	(34)	18.0	(71)	

[1] Mann-Whitney U-test
[2] Fisher´s exact test
[3] Pearson Chi-Square test

[4] Other health care professions, instrument attendants, hospital cleaners, and porters

3.2 Using the participatory working time scheduling software and changes in working hour characteristics

In the participatory scheduling group, the participatory working time scheduling software was used for an average of 193 minutes (range 64–735 minutes) per employee during 2017.

The working hour characteristics showed some parallel changes in both the participatory and the traditional scheduling (Table 2). In the crude GLM analysis, the proportion of long (>40 hours) and very long (>48 hours) work weeks as well as the proportion of long (≥12 hours) work shifts and weekend work increased to a greater extent in the participatory than in the traditional scheduling group. In the adjusted models, only the effect on long work shifts remained ($F= 4.642$, $p= 0.032$). The changes in the proportions of short shift intervals, single days off and evening and night shifts did not statistically significantly differ in the participatory and traditional scheduling, neither in the crude nor adjusted models (F-values ≤3.361 and p-values ≥0.057).

Table 2. Changes in average proportions (%) of studied working hour characteristics between 2015 and 2017 using repeated measures general linear model (GLM).

	Participatory scheduling n= 757				**Traditional scheduling n= 394**				**GLM**			
	2015		**2017**		**2015**		**2017**		**Unadjusted**		**Adjusted[1]**	
Proportion of…	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**F**	**p-value**	**F**	**p-value**
Long (>40h) work weeks of all work weeks	31.97	(13.79)	35.66	(18.68)	34.10	(10.99)	34.35	(16.65)	**7.130**	**0.008**	0.001	0.980
Very long (>48h) work weeks of all work weeks	6.49	(8.25)	9.60	(12.12)	6.92	(8.59)	8.71	(12.04)	**23.159**	**<0.001**	0.639	0.425
Long (≥12h) work shifts of all shifts	6.83	(10.55)	8.32	(9.15)	4.67	(8.69)	4.78	(7.62)	**13.607**	**<0.001**	**4.642**	**0.032**
Short (<11h) shift intervals of all shift intervals <48h	20.53	(11.18)	19.34	(11.43)	16.92	(10.35)	16.76	(10.62)	3.631	0.057	2.693	0.102
Single days off of all day off periods	19.32	(10.11)	18.72	(9.34)	19.10	(10.46)	19.80	(10.39)	0.683	0.409	0.081	0.775
Evening shifts of all shifts	34.22	(11.41)	33.55	(12.06)	35.67	(12.78)	35.71	(11.67)	0.510	0.475	0.033	0.857
Night shifts of all shifts	27.95	(15.58)	27.80	(15.86)	27.60	(15.49)	26.03	(13.51)	3.250	0.072	0.158	0.691
Weekend work of all weekends	46.64	(15.46)	52.47	(16.04)	46.47	(17.99)	51.34	(16.28)	**68.368**	**<0.001**	0.579	0.447

[1] Adjusted for age, sex, level of education, shift work experience, perceived control over scheduling of shifts at baseline (where applicable) and hospital district

3.3 Effects on wellbeing

In the baseline survey, the participatory and traditional scheduling differed only in terms of perceived control over the scheduling of shifts and often having insomnia in connection with evening shifts. Self-rated sleep length, work-life conflict, perceived health, as well as insomnia and excessive sleepiness in association with all the other shift types did not differ in the participatory scheduling compared to the traditional scheduling. (Table 3.)

Table 3. Wellbeing measures at baseline (2015).

			All		Participatory scheduling		Traditional scheduling		Group difference
			%	(n)	%	(n)	%	(n)	Sig.
Work-life conflict	Very often/often		42.3	(173)	43.2	(70)	41.7	(103)	0.420[1]
	Sometimes/seldom/never		57.7	(231)	56.8	(92)	58.3	(144)	
Perceived health	Good/rather good		85.5	(377)	88.6	(155)	83.5	(222)	0.087[1]
	Intermediate/rather poor/poor		14.5	(64)	11.4	(20)	16.5	(44)	
Perceived control over scheduling of shifts		Good	37.5	(165)	50.3	(88)	29.1	(77)	<0.001[2]
		Intermediate	43.9	(193)	37.7	(66)	47.9	(127)	
		Poor	18.6	(82)	12.0	(21)	23.0	(61)	
Sleep length		≤6h	13.0	(57)	10.9	(19)	14.3	(38)	0.563[2]
		>6 - ≤ 8.5h	82.7	(364)	84.6	(148)	81.5	(216)	
		≥9h	4.3	(19)	4.6	(8)	4.2	(11)	
Insomnia	Morning shifts	≤1 x week	75.1	(331)	78.9	(138)	72.5	(193)	0.083[1]
		≥2 week	24.9	(110)	21.1	(37)	27.4	(73)	
	Evening shifts	≤1 x week	90.5	(399)	93.7	(164)	88.3	(235)	0.041[1]
		≥2 week	9.5	(42)	6.3	(11)	11.7	(31)	
	Night shifts	≤1 x week	82.8	(365)	85.6	(149)	80.9	(216)	0.123[1]
		≥2 week	17.2	(76)	14.4	(25)	19.1	(51)	
	Days off	≤1 x week	95.7	(420)	96.0	(167)	95.5	(253)	0.500[1]
		≥2 week	4.3	(19)	4.0	(7)	4.5	(12)	
Excessive sleepiness	Morning shifts	≤1 x week	65.8	(288)	66.5	(115)	65.3	(173)	0.440 [1]
		≥2 week	34.2	(150)	33.5	(58)	34.7	(92)	
	Evening shifts	≤1 x week	93.2	(411)	95.4	(167)	91.7	(244)	0.092[1]
		≥2 week	6.8	(30)	4.6	(8)	8.3	(22)	
	Night shifts	≤1 x week	70.1	(309)	67.8	(118)	71.5	(191)	0.233[1]
		≥2 week	29.9	(132)	32.2	(56)	28.5	(76)	

Days off	≤1 x week	87.7	(384)	87.2	(150)	88.0	(234)	0.462[1]
	≥2 week	12.3	(54)	12.8	(22)	12.0	(32)	

[1] Fisher's exact test
[2] Pearson Chi-Square test

Compared to the traditional scheduling group, perceived control over scheduling of shifts increased significantly in the participatory scheduling group (OR 3.24, 95% CI 1.73–6.06). Experiencing often excessive sleepiness in connection with evening shifts decreased in the participatory scheduling group compared to the traditional scheduling group (OR 0.40, 95% CI 0.16–0.99). The other wellbeing at work variables showed no statistically significant changes in the adjusted models (Table 4.).

Table 4. Changes in wellbeing outcomes between 2015 and 2017 in participatory scheduling group (traditional scheduling as reference). Results from generalized logit model to binomial and multinomial variables presented as odds ratios (OR) and their 95% confidence intervals (CI).

		Unadjusted	**Adjusted[1]**
		Participatory scheduling	**Participatory scheduling**
		OR (95% CI)	**OR (95% CI)**
Sleep length (hours)	≤6h vs 6–8.5h	0.86 (0.63-1.19)	0.93 (0.58-1.49)
	≥9h- vs 6–8.5h	1.01 (0.46-2.20)	1.43 (0.51-4.02)
Work-life conflict	Often vs seldom/never	1.27 (0.95-1.70)	1.03 (0.67-1.59)
Control over scheduling of shifts	High vs intermediate	**2.30 (1.52-3.48)**	**3.24 (1.73-6.06)**
	Low vs intermediate	**0.27 (0.09-0.81)**	0.41 (0.09-1.84)
Perceived health	Poor vs good	0.56 (0.14-2.15)	1.17 (0.15-9.32)
Insomnia[2] in connection with...			
Morning shifts	≥2/wk vs ≤1/wk	0.92 (0.65-1.30)	1.29 (0.79-2.08)
Evening shifts	≥2/wk vs ≤1/wk	0.88 (0.67-1.16)	0.84 (0.56-1.26)
Night shifts	≥2/wk vs ≤1/wk	1.09 (0.79-1.51)	1.29 (0.81-2.06)
Days off	≥2/wk vs ≤1/wk	1.11 (0.85-1.46)	1.09 (0.74-1.61)
Excessive sleepiness[2] in…			
Morning shifts	≥2/wk vs ≤1/wk	0.96 (0.69-1.32)	1.08 (0.70-1.66)
Evening shifts	≥2/wk vs ≤1/wk	0.73 (0.41-1.28)	**0.40 (0.16-0.99)**
Night shifts	≥2/wk vs ≤1/wk	**1.43 (1.03-1.98)**	1.00 (0.64-1.58)
Days off	≥2/wk vs ≤1/wk	1.10 (0.71-1.71)	1.08 (0.60-1.94)

[1] Adjusted for age, sex, level of education, shift work experience, perceived control over scheduling of shifts at baseline (where applicable), and hospital district

[2] during past 3 months

4. Discussion

The aim of this study was to investigate the effects of the implementation of participatory working time scheduling software on realized working hour characteristics and perceived wellbeing. The study was conducted among hospital employees from wards that used the participatory working time scheduling software throughout 2017 and employees from wards that continued with traditional shift scheduling.

Working hour characteristics showed parallel changes in both participatory and traditional scheduling during the follow-up, demonstrating a small increase in the proportion of long and very long work weeks, long work shifts and weekend work, and a decrease in the proportion of short shift intervals in both groups. However, only the increase in the proportion of long work shifts was greater in the participatory scheduling than in the controls. Therefore, the expected increase in irregularity of shift schedules in the participatory scheduling was not confirmed. Perceived control over scheduling of shifts increased and excessive sleepiness in connection with evening shifts decreased significantly with participatory scheduling. The other wellbeing outcomes did not show statistically significant differences in the participatory scheduling and traditional scheduling.

To the best of our knowledge, no previous studies have investigated the effect of participatory working time scheduling on objective working hour characteristics. Moreover, only a few studies that have used the partly overlapping concept of self-rostering and objective working hour data exist. In Denmark, self-rostering decreased the proportion of single days off (Garde *et al.* 2012). In this study, the non-significant results showed a tendency for the proportion of single days off to decrease with participatory scheduling and increase with traditional scheduling. However, in this study, the only statistically significant difference in working hour characteristics between the participatory scheduling and the traditional scheduling after adjustment was the increase in the proportion of long work shifts, which was higher in the participatory scheduling. This is also in line with results from a Danish self-rostering study (Garde *et al.* 2012). Among nurses, working long shifts has been associated with negative outcomes, such as fatigue (Dall'Ora *et al.* 2016) and higher error rates (Clendon and Gibbons 2015). However, in this study, the proportion of long work shifts of all shifts was low (<10% of all shifts in the participatory scheduling) and the results showed no other differences in excessive sleepiness except for evening shifts according to whether the scheduling was participatory or traditional. The overall minor effects on working hour characteristics can be partly due to the shift ergonomics information in traffic light colour coding that was a part of the participatory working time scheduling software.

In this quasi-experimental study, we found an increase in the perceived control over the scheduling of shifts after using participatory working time scheduling software. Previous intervention studies have shown somewhat conflicting results regarding the effects of the implementation of self-rostering on different aspects of wellbeing. A previous Finnish study reported positive effects on health care workers' sleep, social life and leisure time (Hakola *et al.* 2007). However, several other studies (Lowden and Åkerstedt 2000, Garde *et al.* 2011, Nabe-Nielsen *et al.* 2011), like ours, have found no effect on sleep quality. A plausible explanation for no effects on sleep in this and previous studies (Garde *et al.* 2011, Nabe-Nielsen *et al.* 2011) is that even when self-rostering or participatory working time scheduling is in use, shift start and end times in the health care sector are rather fixed, including the start of morning shifts and the end of evening shifts, which play a role in having the opportunity for sufficient sleep. Moreover, even though interventions aiming to increase control over working hours seem to increase employees´ satisfaction with working hours (Lowden and Åkerstedt 2000), employees may have unrealistic expectations of how much their control over working hours increases, whereas in reality shift start and end times and staffing requirements, for example, still set boundaries for individual schedules. In addition, when working time control increases, some employees also experience strong injustice regarding the way in which the new scheduling methods are used (Hansen *et al.* 2015), which in turn may influence their estimations of the effects on wellbeing.

To the best of our knowledge, this is among the largest studies on self-rostering or participatory working time scheduling and one of the first to utilize objective working hour data. The use of objective working hour data is the main strength of this study, as it allowed us to calculate very detailed and accurate exposure to the working hour characteristics. In previous research, working hour data has mostly been self-reported, which is prone to recall bias (Härmä *et al.* 2017), especially when studying more complex or irregular working hour characteristics such as long work shifts or short shift intervals. The objective working hour characteristics used in this study have been validated previously (Härmä *et al.* 2015). The effects of the implementation of the participatory working time scheduling were studied before the intervention and after one year of continuous use of the new software to minimize possible resistance to change, or alternatively, a 'honeymoon period', i.e., stronger adherence in the beginning. The used time period also covered summer vacations and other public holidays, which may set challenges for fair shift scheduling. Another strength of this study was that its large sample included a variety of hospital occupations and that the combination of register and survey data enabled multiple adjustments in the statistical models.

Some limitations need to be addressed. The study design and data did not allow us to follow the actual implementation processes in each hospital district. It is likely that the wards that volunteered to start using the new software may have had more flexible scheduling practises before the participatory working time scheduling intervention, as the participants in the participatory scheduling group had higher estimations of work time control at baseline. The proportion of participants in the participatory scheduling group varied between the three hospital districts (11.3%, 33.2% and 55.5%), and it is possible that other staffing policy changes took place in parallel. However, we used hospital district as a covariate in the analysis to control the potential effect on the estimates. It is also possible that successful utilization of participatory working time scheduling requires, for example, more training and staff meetings to set up the policies and rules for each ward.

Secondly, the categorical variables for the wellbeing outcomes set limits for the statistical analysis, and the binomial/multinomial analysis used may have lacked the sensitivity to distinguish small changes in the outcomes. Even though participatory working time scheduling seems a recommendable practice, the generalizability of the results to other working time arrangements may be limited, as shift schedules in hospitals are quite irregular and the Finnish practice is to avoid overtime, when possible (Ropponen et al. 2017).

Despite the analyses being conducted among employees who had used the participatory working time scheduling software for at least a year, the results would merit confirmation by longer follow-up. Previously, good work time control has been associated with strong outcomes, for example, postponed retirement beyond the pensionable age (Virtanen *et al.* 2014). Further studies should investigate whether successful implementation of participatory working time scheduling would have similar beneficial short- and long-term effects to good work time control. Further research could also more specifically analyse whether the effects of participatory working time scheduling differ between different occupational sectors and which organizational factors, for example, the size and type of the unit, play a role in how fluently working times can be participatorily scheduled.

5. Conclusion

Implementing participatory working time scheduling had no major effect on shift ergonomics. The employees with participatory working time scheduling had long work shifts more often than the employees who continued with traditional scheduling. Using participatory working time scheduling software increased perceived control over scheduling of shifts and decreased excessive sleepiness in connection with evening shifts in comparison to traditional scheduling.

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Conflict of Interest

The authors report no conflict of interest. The authors are solely responsible for the content and writing of the article.

Contributorship statement

All authors (KK, JT, TH, AO, SP, AR, MK, MH) were responsible for the conception and design of the study. KK, JT and MH were responsible for the registration of the intervention, KK, JT and data manager Aki Koskinen for the acquisition of the data, and KK and AO for the data analysis. All the authors took part in interpreting the results. KK wrote the draft of the article and all the authors took part in revising the article. All the authors approved the final version before submission.

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