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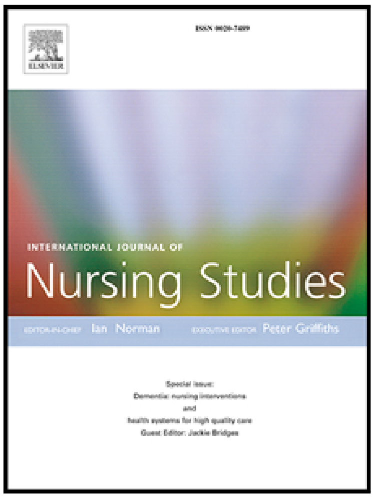

The effects of using participatory working time scheduling software on sickness absence: A difference-in-differences study

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Abstract (max 400 words, 283 words)

Background: Participatory working time scheduling is a collaborative approach to scheduling shift work. As a potential way of improving work time control, it may provide a means to reducing sickness absence in shift work. So far, experimental and quasi-experimental studies on the effects of increased work time control on sickness absence are lacking.

Objective: To investigate the effects of using digital participatory working time scheduling software on ward-level sickness absence among Finnish hospital employees.

Participants and methods: This quasi-experimental study compared the amount of sickness absence in hospital wards using participatory working time scheduling software (n=121 wards) and those continuing with traditional working time scheduling (n=117 wards) between 2014 and 2017. We used continuous panel data from 238 hospital wards with a total number of 9000 hospital employees (89% of women, primarily nursing staff). The ward-level measures consisted of number of employees, working hours, sickness absence spells per employee, and short (1–3) sickness absence days per employee. Two-way fixed effects and event study regressions with clustered standard errors were used to estimate the effect of using participatory scheduling software on sickness absence.

Results: Sickness absence spells and short (1–3) sickness absence days decreased by 6% and 7%, respectively in the wards using participatory scheduling compared to those using traditional scheduling. The effect became stronger as the time measured in quarters of using the participatory working time scheduling software increased.

Conclusions: The effects of using participatory working time scheduling software indicated less ward-level sickness absence measured as spells and days in comparison to continuing with traditional scheduling. The encouraging findings are relevant not only to the health care sector but also to other sectors in which irregular shift work is a necessity.

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

Key words

health care, nursing, self-rostering, shift work, sickness absence, work time control

What is already known about the topic?

- Shift work is associated with adverse health effects, poorer work time control and increased risk of sickness absence.
- Good work time control is associated with a lower risk of sickness absence and an increased match between desired and actual working hours.
- The introduction of self-rostering by means of participatory scheduling can increase work time control.
- Studies to analyse the effects of participatory working time scheduling software, or any other self-rostering method, on sickness absence are rare.

What this paper adds

- The use of objective working hour data together with the intervention group and the generalization of difference-in-differences method enables to identify the effect of using participatory working time scheduling software on ward-level sickness absence.
- Using participatory working time scheduling software reduced ward-level sickness absence compared to wards with traditional scheduling. It took several quarters for the effects to manifest.
- Participatory working time scheduling seems promising to support shift work management for reduction of sickness absences in hospitals.

1. Introduction

Sickness absence introduces costs to individual employees, employers, and society. In the majority of Nordic countries, the highest sickness absence rates are found in the health and care sectors (Krane et al., 2014; Marklund et al., 2019), and to the NHS England, the cost of sickness absence is estimated to exceed 2.5% of the total budget (The Health Foundation, 2016). The sickness absence of nurses and other healthcare employees is an issue of relevance for both public and employer policy. As hospitals work around the clock, shift work i.e. work carried in shifts to cover operation outside traditional working hours, is necessary. Shift work is known to be associated with adverse health effects (Kecklund & Axelsson, 2016; Merkus et al., 2012) and an increased risk of sickness absence in health care (Dall'Ora et al., 2019; Ropponen et al., 2019). Working conditions in shift work, such as the scheduling i.e. timing, duration, and distribution of shifts, can be altered by employer policy. Studies are warranted to shed light on the associations between shift work in health care and sickness absence. Further knowledge would be important for nurses at hospitals and for those responsible for shift scheduling and nursing management. Specifically, knowledge and practical solutions that would lead to a reduction of sickness absence would diminish the burden due to lost working hours and difficulties in finding substitutes at short notice.

Shift work is associated with a higher rate of sickness absence due to poorer work time control (Nätti et al., 2014), i.e., employees being less able to control the timing, duration, and distribution of their work time. Poor work time control is prospectively associated with lower subjective health and an increased risk of sickness absence (Ala-Mursula et al., 2002). In contrast, good work time control is associated with improved sleep quality (Takahashi et al., 2011; Tucker et al. 2015), less depressive symptoms (Takahashi et al., 2011), and a reduced risk of long-term sickness absence (Nätti et al., 2015). Whereas good work time control in form of schedule flexibility is negatively associated with both the frequency and duration of sickness absence (Possenriede et al., 2014), and work-related stress and burnout symptoms (Grzywacz et al., 2008). Previous studies on work time control have mostly been based on cross-sectional surveys. Regardless of the study designs, the findings on shift work and its effects on work time control and various health or non-health related outcomes suggest that practical countermeasures to increase control over one's work schedule might have the potential to reduce the risk of sickness absence.

To the best of our knowledge, no earlier experimental or quasi-experimental studies have evaluated the effect of improving work time control on sickness absence. The few quasi-experimental studies that exist show that work time control, increased by means of self-rostering, i.e. allowing employees to choose their shift patterns to some extent, supports recovery and health among hospital employees (Garde et al., 2012), and can have positive effects on the work of both nurses and their managers (Bailyn et al., 2007). However, no effects on sleep quality (Garde et al., 2011) or on health and perceived well-being were observed among eldercare workers (Nabe-Nielsen et al., 2011).

Participatory working time scheduling presents a collaborative approach to the self-rostering of shifts, combining and taking into account ward-level operation, working time legislation and employees' equality and fairness (Hakola et al., 2007) and has potential to improve employees' work time control. This study contributes to the literature on self-rostering of shifts by reporting its effects on sickness absence. The aim of this study was to investigate the effects of using participatory working time scheduling software on sickness absence spells and short (1–3) sickness absence days.

2. Methods

2.1 Study sample and participants

Based on the Finnish Public Sector study (Kivimäki et al., 2009), we collected ward-level data from employer's electronic working time records, resulting in a balanced panel of 692 wards from five hospital districts and one division of municipal health services (from here on hospital districts) in Finland from 1.1.2014 to 31.12.2017. The hospital district data did not include information on the hospitals themselves, but on the wards within the hospitals that operated within the hospital districts. A shift scheduling program (Titania®, CGI Finland Ltd) was used to retrieve the ward-level shift scheduling data from the employer's payroll-based daily working hour records. The working hour data used were based on three-week realised shift schedules made by Titania® for each hospital employee. The data were aggregated into quarters. Between 1.1.2014 and 31.12.2017 there were 16 quarters. The working-hour data included the start and end times of all the shifts worked and the reasons for absences, including days-off, sick leaves and annual leaves. A shift was classified as an evening shift if it started after 12:00 and was not a night shift; a night shift had to include at least three hours of work between 23:00 and 6:00. Other work shifts were considered non-evening and non-night shifts. The data also included information on the version of software used at ward level, and whether the participatory scheduling tool was used. Data collection, cleaning, reliability, validity, and accuracy have been previously assessed in detail (Härmä et al., 2015).

The data were restricted to include only wards with at least an average number of 20 employees and wards whose share of evening and/or night shifts was 10% of all shifts. After the elimination of wards considered too small to conduct participatory scheduling effectively (exclusion of 358 wards, of which 35 were participatory scheduling wards) and wards with no shift work (exclusion of 96 wards, of which 2 were participatory scheduling wards). The final sample size was 238 wards from six hospital districts that employed altogether approximately 9000 employees (89% women, primarily nursing staff) on average each quarter. Information on the proportion of nursing personnel was based on all employees on permanent or fixed-term contracts for six or more months, who were eligible for the cross-sectional survey conducted in the Finnish Public Sector study (Kivimäki et al., 2009) in 2015. Information on occupation was available for 75% of employees eligible for the survey. Out of the total 238 shift working wards in our final sample, we had information on occupation for 203 wards (85% of all wards). Among those, 90% of employees were nursing staff, i.e., had occupational titles such as nurse, midwife, or practical nurse. The remaining 10% were in other professions such as administrative assistant, pharmacist, physiotherapist, and other non-nursing professions. The descriptive statistics of the 238 wards are presented in Table 1.

Robustness was checked by restricting data to include wards whose night shifts consisted of at least 10% of all shifts on average, which reduced the number of wards to a total of 111 wards that used participatory scheduling software and 59 wards that continued with traditional scheduling.

2.2 Sickness absence practice in Finland

In Finland, all employees are eligible for sickness allowance based on symptoms or diseases that restrict their work ability. Sickness allowance is dependent on the duration of employment and specific collective labour agreement. Usually the employer is responsible for paying a full salary for the first 10 days of sickness absence, after which The Social

Insurance Institution of Finland pays the sickness allowance for absences up to 300 days. Full salary is paid for the first 60 days of absence, after which 2/3 of the salary is paid for the next 120 days. This benefit is paid to the employer if the employer continues to pay the employee their salary. In the Nordic countries, the employee can usually be absent from work for 1–3 days without a medical certificate, i.e., by own notification.

2.3 Shift scheduling and intervention

Shift scheduling was conducted by two different versions of Titania© (CGI Finland, Finland). The basic version is used for traditional working time scheduling. The scheduling is carried out by the head nurse, who generates a draft plan for a three-week period at least two weeks before the start of the period. Individual nurses have limited opportunities to influence the scheduling of their shifts by expressing their separate wishes. The acceptance of the final version of the scheduled shifts is the responsibility of the head nurse. The wards that continued with traditional scheduling formed the control group in this study (from here on traditional scheduling). The intervention group consisted of the wards that used interactive, participatory shift scheduling software (from here on participatory scheduling).

The participatory working time scheduling software allows both the employees and the head nurse interactively schedule the work shifts, based on agreed rules and principles. Participatory scheduling offers the opportunity and eventually the obligation to individual hospital employees to participate in scheduling. It introduces the operational demands of the wards, staffing, legislation, and equality in shift scheduling. This is enabled by the employee entering their own desired shifts into the wards' shift plan according to the shift demands for the number of employees and considering other employees' inputs. The software gives the employees better opportunities to influence the work schedules. In addition to the self-rostering of shifts, it offers a transparent outlook on individual shifts and directions for individual employees on self-rostering. Moreover, the individual employee is able to see who will be working the same shift. The rules framing participatory scheduling are made on the ward level. These include, for example, a minimum number of night shifts or weekend duties per employee for each three-week period. The rules may cover, for example, the order of inputting the shifts and shift types into the software, i.e., those who have the first options in a certain three-week period, and whether one has to opt for night shifts before day shifts. In these wards also, the head nurse is responsible for checking and accepting the final shift schedules.

The hospital districts made the decision to start using participatory scheduling software and agreed on the implementation timetable. The participatory working time scheduling was done directly using the shift scheduling software. The detailed information on the daily use of participatory scheduling software offered us an objective measure of the use or non-use of the software on the ward level.

The participatory working time scheduling software was implemented in 66 wards in districts A, B and C in 2016, followed by 55 wards from hospital districts A, B and D in 2017 (Table A1 in the supplemental material). Participatory working time scheduling replaced traditional scheduling in 121 wards in four hospital districts. A total of 117 wards in six hospital districts continued with traditional scheduling. The effects of the use of the participatory working time scheduling software on the sickness absence of the hospital employees was studied by comparing the sickness absence in the wards using participatory working time scheduling and those continuing with traditional scheduling in 2014 and 2017.

Scheduling per employee was done more often as the time from beginning the participatory scheduling passed, with less than one login per employee in the adoption quarter. However, six months after beginning this increased to approximately five logins per employer for each three-week period scheduled. After one year, logins further increased to a total of 10 logins. The average share of participatory scheduling employees in the intervention wards grew quarter by quarter, from approximately 0.6 to 0.8 in one year.

2.4 Study variables

As the main interest of this study, the number of incident sickness absence spells and the number of short (1–3) sickness absence days per employee were assessed for each ward in all the quarters between 2014 and 2017. Sickness absence spells of 1-3 consecutive days were considered as short absence spells, whereas sequential sickness absences exceeding 3 consecutive days were defined as long sickness absence spells. Each hospital employee could have multiple short, long, or both short and long absence spells within a quarter. Only sequential consecutive sickness absence days were counted to each spell. The sickness absence data did not include any medical information on the causes of sickness absence.

The ward-level measures used as covariates in the regression analysis included a logarithm of the number of employees, shifts per employee, and proportion of evening and night shifts of all shifts. For short (1–3) sickness absence days per employee as the dependent variable, sickness absence days from long (i.e. ≥ 4 days) sickness absences were also included as covariate in the regression model.

Aggregate ward-level information was divided by the average number of employees in the ward for each quarter to obtain 'per employee' measures. The proportion of evening and night shifts was calculated by dividing the number of shifts by the total number of shifts on the ward level for each quarter.

2.5 Ethical considerations

The Finnish Institute of Occupational Health received written permission to use the employers' working time registries for research from all the hospital districts. All the data were anonymized, and international ethical standards were conformed to. The Finnish Public Sector study was approved by the ethics committee of the Hospital District of Helsinki and Uusimaa, Finland (HUS; HUS 1210/2016). The intervention was registered with ClinicalTrials.gov (NCT02775331) before starting the intervention phase. The primary outcome of the registered intervention, sickness absence, is reported in this study.

2.6 Statistical analysis

The statistical analyses were conducted using Stata/MP 15.1 (StataCorp LLC, College Station, TX, USA). The average effects of using participatory working time scheduling software on those using it was estimated using two-way fixed effects regression. This is a generalization of the difference-in-differences setup for multiple time periods and multiple groups (Bertrand et al., 2004), in which unobserved time-specific and ward-specific confounders are controlled for by including dummies for each ward and dummies for all quarters in the regression models. The two-way fixed effects estimator produces unbiased estimates under two important conditions. First, the trends of the outcome variable of the comparison groups are parallel. Second, the effect is homogenous across and within the wards over time. To estimate the time-varying effects, indicators of the quarterly leads and lags relative to the use of the participatory working time scheduling software were included in the regression model (Sun & Abraham, 2020), thus introducing an event study regression specification. This allowed for testing conditional parallel trends between wards in different comparisons.

Two-way fixed effects regression estimates are a weighted average of three comparisons (Goodman-Bacon, 2019): (i) between early and later implementors over the time periods until later implementors are treated, (ii) between early and later implementors over the periods when only early implementors are treated, and (iii) between the implementors and the controls. This study compares wards that used the participatory working time scheduling software early and later, and the wards that used participatory and traditional scheduling. The identification strategy was based on the parallel trends of sickness absence between wards, i.e., the time-varying changes in the wards using the traditional working time scheduling provided a counterfactual point of comparison to the wards using the participatory working time scheduling if they had not used participatory scheduling. Decomposition of the effect was carried out to investigate each estimated total effect in detail.

Participatory scheduling was introduced as a dummy variable, taking a value of 1 when in action and 0 otherwise. The partial effect of each covariate on the dependent variable was estimated by regressing sickness absence spells and short (1–3 days) sickness absences per employee on covariates, an intervention dummy, and time and ward dummies. The individual coefficients' statistical significance was assessed using t-statistics, and ward-level clustered standard errors were used (Bertrand et al., 2004). The estimated regression equations are described in detail in Appendix 2.

Different models were analysed. The baseline model (Model 1) included only the intervention dummy, and the time and ward dummies. The augmented model (Model 2) was adjusted for the logarithm of the number of employees, shifts per employee, and the share of evening and night shifts of all shifts. The model for short (1–3 days) sickness absence days per employee as the dependent variable also adjusted for sickness absence days per employee from long absences (≥4 days). The treatment effect decompositions and event-study regressions were carried out using regression Model 2 and the robustness of the results were examined using regression Model 2 on a restricted sample. In Model 3, the proportion of employees using the software in the ward was used as the intervention measure.

3 Results

3.1 Ward characteristics and sickness absence

The wards had approximately 39 to 42 employees throughout each year, with no statistically significant differences between the wards using the participatory working time scheduling software or continuing with traditional scheduling (Table 1). The proportion of nurses of all employees was 88% in the wards continuing with traditional scheduling, and 92%, in the wards using the participatory scheduling software. Information on the occupational title was available for 73% of employees in traditionally scheduling and 74% of employees in participatory scheduling wards, respectively. There was no statistically significant difference in the proportion of nurses of all employees between the participatory and traditionally scheduling wards.

In all the wards, evening shifts were approximately 28–30% of all shifts. The participatory scheduling wards had more night shifts, 17% versus 9%–10% in traditional scheduling wards, depending on the year. The traditionally scheduling wards had more work shifts per employee in each quarter, with number of shifts ranging between 35.7 for the participatory scheduling wards and 37.7 for the traditional scheduling wards.

The wards continuing with traditional shift scheduling had more absence spells per employee from 2016 onwards (Table 1). The difference in the average number of absence spells per employee between the wards further increased in 2017. Shorter (1–3 days) sickness absence spells were more common in the wards using the participatory scheduling software than in the traditional scheduling wards, with annual differences of 6%–3% ($p<0.01$) of all sickness absences.

Of sickness absence days in 2015, total sickness absence days per employee were 16.2 and 14.9 in the traditional and participatory scheduling wards, respectively. The wards continuing with traditional scheduling had more sickness absences: long (≥4 days) absence days accounted for the larger number of total sickness absence days. There was no statistically significant difference between the number of short (1–3) absence days between the wards using the participatory scheduling software or those continuing with traditional scheduling.

Table 1. Ward characteristics and sickness absence.

		Ward characteristics **Annual means, standard deviation, and difference in means with t-test p-value**				**Sickness absence** **Quarterly means, standard deviation, and difference in means with t-test p-value**				
		Number of employees	Shifts per employee	Proportion of evening shifts	Proportion of nights shifts	Absence spells per employee	Proportion of short (1–3 days) absence spells of total sickness absence spells	Short (1–3 days) absence days per employee	Long (≥4 days) absence days per employee	Absence days per employee
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
2014	Traditional	39.86 (22.77)	37.40 (6.37)	0.29 (0.10)	0.09 (0.09)	0.63 (0.32)	0.67 (0.17)	0.80 (0.46)	3.24 (2.41)	4.04 (2.56)
	Participatory	39.04 (16.99)	35.65 (5.25)	0.29 (0.06)	0.17 (0.06)	0.65 (0.25)	0.74 (0.11)	0.85 (0.37)	2.88 (1.88)	3.73 (1.95)
	Difference in means (p-value)	0.82 (0.53)	1.75 (<0.01)	-0.01 (0.29)	-0.08 (<0.01)	-0.02 (0.28)	-0.06 (<0.01)	-0.05 (0.06)	0.36 (0.01)	0.31 (0.04)
2015	Traditional	40.11 (23.28)	37.57 (6.05)	0.29 (0.10)	0.10 (0.08)	0.66 (0.29)	0.69 (0.15)	0.85 (0.44)	3.19 (2.21)	4.04 (2.36)
	Participatory	39.68 (17.19)	35.67 (4.66)	0.30 (0.06)	0.17 (0.06)	0.64 (0.25)	0.74 (0.11)	0.84 (0.37)	2.79 (1.83)	3.63 (1.92)
	Difference in means (p-value)	0.43 (0.75)	1.89 (<0.01)	-0.01 (0.06)	-0.08 (<0.01)	0.02 (0.24)	-0.05 (<0.01)	0.01 (0.84)	0.40 (<0.01)	0.41 (<0.01)
2016	Traditional	41.01 (23.36)	37.54 (5.86)	0.28 (0.10)	0.09 (0.08)	0.72 (0.28)	0.70 (0.13)	0.91 (0.42)	3.46 (2.29)	4.38 (2.45)
	Participatory	39.19 (17.42)	36.26 (4.85)	0.30 (0.07)	0.17 (0.06)	0.67 (0.26)	0.74 (0.12)	0.89 (0.39)	2.54 (1.79)	3.43 (1.89)
	Difference in means (p-value)	1.82 (0.17)	1.28 (<0.01)	-0.02 (<0.01)	-0.08 (<0.01)	0.05 (<0.01)	-0.04 (<0.01)	0.02 (0.37)	0.92 (<0.01)	0.94 (<0.01)
2017	Traditional	41.71 (23.75)	37.67 (5.95)	0.29 (0.10)	0.09 (0.09)	0.70 (0.28)	0.70 (0.12)	0.88 (0.41)	3.57 (2.44)	4.45 (2.56)
	Participatory	39.65 (18.33)	36.04 (4.64)	0.30 (0.07)	0.17 (0.07)	0.64 (0.26)	0.73 (0.13)	0.83 (0.41)	2.69 (1.90)	3.52 (1.96)
	Difference in means (p-value)	2.06 (0.13)	1.64 (<0.01)	-0.02 (<0.01)	-0.08 (<0.01)	0.06 (<0.01)	-0.03 (<0.01)	0.04 (0.10)	0.88 (<0.01)	0.92 (<0.01)

Table note 1. Traditional and participatory refer to wards continuing with traditional shift scheduling (n=117) or using participatory scheduling software (n=121), respectively. Employee and shift information are annual means. Sickness absence figures: table presents per employee quarterly means.

For both dependent variables, full support for the parallel trends assumption for crude values of comparison between those using participatory scheduling and those continuing with traditional scheduling was lacking in two quarters in 2014 (Figures 1 and 2), yet parallel trends were observed for the majority of periods before implementation. Common shocks to both groups throughout the time span for both dependent variables were observed in the form of seasonal fluctuations during the autumn and winter quarters.

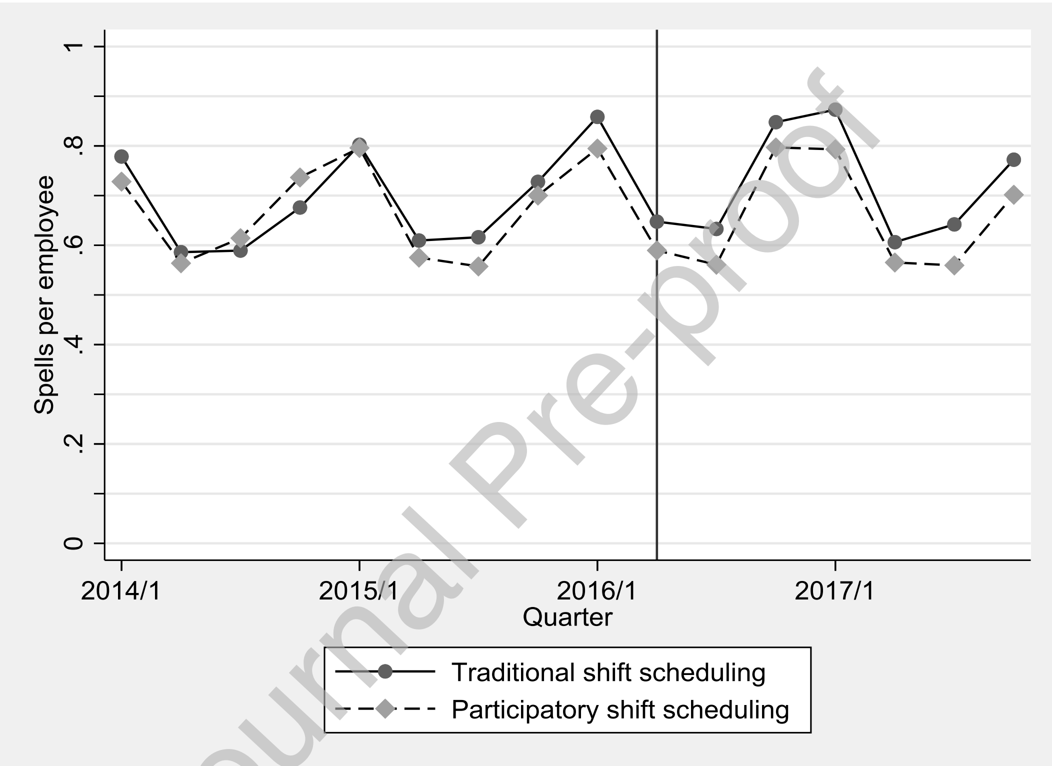

Figure 1. Sickness absence spells per employee, quarterly average. Vertical line depicts timing of intervention implementation in first wards.

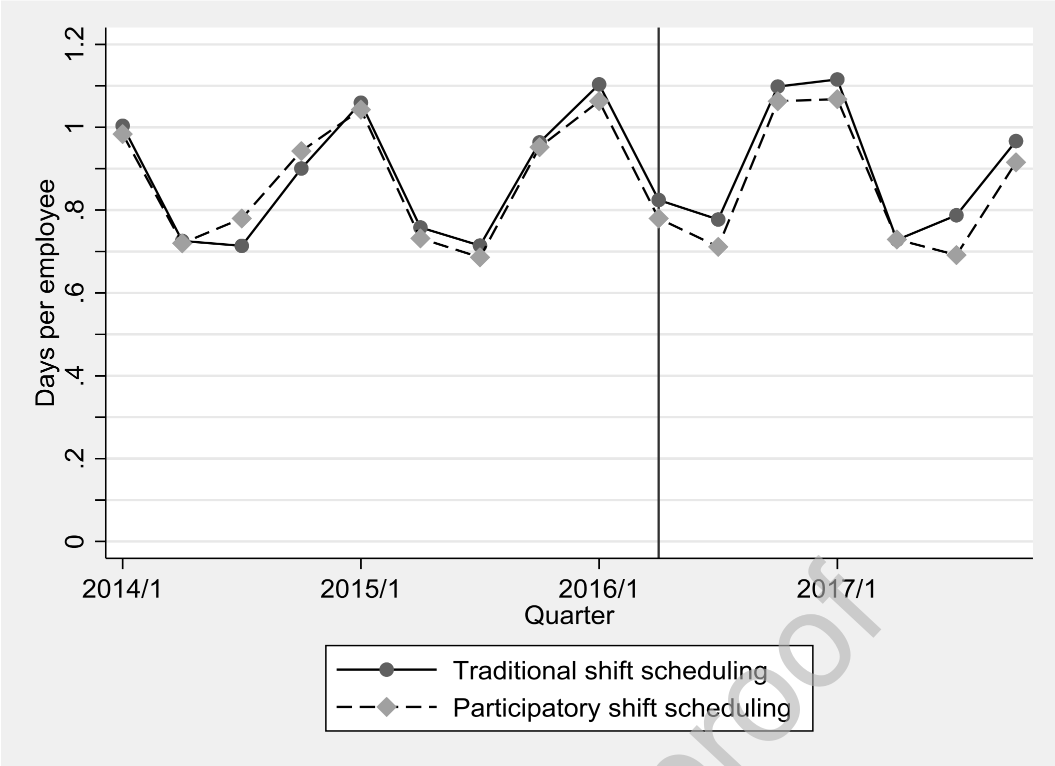

Figure 2. Short (1–3) sickness absence days per employee, quarterly average. Vertical line depicts timing of intervention implementation in first wards.

3.4 Regression results

3.4.1 Effect on sickness absence spells

The two-way fixed effects regression estimates show that the effect of using participatory work-time scheduling software on sickness absence spells was robust, varying from -0.043 (CI: -0.073, -0.013) spells in Model 1 to -0.068 (CI: -0.109, -0.025) spells in Model 3 (Table 2). The decomposition of effect for augmented Model 2 suggest that the total estimated effect of -0.048 (CI: -0.077; -0.018) spells per employee was driven by the comparison between the participatory and traditionally scheduling wards accounting for 81%, and the timing of the participatory scheduling accounting for 18% of the total variation in effect (Table 2).

In event study regression specification, the pre-treatment dummy coefficients were close to zero and non-significant, providing support to the parallel trends assumption (Figure 3 and Table A2). A statistically significant, negative effect was observed in the second, fifth and sixth quarter after the implementation of participatory scheduling, and the effects of the third and fourth quarter were close to statistical significance.

The coefficients for the covariates (Tables 2 and A2) were negative for the logarithm of the number of employees, and positive for shifts per employee and the proportion of evening and night shifts, yet not all variables were statistically significant. The logarithm of the number of employees showed a negative effect, although it was non-significant. Larger wards had less sickness absence spells per employee. The number of shifts per employee was associated with increased sickness absence spells. The proportion of evening and night shifts were associated with an increased number of sickness absence spells per employee.

Robustness analysis of the wards whose night shifts were at least 10% of all shifts showed the same estimated effect of -0.047 (CI: -0.079; -0.012) (Table A3). Decomposition of effect showed that the comparisons between those using participatory working time scheduling software at different times gained a weight of 29% in the total estimated effect. The weight of comparing participatory scheduling wards to traditionally scheduling wards was 70% of the total estimated effect.

Table 2. Two-way fixed effects regression models. Effect coefficients β with 95% confidence intervals. Decomposition of effect for Model 2.

Sickness absence spells per employee									
	Model 1		Model 2		Model 3		Decomposition for Model 2		
	β	95% CI	β	95% CI	β	95% CI		Weight	β
Participatory scheduling	**-0.043**	**(-0.073; -0.013)**	**-0.048**	**(-0.077; -0.018)**	**-0.068**	**(-0.109; -0.025)**	Earlier vs later	0.184	-0.006
Log of number of employees			-0.022	(-0.086; 0.043)	-0.024	(-0.089; 0.042)	Participatory vs traditional	0.810	-0.052
Shifts per employee			**0.009**	**(0.006; 0.012)**	**0.009**	**(0.006; 0.012)**	Within	0.006	-0.773
Share of evening and night shifts			0.285	(-0.048; 0.618)	0.286	(-0.049; 0.621)	Total effect		**-0.048**
R-squared (within / between / overall)	0.24 / 0.04 / 0.13		0.26 / 0.04 / 0.15		0.26 / 0.04 / 0.15				

Short (1–3 days) sickness absence days per employee									
	Model 1		Model 2		Model 3		Decomposition for Model 2		
	β	95% CI	β	95% CI	β	95% CI		Weight	β
Participatory scheduling	**-0.057**	**(-0.100; -0.0134)**	**-0.060**	**(-0.101; -0.019)**	**-0.088**	**(-0.147; -0.028)**	Earlier vs later	0.184	-0.031
Log of number of employees			-0.013	(-0.091; 0.065)	-0.016	(-0.095; 0.063)	Participatory vs traditional	0.807	-0.063
Shifts per employee			**0.017**	**(0.013; 0.020)**	**0.017**	**(0.013; 0.020)**	Within	0.008	-0.459
Share of evening and night shifts			0.338	(-0.092; 0.767)	0.339	(-0.094; 0.771)	Total effect		**-0.060**
Absence days from long (≥4days) absences			**0.011**	**(0.004; 0.017)**	**0.011**	**(0.004; 0.017)**			
R-squared (within / between / overall)	0.22 / 0.02 / 0.13		0.25 / 0.12 / 0.19		0.25 / 0.12 / 0.19				

Table note 2. The number of traditionally and participatory scheduling wards was 117 and 121, respectively. The number of observations was 3808. Standard errors were clustered by ward. β's are regression coefficients representing the partial effects of the covariates on the dependent variable. Statistically significant betas and related CIs are bolded. Earlier vs later refers to comparisons of wards implementing the software earlier and later, participatory vs traditional refers to comparisons between those using participatory scheduling software and those continuing with traditional scheduling. Within refers to within ward changes.

Model 1. Time- and ward-fixed effects. Participatory scheduling dummy: software is in use.

Model 2. Time- and ward-fixed effects, and all covariates. Participatory scheduling dummy: software is in use. Decomposition of effect in Model 2 is included in the table.

Model 3. Time- and ward-fixed effects, and all covariates. Participatory scheduling: proportion of employees using the software

3.4.2 Effect on short sickness absence days

The two-way fixed effects regression estimate of participatory scheduling on short (1–3 days) absence days per employee varied from -0.057 (CI: -0.100, -0.0134) days in Model 1 to -0.088 (CI: -0.147, -0.028) days in Model 3 (Table 2). Of the total estimated effect of -0.060 (CI: -0.101; -0.019) days, weight of 81% came from comparing the participatory scheduling wards to the traditionally scheduling wards. The comparison of wards introducing participatory scheduling software earlier rather than later had a weight of 18% on the total estimated effect.

In event study regression specification, the pre-treatment dummy coefficients for short (1-3) absence days were near zero and non-significant, supporting the parallel trends assumption (Figure 4, Table A2). Statistically significant, negative effects of using the participatory scheduling software were observed in each quarter after the second quarter after implementation.

The coefficients for the covariates show the same signs as in the analysis of sickness absence spells. Long (≥4 days) sickness absences included as a covariate had a positive and statistically significant effect of 0.011 (CI: 0.004, 0.017) on short (1–3 days) sickness absences (Table 2 and A2).

The estimated effect on wards whose night shifts were at least 10% was -0.059 (CI: -0.106; -0.012) (Table A3). Of the total estimated effect, 29% came from comparisons between wards that started using the participatory working time scheduling software at different times. The weight on the total estimated effect of comparing participatory and traditionally scheduling wards was 70%.

A conservative estimate of the value of reduced sickness absence was calculated using trained nurses' gross average monthly wage (Local government employers, 2020) divided by 30. In Model 3 in Table 2, we inferred the effect of the use of the participatory scheduling software to be approximately 0.09 days per employee for each quarter, totalling 0.36 days per employee per year. To calculate the savings, we utilised 0.36 times the average daily gross wage and multiplied it by the number of employees in our sample, approximately 9000, resulting in savings of 340 200€.

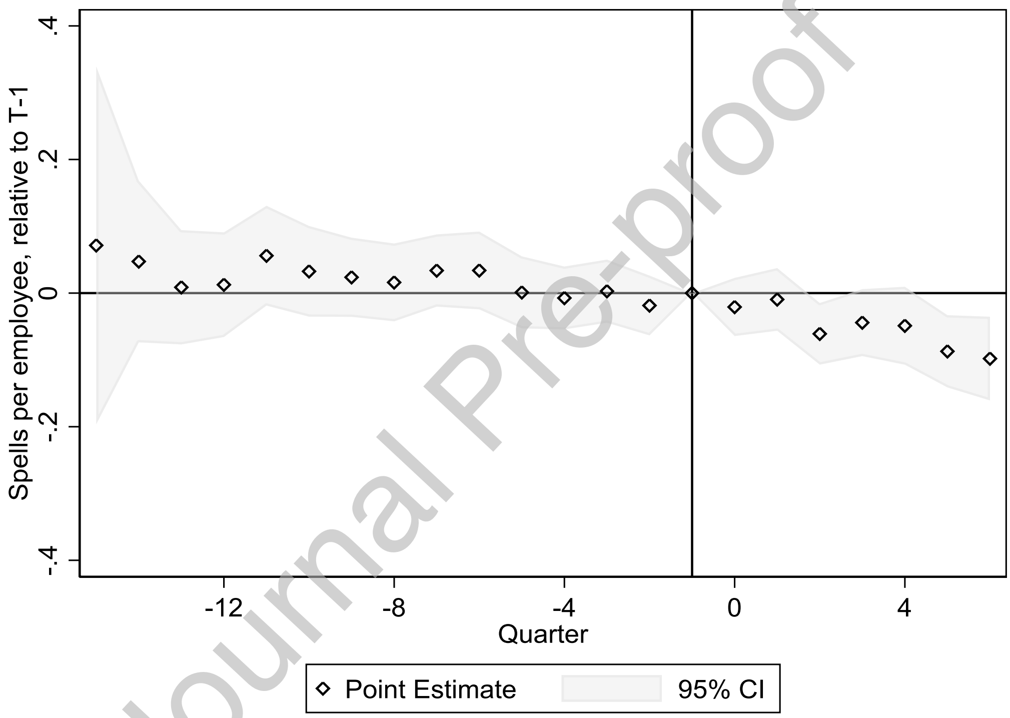

Figure 3. Sickness absence spells per employee. Event study regression estimates and 95% confidence intervals.

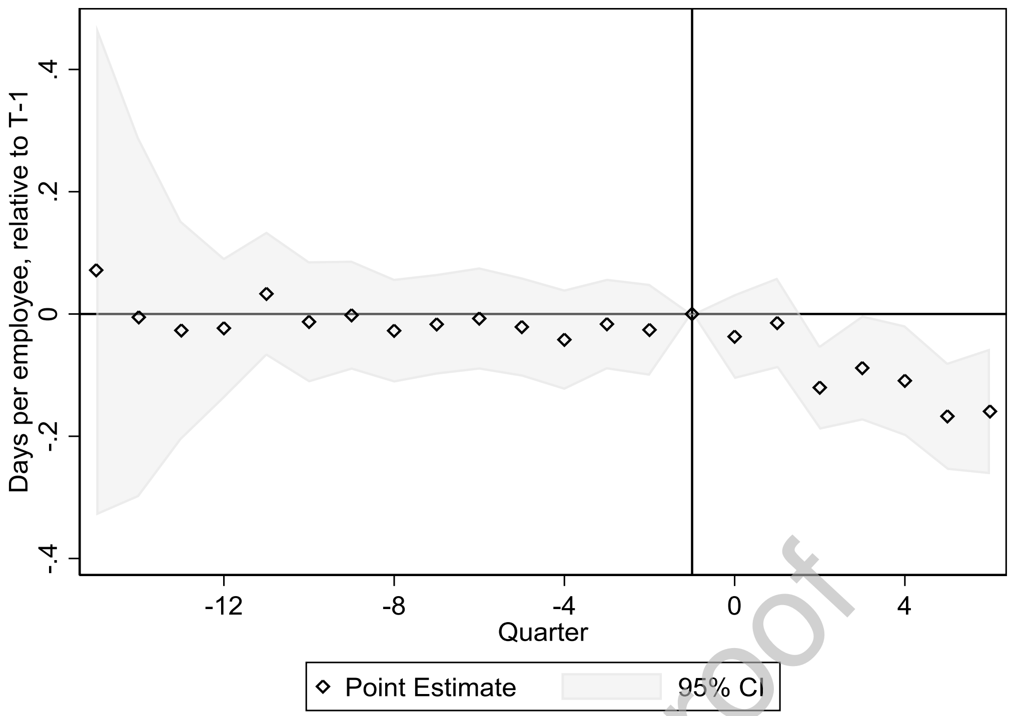

Figure 4. Short (1–3) sickness absence days per employee. Event study regression estimates and 95% confidence intervals.

4. Discussion

This study investigated the effects of using participatory working time scheduling software on the sickness absence of hospital employees. The study used a quasi-experimental design by comparing the sickness absence in wards using the participatory working time scheduling software and those alternatively continuing with traditional scheduling between 2014 and 2017. Until now, effects of participatory working time scheduling on sickness absence have been rarely investigated.

In comparison to average sickness absence measures in 2015, the estimated average effects of using participatory scheduling software on sickness absence spells and short (1–3 days) sickness absence days per employee were reductions of 6% and 7% in sickness absence, respectively. The estimated effects originated from comparisons between the wards using the participatory scheduling software and those continuing with traditional shift scheduling (weight of 71% to 81% in different samples). Comparison of those implementing participatory scheduling earlier versus later, i.e., the timing of implementation, showed a smaller effect (weight of 18% to 28%) on the total estimated effect, which suggests that the timing of implementation is a less important factor in the estimated total effects.

The wards that continued with traditional scheduling had more long-term sickness absences. To control for the effect of long absences, long (≥4 days) absence days were included as a covariate in regression analyses with short (1–3) absence days as dependent variable. Participatory scheduling wards had more night work. Night work could potentially lead to an increased need for recovery from increased fatigue (Härmä et al. 2018), that could manifest as an increased need for sickness absence. The estimated total effects on both dependent variables remained the same when the sample was restricted to wards whose night shifts were at least 10% of all shifts. The time-varying, increasing effects of participatory scheduling were observed for both dependent variables after one year of use. This may be a sign of selection effect. Either the early adopters were the most effective users of the participatory scheduling software or the effective utilization of participatory scheduling is learned over time. The effects of using participatory scheduling software on sickness absence may be resulting from improved work time control, for example its buffering effect on the impact of night work on sleep (Tucker et al., 2015), or improved work-life balance and job satisfaction (Pryce et al., 2006; Possenriede et al., 2014). Another potential pathway to decreased sickness absence would be health effects and increased recovery from work (Garde et al., 2012), in case participatory scheduling improved shift ergonomics, i.e., health supporting shift characteristics. Regardless of the mechanism, a change in the rate of sickness absences takes some time to materialise.

Ensuring adequate staff levels and the rescheduling of shifts are one of the most time-consuming tasks of head nurses (Clark et al., 2015). Both participatory working time scheduling and its decreasing effect on sickness absence could help head nurses focus on more productive activities. A conservative estimate suggests that using participatory shift scheduling software produces annual savings of 37 000€ per 1000 employees. A cost estimate based on direct wage cost forms a lower threshold on the cost of sickness absence. Organizing work in teams leads to individual sickness absence having consequences for the output of the whole team (Zhang et al. 2017; Heywood et al. 2008), which in turn leads to greater productivity loss associated with sickness absence. In addition to productivity loss, total welfare loss includes lower patient satisfaction, which has also been associated with sickness absence in health care (Duclay et al. 2015).

Spillover effects of participatory scheduling to wards continuing with traditional scheduling are highly unlikely because the new software was not available to these wards. It is possible that some of the wards continuing with traditional scheduling carried out participatory scheduling without the software. However, statistically controlling for ward-specific but time-invariant, and time-specific but ward-invariant unobserved variables decreases this and many other sources of bias. Time-specific unobserved variables include factors associated with sickness absence such as seasonal infectious illnesses (Barmby & Larguem, 2009) and macroeconomic conditions' procyclical effect on sickness absence (Leigh, 1985; Pichler, 2015), shown to be stronger among females working in the public sector (Bratberg & Monstad, 2015). Unobserved ward-level confounders include work characteristics, management practices, employees´ age and the share of female employees, which are associated with the risk of sickness absence (e.g. Marmot, 1995; Avdic & Johansson, 2016; Böckerman et al., 2012).

To the best of our knowledge, no previous experimental or quasi-experimental studies have estimated the effects of work time control on sickness absence. An ideal experiment on participatory working time scheduling would randomly assign wards to participatory and traditional scheduling. In this study, the choice of wards or timing for implementing the participatory scheduling software were unlikely to have been random processes. Hospital districts acquired the new software and implemented it following internal processes. In this study, the main identifying assumption was that time-varying changes in the wards using traditional scheduling would provide a counterfactual point of comparison to the wards with participatory scheduling if they had not used participatory scheduling. Conditional parallel trends assumption was examined in detail with event study regression specification, and the results support the parallel trends assumption.

The main strength of this study is that it used comprehensive, detailed, and objective working hour and sickness absence panel data over four years with a large sample size, combined with a quasi-experimental intervention. As the objectively measured intervention occurred in two waves in 2016 and 2017, there may be exogenous variation in the implementation of the participatory scheduling, which supports the findings. With objective data on both the studied intervention and sickness absence, recall and dropout bias are obviated (see, e.g., Härmä et al., 2015). Sickness absence was determined from pay roll-based data, enabling the evaluation of short absences, which is not usually possible with register, survey or other types of data (Ropponen et al., 2019). Furthermore, objective measures for the actual use of the participatory scheduling software tackled the known methodological shortcomings of two-way fixed effects regression: problems in the estimation of treatment effects when units can go in and out of treatment conditions at different points in time (Imai & Kim, 2020), or the timing of the treatment influencing the total treatment effect (Goodman-Bacon, 2019).

This study also has its limitations. The most important limitation is that the study design did not include information on the actual mechanism through which the effects on sickness absence manifested. The effects on sickness absence were observed at ward level, but many factors affecting sickness absence are associated with employees' individual and work-related characteristics (Alexandersson & Norlund, 2004). The study design also lacks the information of actual changes in work time related choices, such as part-time work and other job modifications. There may be heterogenous effects among different employee groups and on the individual level, and this should be studied in the future. Longer follow-up would be needed to assess the stabilized use of participatory scheduling software on sickness absence. Further questions on the effects of participatory scheduling could include other measures of working conditions such as changes in actual working hours or, for example, measures of performance at hospitals, such as productivity.

The results of this study are of importance for the hospital management responsible for shift scheduling and may be relevant for all workplaces that can or may be able to introduce participatory shift scheduling. Offering employees increased control over work time, while facilitating the adaptation to the timing of shifts and taking into account the operational requirements of hospitals may help in confirming occupation-specific labour supply and reduce labour costs in hospitals, thus lowering health care expenditures.

5. Conclusion

The investigation of the effects of participatory working time scheduling on sickness absence with objective, ward-level working hour data has been lacking. Using participatory scheduling software in hospital wards resulted decrease in both sickness absence spells and short (1–3) sickness absence days per nurse. The timing (early vs. later) of implementation showed less importance. These encouraging findings are relevant not only to the health care sector but also to other sectors in which irregular shift work is a necessity.

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Description of authors' roles

JT, KK, AR, TH, SP, AK, and MH were responsible for the conception and design of the study. JT, KK, AK, AR, MH, KH, and JP were responsible for methodological considerations; KK, JT, and MH for the registration of the intervention; KK, JT, and AK for the acquisition of the data; and JT for the data analysis. All the authors took part in interpreting the results. JT 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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