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Deliverable

D6.1 Evaluation of Smart Shift Scheduling including cost-benefit ratios

COADAPT

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Notices

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Table of Revisions

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Partners

1 HELSINGIN YLIOPISTO (UH)

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3 INNOVATION SPRINT (INNO)

4 UNIVERSITA DEGLI STUDI DI TRENTO (UNITN)

5 UNIVERSITA DEGLI STUDI DI PADOVA (UNIPD)

6 IDEGO SRL (IDEGO)

7 BNP SRL (BNP)

8 AALTO KORKEAKOULUSAATIO SR (AALTO)

9 ETSIMO HEALTHCARE OY (ETSH)

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List of Abbreviations

CI	confidence interval
FIOH	Finnish Institute of Occupational Health
FPS	Finnish Public Sector study
OR	odds ratio
WHFPS	Working Hours in the Finnish Public Sector study
WP	Work package

Definitions

Ageing worker	employees aged 50 years or older as agreed in the CO-ADAPT consortium, additionally analysis on 55 or older employees, where applicable
Duty roster	a plan including the scheduling of work shifts
Payroll data of working hours	objective daily working hour data consisting on the employer-verified shift starting and ending times of shifts that is utilized for payroll
Participatory working time scheduling	a collaborative approach to working time scheduling where working time legislation, operation of the ward, and employees´ equality and fairness are all taken into account in cycles of negotiations and adjustments of schedules
Shift scheduling	planning a duty roster for a specific period (e.g. 3 weeks) of a work unit including information on the future work shifts of the employees
Smart shift scheduling	digital shift scheduling software including FIOH traffic light recommendations supporting health and safety and/or option to use participatory working time scheduling

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1 Executive Summary

Introduction

Shift scheduling with computerized methods is common in different types of shift work. Although the EU and national working time legislation restricts the average working hours and sets minimum time limits for recovery, the worktime planning process includes important decision making on the length, timing and intensity of the daily and weekly working hour patterns that influence health and well-being of shift workers. Ageing employees could benefit more from ergonomic and health-promoting working times, because the health risks of shift work start to increase after 45–50 years. However, such studies are sparse.

Aim of the deliverable

This deliverable is a report of Task T6.1 "Intervention study on Smart Shift Scheduling among ageing workers" (M1-31) that investigates the effects of smart shift scheduling adaptations on the well-being and sickness absence among ageing shift workers. This deliverable presents the main results from two published and two unpublished CO-ADAPT studies and merges the current new evidence on the use of smart shift scheduling tools with the results produced in deliverables D1. "Work ability framework report" and D3.3 "Implementation generalizability of Smart Shift Scheduling".

Results

Well-being

In the first study on the effects of participatory shift scheduling on well-being, we found that among early starters of the participatory working time scheduling (n= 283) and those remaining in traditional shift scheduling (n= 394) perceived control over scheduling of shifts increased significantly with participatory scheduling. Due to sample size restriction in this pilot study, we were not yet able to study the age-related effects of using the software.

Based on a new unpublished study, we further investigated the age-related effects on association of the participatory shift scheduling software with various measures of well-being. Using propensity score matching of nearly 2500 hospital employees, the main result was that employees who used the participatory working time scheduling software were at lower risk of decreased work ability, mental distress, and short sleep duration than those remaining in traditional shift scheduling. The positive effects of the software were of the same magnitude both among younger and older employees. In the age-group of ≥55 years employees, the risk of poor work ability was 42% lower among users of participatory working time scheduling software compared with non-users of the software.

Sickness absence

We first investigated the effects of using participatory working time scheduling software on ward-level sickness absence among Finnish hospital employees, mainly women. In a quasi-experimental design, we compared the amount of short sickness absence (1-3 days) in hospital wards using participatory working time scheduling software (n= 121 wards) and wards continuing with traditional time scheduling (n= 117 wards) between 2014 and 2017. In the second study, we used continuous panel data from 238 hospital wards with approximately 9 000 hospital employees (89% of women, primarily nursing staff).

The first study on sickness absence estimated the effects of using participatory scheduling software by difference-in-differences regression. On the ward level, the use of participatory shift scheduling software decreased the frequency of sickness absence spells and short (1–3 days) sickness absence days by 6% and 7%, respectively, in hospital wards using participatory working time scheduling software (n= 121 wards) and wards continuing with traditional time scheduling (n= 117 wards).

In the subsequent study, we further investigated the effects of the software on individual level and according to age using difference-in-differences and entropy balancing. Based on the preliminary results, we found age-related differences in the effects of the use of participatory shift scheduling. The use of participatory shift scheduling software decreased the amount of sickness absence days by 1.85 days (9% of sickness absence days) per year, in the sample of ≥50 years old hospital employees. The effect was statistically significant. The decreasing effect of 0.59 days within the sample of ≤50-year-old hospital employees was not statistically significant.

Cost-benefit ratios

We calculated a conservative estimate of the value of reduced short sickness absences in ward-level. This estimate was based on realised savings for paying the wages of sickness absent employee. No other benefits, such as replacing the sickness absent employee or loss of output were considered. This lower limit of realised benefits was 40 euros per employee per year. The estimates based on the preliminary results for the ageing workers of ≥50 years of age, preliminarily indicate realised benefits of 190 euros per employee per year.

The cost-benefit ratio of acquiring participatory shift scheduling software based on simple calculations on both published and preliminary results show benefits to outweigh the costs by a ratio of 4 in already published results. For the preliminary results, benefit to cost ratio is estimated to be almost 20. These results do not include all possible benefits and costs, and thus should be taken with precaution.

Ethical evaluation

The intervention was registered to ClinicalTrials.gov before start of the intervention and The Coordinating Ethics Committee of the Hospital District of Helsinki and Uusimaa (HUS) approved the study (HUS 1210/2016). Beyond formal compliance with ethical regulation, this digital solution fulfils the principles of fairness, trustworthy and privacy respectfulness for technology design, for example, the data collection is limited to the information necessary for shift scheduling, shift schedules are transparent while in preparation, and the solution provides explanation for the system decision on shift ergonomics to prove accuracy.

Conclusion and relevance

Participatory and “smart” working time scheduling software is a promising tool to support shift work management for the reduction of sickness absences and promoting well-being among hospital employees. The conservative cost-benefit estimates from employer point of view show that participatory scheduling´s benefits outweigh the costs. These encouraging findings are relevant not only to the health care sector but also to other sectors in which irregular working hours (shift work) are a necessity.

Due to increased risks for poor work ability and sickness absence with older age, good work time control and proper shift ergonomics in the form of using smart shift scheduling tools developed in the CO-ADAPT can be recommended. However, we recommend that special emphasis should be put on not only the good control over working hours, but the possibilities to select shorter average working hours, more recovery between the shifts, and less night shifts with older age. These age-specific recommendations are possible to implement to the new versions of the Titania® shift scheduling software to disseminate the good practises developed in the CO-ADAPT project.

2 Introduction

Shift workers comprise more than one fifth of the workforce (Eurofound, 2017). Even though the employment rate for 55–64-year-olds has steadily increased in the EU28 countries during the 21st century, the employment rate was still only 59% in 2019 (Eurostat, 2020). Moreover, the ageing workers are also often employed in social and health care sector where providing services requires 24/7 irregular working hours, i.e. working in shifts. Shift work, especially shift work including night work, has many negative impacts on employees´ health and well-being, including circadian disruption and insufficient sleep (Kecklund & Axelsson, 2016) and increased risk for various chronic diseases (Gao et al., 2020; Nielsen et al., 2019; Torquati, Mielke, Brown, & Kolbe-Alexander, 2018).

We have shown in an earlier CO-ADAPT study (Ropponen, Koskinen, Puttonen, & Härmä, 2020), that ageing was associated with beneficial changes in objective working hour characteristics, older employees having more often shorter weekly working hours and less night work. Similarly, changes towards shorter working hours and lower work tempo (with decreased workload) among ageing workers were associated with less retirement intentions (D1.1 “Work ability framework report”). Our latest CO-ADAPT study with prospective cohort design shows a significant association between shift work and clinically significant levels of sleep disturbances (Tucker et al., 2021). Our results in an earlier CO-ADAPT study (Ropponen, Koskinen, Puttonen, & Härmä, 2020), that ageing was associated with beneficial changes in objective working hour characteristics, older employees having more often shorter weekly working hours and less night work. Similarly, changes towards shorter working hours and lower work tempo (with decreased workload) among ageing workers were associated with less retirement intentions (D1.1 “Work ability framework report”). Our latest prospective cohort study shows a significant association between shift work and clinically significant levels of sleep disturbances (Tucker et al., 2021).The effects were stronger among night shift workers and those aged ≥40 years. When studying the effects of irregular working hours in shift work, employees’ age needs to be considered because the health risks seem to increase after 45–50 years (Costa & Di Milia, 2008; Härmä, 2014).

The EU Working Time Directive (European Union, 2003) and national working time legislation, in Finland the Working Act (Ministry of Economic Affairs and Employment, 2019), restrict the maximum average working hours and set minimum time limits for recovery. In addition to the regulative limits, shift scheduling process includes important decision making on the length, timing and intensity of the daily and weekly working hour patterns that influence the health and well-being of shift workers. Typical examples of the working time patterns that are set during the shift scheduling process are the number of consecutive night shifts, the length of work shifts and the time between the shifts. However, there is an interplay between good working time ergonomics and individual preferences.

Good opportunities to influence working hours have many positive effects on workers´ well-being, such as improved sleep quality (Takahashi et al., 2012), work-life balance (Keeton, Fenner, Johnson, & Hayward, 2007; Nijp, Beckers, Geurts, Tucker, & Kompier, 2012) and job/career satisfaction (Clem et al., 2008; Lowden & Åkerstedt, 2000; Pryce, Albertsen, & Nielsen, 2006). Good work time control in the form of schedule flexibility is negatively associated with both the frequency and duration of sickness absence (Possenriede, Hassink, & Plantenga, 2014). In occupational sectors with labor shortage, such as nursing, good opportunities to influence working hours can augment staff retention (Barrett & Holme, 2018; Leineweber et al., 2016). Good work time control is even related to later retirement beyond the pensionable age (Virtanen et al., 2014). Some of these effects have been found among employees in different age groups. For example, in a CO-ADAPT study, binding ergonomic shift scheduling rules were shown to have a buffering effect towards worsening of sleep among ageing (45+) employees (Karhula et al., 2020a). In Danish nurses, a higher risk for long-term sickness absence was found on older age groups (41-50, >50 years) for all studied working hour characteristics (e.g., evening, night and consecutive night shifts) except day work (Larsen et al., 2020).

As part of the T3.3 "Implementation generalizability of the smart shift scheduling" FIOH has produced updated the *Traffic Light Recommendations* for the length, timing, recovery and social life -related characteristics of working hours supporting health and well-being in practical shift scheduling (Table 1). The evidence-based FIOH Traffic light recommendations (Härmä et al., 2020) are utilized by several shift scheduling companies, but especially by CGI Finland in its Titania® shift scheduling software that are used by over 95% of the public sector organizations in Finland. Most of the Titania® software versions nowadays utilize directly the FIOH's recommendations and evaluate whether the draft shift schedules follow the FIOH recommendations. Self-scheduling is another feature that has been added to some versions of the software.

Table 1. The FIOH updated traffic light recommendations for shift ergonomics. Published in Finnish under www.ttl.fi/tyoaika. Direct link here.

	High overload, should be corrected	Overload, not recommended	Increased workload	Recommended
1. Length of the working hours				
1.1. The length of working hours between 2 free days (h)	>55:00	48:01-55:00	40:01-48:00	≤40:00
1.2. The length of work shifts (full-time work, h)	>14:00	12:01-14:00	10:01-12:00	04:00-10:00
1.3. No of consecutive work days in full-time work	≥ 8 or 1	7	6 or 2	3-5
2. Timing of working hours				
2.1. No of work shifts starting before 06:00 in 4 weeks	≥12	7-11	3-6	0-2
2.2. No of consecutive evening shifts	6	5	4	0-3
2.3. No of night shifts (3 hours btw 23-06) in 4 weeks	≥12	7-11	3-6	0-2
2.4. No of consecutive night shifts	≥6	5	3-4	0-2
3. Recovery				
3.1. No of <11 h shift intervals between 2 free days	≥3	2	1	0
3.2. No of <11 h quick shift intervals in 4 weeks	≥12	5-11	2-4	0-1
3.3. The length of free time after last night shift (h)	<11	11:00-27:59	28:00-48:00	>48
3.4. Weekly rest time (Mon 00:00-Sun 24:00, h)	<24	24:00-34:59	35:00-48:00	>48
4. Social aspects of working hours				
4.1. No of free weekends in 4 weeks		0	1	2-4
4.2. No of single free days in 4 weeks	≥5	4	2-3	0-1
4.3. No of split shifts in 4 weeks	≥4	2-3	1	0
5. Individual possibilities to control working hours				
5.1. Shift wishes possible to influence working hours		no		yes

3 Objectives

This deliverable is a report of Task T6.1 “Intervention study on Smart Shift Scheduling among ageing workers” (M1-31) that investigates the effects of smart shift scheduling adaptations on the well-being and sickness absence among ageing shift workers. The objective was to investigate the health and well-being effects of the use of interactive worktime planning tools that support work-time control (possibilities to influence individual shift rosters, i.e. self-rostering) and guide for health-supporting shift ergonomics. We also assessed the economic benefits of the used worktime planning tools in the form of cost-benefit ratios. The overall aim of the smart shift scheduling related tasks T1.2 “Applying work ability framework for worktime planning with computerized methods”, T3.3 “Implementation generalizability of the smart shift scheduling solution” and T6.1 is to support age-friendly shift systems by considering the specific needs of ageing employees during the shift scheduling process. This deliverable 6.1 utilizes output presented in T1.2 deliverable D.1. “Work ability framework report” that was completed by M12. The results of the Task 6.1 will be disseminated through WP7 on dissemination, communication and exploitation and utilized later in WP1 as one part of the T1.5 “Consolidating a CO-ADAPT framework for active ageing” (M24-42, contribution from all partners) and the related D1.4 “Consolidated CO-ADAPT framework” which has a timespan until M40.

4 Work done and main achievements

4.1 Registration of the intervention and ethical issues

The T6.1 intervention was registered to ClinicalTrials.gov before start of the intervention (NCT02775331), as is required by The International Committee of Medical Journal Editors (Zarin, Tse, Williams, Califf, & Ide, 2011).

All the participating hospital districts gave FIOH a written permission to use the employers’ working time registries for this research purpose. 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). No ethical approval was needed for the organizations providing only register-data ("Data Protection Act 1050/2018," 2018). All the data were anonymized for research purposes, and international ethical standards, good scientific practise and FIOH data protection policy were conformed to.

Beyond formal compliance with ethical regulation, the studied Titania® shift scheduling solution fulfils the principles of fairness, honesty, trustworthy and privacy respectfulness for technology design (Preece, Sharp & Rogers, 2015) by, e.g., following procedures:

– The use of applications is based on voluntariness.
– The data collection is limited the information necessary for shift scheduling, and no additional data is collected or stored with the new tools compared to the traditional shift scheduling

- *transparency* of shift schedules is fulfilled while a schedule is under preparation
- explanation is available for the system decision on shift ergonomics to prove accuracy and correctness (i.e. *accountability*).

4.2 Working hour data transfer process and information security

The Titania® working hour data transfer process was described in D3.3 “Implementation Generalizability of Smart Shift Scheduling”. The Working Hours in the Finnish Public Sector (WHFPS) cohort includes payroll-based data of daily working hours and absences due to various reasons, e.g., sickness absence, of over 219 000 employees in altogether 12 hospital districts and 13 cities. During the CO-ADAPT -project, the original database of 17 hospital districts and cities has been extended to eight new hospital districts including now all the largest hospital districts and cities in Finland.

The WHFPS registry data is based on retrieval of daily data from the Titania® shift scheduling software retrospectively and prospectively using a specific sampling software developed by CGI Finland Ltd to FIOH. The updated data transfer process used currently is described in Figure 1. Transfer via SFTP connection has been changed to Sharefile -system, where the main user transfers the working hour data via creating single-use username and password. The project data manager transfers the data to a secure, restricted-use server, where only the named data manager has access to the data.

In FIOH, based on separate permissions by each WHFPS organization, register authority, and the employees, the data has been linked on individual bases (using unique ID code) to individual health and safety data, e.g., the biannual surveys of the Finnish Public Sector (FPS) study since 1997.

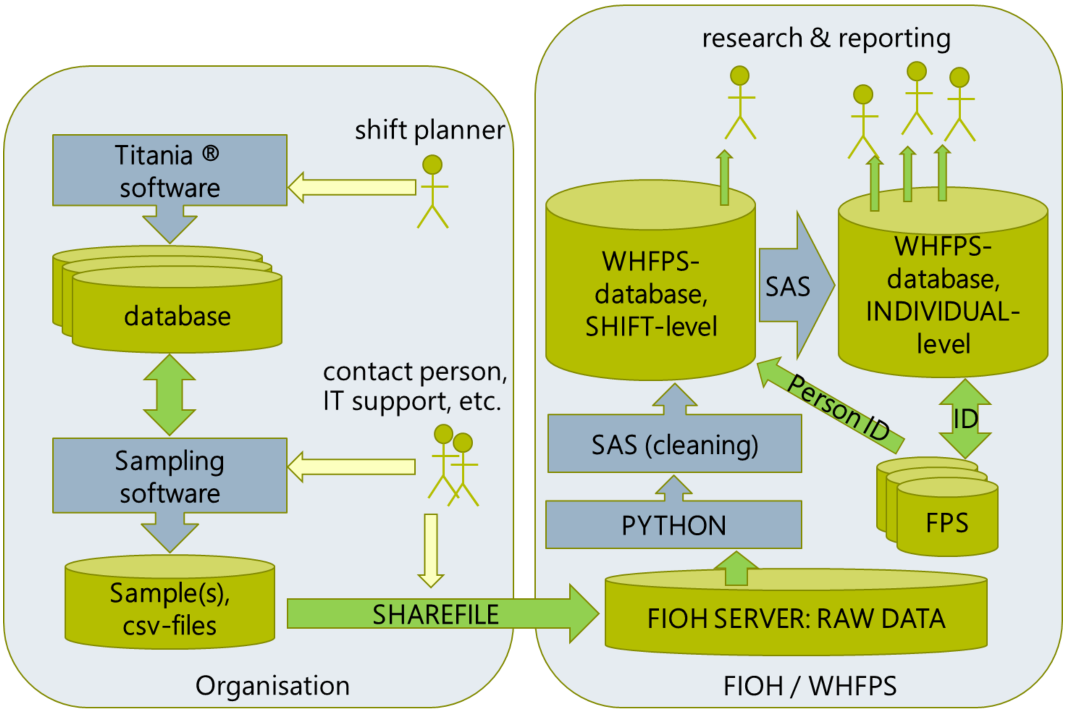

Figure 1. The working hour data transfer process.

4.3 *Studies on well-being and work ability*

Study 1 (published)

The aim of this study (Karhula et al., 2020b) was to investigate the effects of using participatory working time scheduling software on working hour characteristics and well-being among Finnish hospital employees, mainly nurses and practical nurses. We compared changes in objective working hour characteristics and well-being between 2015 and 2017 among early starters of the participatory working time scheduling (n= 283) and those remaining in traditional shift scheduling (n= 394). The statistical analyses were conducted using repeated measures general linear model and 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.

The main results showed that in comparison to traditional scheduling, perceived control over scheduling of shifts increased significantly with participatory scheduling (OR 3.24, 95% CI 1.73–6.06). None of the other well-being variables showed statistically significant changes in the adjusted models. 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. We concluded that among the early starters of the participatory working time scheduling, the proportion of long work shifts and perceived control over scheduling of shifts increased more than among those using traditional scheduling. Due to the sample size restrictions of this pilot study, we were not yet able to study the age-related effects of the software.

Study 2 (unpublished, under preparation)

In a subsequent larger study (Shiri et al., 2021) with longer follow-up, the participants were shift working hospital employees identified based on the survey data from the Finnish Public Sector Study (n=2 427, 90% females) who used participatory working time scheduling software or traditional scheduling between 2015 and 2019. The participants utilized participatory working time scheduling software for at least one year either during 2015-2017 or during 2017-2019. We estimated the propensity score of using participatory working time scheduling software on the baseline characteristics (2015 survey for the 2015-2017 cohort and 2017 survey for the 2017- 2019 cohort) using multilevel mixed-effects logistic regression. We used three-level random-intercept model of using participatory working time scheduling software on 43 baseline characteristics from surveys (including, e.g., sociodemographic, lifestyle and psychosocial factors, and chronic medical condition) as well as outcome variables at baseline with individuals nested within wards and wards nested within hospitals. We then created and stabilized inverse probability of treatment weight for each employee.

The propensity score weighting analysis showed that employees who used participatory working time scheduling software were at lower risk of self-reported low control over scheduling of shifts (p <0.001), poor work ability (p= 0.048) and short sleep (p= 0.023) than those who used traditional scheduling. In age-specific (<50 years and ≥50 years) subgroup propensity score weighting, using participatory working time scheduling software had beneficial effects only on control over scheduling of shifts in both participants <50 years and in those aged ≥50 years. For poor perceived work ability and short sleep, the estimates neither reached statistical significance in employees <50 years nor in those aged ≥50 years. (Shiri et al., 2021)

Of the 2 427 employees at baseline, 517 (21.3%) were aged ≥55 years. A subgroup analysis among those aged 55 years or older showed that the risk of low control over scheduling of shifts among users of participatory working time scheduling software was half of the risk among non-users of the software (Table 2). Moreover, the risk of poor work ability was 42% (95% CI 1-66%) lower among users of participatory working time scheduling software compared with non-users of the software. The main conclusion of this study was that participatory shift scheduling software had beneficial effects on self-reported perceived control over working hours, work ability and sleep length, and the positive effects were of the same magnitude both among younger and older employees.

Table 2. Effects of using participatory working time scheduling software on well-being and work ability among employees aged 55 years or older.

Well-being and work ability	Risk ratio	95% CI
Control over scheduling of shifts		
Intermediate or low vs. good	0.84	0.70-1.00
Low vs. good or intermediate	**0.50**	**0.27-0.95**
Perceived work ability, poor vs. good	**0.58**	**0.34-0.99**
Perceived health, poor vs. good	1.21	0.36-4.06
Work-life conflict, yes vs. no	1.18	0.92-1.51
Psychological distress, yes vs. no	0.78	0.55-1.12
Short sleep (≤6 hours), yes vs. no	0.71	0.43-1.17

4.4 Sickness absence and cost-benefit ratios

Study 3 (published)

The aim of third study (Turunen et al., 2020) was to investigate the effects of using participatory working time scheduling software on ward-level sickness absence among Finnish hospital employees. We compared in a quasi-experimental study the amount of short sickness absence (1-3 days) in hospital wards using participatory working time scheduling software (n= 121 wards) and wards continuing with traditional time scheduling (n= 117 wards) between 2014 and 2017. We used continuous panel data from 238 hospital wards with approximately 9 000 hospital employees (89% of women, primarily nursing staff). The sickness absence data did not include any medical information on the causes of sickness absence. Two-way fixed effects and event study regressions with clustered standard errors were used to estimate the effects of participatory working time scheduling.

The main results showed that sickness absence spells and short (1–3 days) 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 using the participatory working time scheduling software increased.

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. Benefits outweighed costs by a ratio of 4. However, these simple estimates are based only on the direct costs of sickness absence and the acquisition of the participatory working time scheduling software. Thus, these estimates should be taken with caution.

Both participatory working time scheduling and its decreasing effect on sickness absence could help head nurses focus on more productive activities. 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).

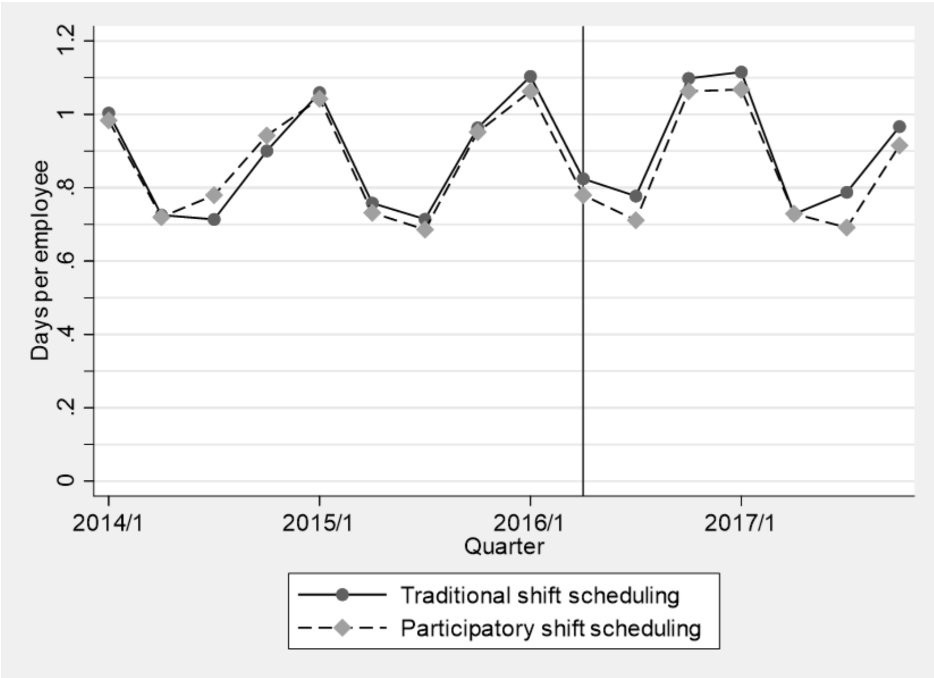

Figure 2. Short (1–3) sickness absence days per employee, quarterly average. Vertical line depicts timing of intervention implementation in first wards. Published in Int J Nurs Stud (Turunen et al., 2020).

Study 4 (unpublished, under preparation)

The previous study on the effect of participatory working time scheduling on sickness absence was carried in ward-level. The study design did not allow to investigate the association of individual-level characteristics on the estimated effect. For example, there may be heterogenous effects of participatory working time scheduling for different groups of hospital employees. Our unpublished, preliminary results (Turunen et al., 2021) are based on payroll data, which is built into an employee-level balanced panel data for years 2015-2019. Total number of hospital employees in the data was 9581. We excluded the 4 062 employees who had less than 20 % of evening and night shifts of all shifts. The sample used in analysis consisted of 1 641 employees who were ≥50 years old, and 3 878 employees who were ≤49 years of ages in the beginning of 2015. The sample was not large enough to be further analysed in older age-group. For example, the number of >55 year-olds in the sample of employees conducting shift work was 685.

We estimated average treatment effect for the participatory scheduling group by using generalized difference-in-differences regression. The table 3 shows the number of hospital employees in participatory and traditional scheduling from 2015 to 2019. The first employees begun using participatory shift scheduling software in 2016 and increasing proportion of employees joined later during the follow-up period.

Table 3. Number of hospital employees in participatory and traditionally scheduling groups 2015-2019, employee-level panel data.

	≥50 years (N=1 641)		≤49 years (N=3 878)	
	Participatory	**Traditional**	**Participatory**	**Traditional**
2015	0	1 641	0	3 878
2016	273	1 368	727	3 151
2017	703	938	1 789	2 089
2018	806	835	2 099	1 779
2019	765	876	1 991	1 887

The proportion of female employees was larger in the group that started participatory scheduling between 2016 and 2019. They were also younger in comparison to those in the group that remained traditional scheduling. The employees in the participatory scheduling group had on average more night and evening shifts out of all shifts. Due to small differences in these groups, we repeated our analysis with entropy balanced samples for both age groups separately. Entropy balancing (Hainmueller, 2012) weights the individuals in traditional scheduling control group so that the exact balance between groups is achieved. We balanced the groups in respect to gender, age, and the share of the evening night shifts separately. After the balancing the characteristics of the two groups matched exactly.

Table 4. Gender, age and share of the evening and night shifts in the participatory and traditionally scheduling groups 2015-2019, employee-level panel data.

	≥50 years (N=1641)		≤49 years (N=3878)	
	Participatory (N=751)	**Traditional (N=890)**	**Participatory (N=1 472)**	**Traditional (N=2 406)**
Female, %	91	85	89	77
Age, years	54.5	54.8	36.3	37.8
evening shifts, %	54	46	54	50
night shifts, %	55	45	51	47

The course of sickness absence days per employee for those that start participatory scheduling and those that remain traditional scheduling had parallel trends in pre-intervention time (Figures 3 and 4). The difference between group's sickness absence days increased during 2017 and 2018, and eventually more or less merged.

For the younger (≤49 years) hospital employees, the differences in sickness absence days per employee between employees that start participatory scheduling later and those that continue traditional scheduling are close to non-existing during 2015 and 2016. The difference increases slightly during 2017, 2018 and 2019 (Figures 5 and 6). For both age groups, parallel trends of sickness absence days were observed, thus enabling to estimate the effect of participatory working time scheduling by using difference-in-differences regression.

The estimated effects using entropy-balanced sample showed a decreasing effect of 1.85 days on sickness absence days of ≥50 year-old employees. However, 95% confidence intervals were wide, ranging from -3.33 to -0.38, yet the estimated effect was statistically significant. Multiplying the estimated effect with gross daily wage allows the valuation of the estimated effect. This estimated value was 190 euros per employee.

The estimated effects using entropy-balanced sample for the younger (≤49 years of age) hospital employees showed a decreasing effect of -0.59, yet the estimated effect was not statistically significant.

The main conclusion of these preliminary findings was that participatory shift scheduling software had a decreasing effect on sickness absence days for those aged ≥50 years. The effect on the sickness absence days for younger ≤49 years was smaller and statistically insignificant. We will study further these preliminary results to be published in an international peer-reviewed journal.

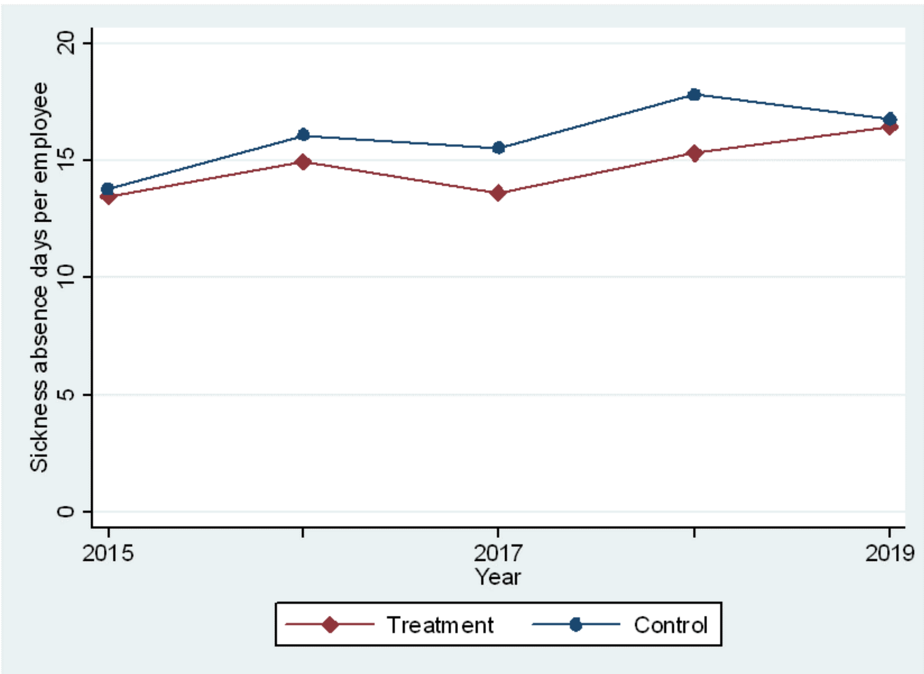

Figure 3. Sickness absence days per hospital employee, ≥50 years. Employees participatory scheduling in 2015: 0 employees, in 2016: 273, in 2017: 703 employees, in 2018: 806 employees, and in 2019: 765 employees, respectively.

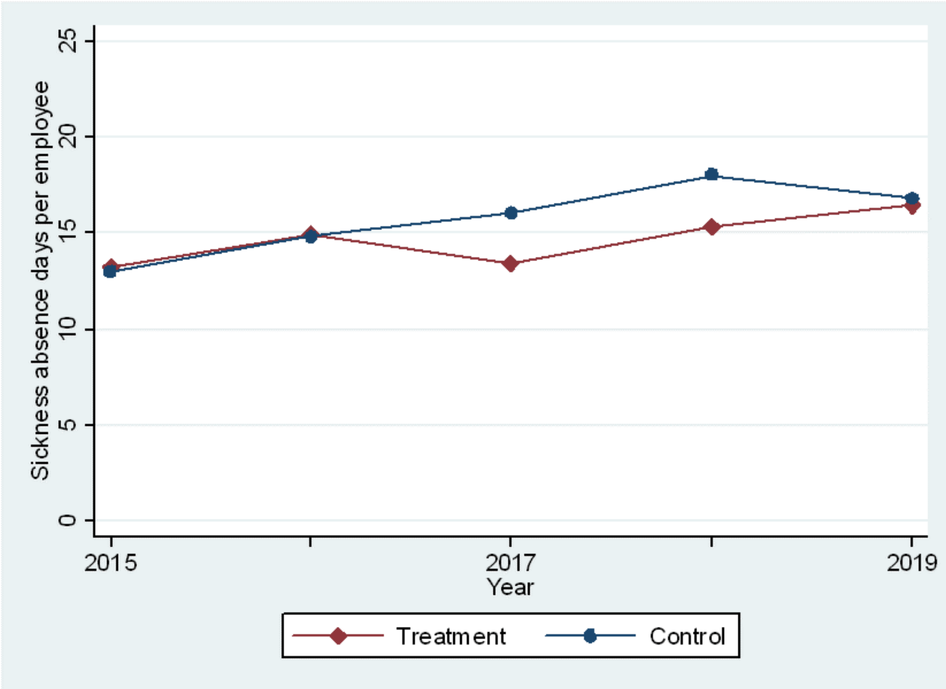

Figure 4. Sickness absence days per hospital employee, ≥50 years. Entropy-balanced sample. Employees participatory scheduling in 2015: 0 employees, in 2016: 273, in 2017: 703 employees, in 2018: 806 employees, and in 2019: 765 employees, respectively.

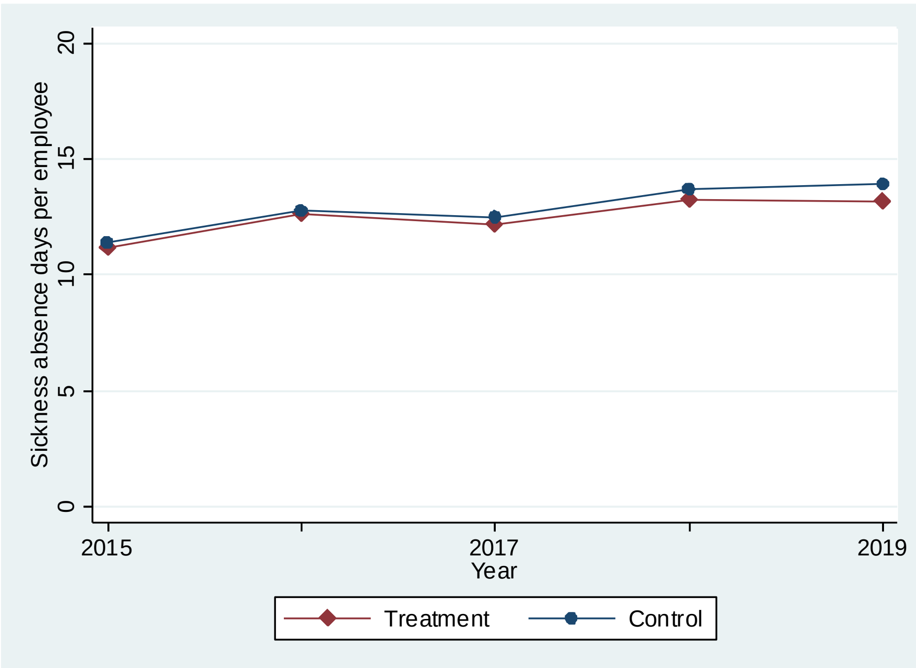

Figure 5. Sickness absence days per hospital employee, ≤49 years old. Employees participatory scheduling in 2015: 0 employees, in 2016: 727 employees, in 2017: 1 789 employees, in 2018: 2 099 employees, and in 2019: 1 991 employees.

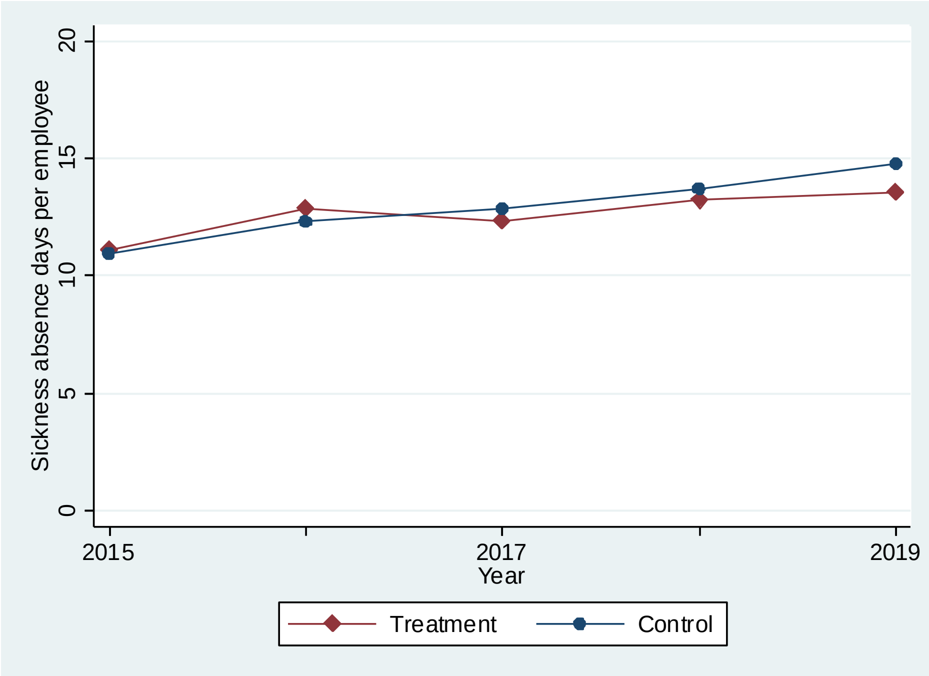

Figure 6. Sickness absence days per hospital employee, ≤49 years old. Entropy-balanced sample. Employees participatory scheduling in 2015: 0 employees, in 2016: 727 employees, in 2017: 1 789 employees, in 2018: 2 099 employees, and in 2019: 1 991 employees.

Table 5. Statistical testing of the effect of participatory working time scheduling on sickness absence days according to age. Difference-in-differences regression.

	≥50 years (N=1641)		**<u>≤49</u> years old (N=3878)**	
	Unbalanced sample	Entropy balanced sample	Unbalanced sample	Entropy balanced sample
Sickness absence days (95 % confidence intervals)	-1.25 (-2.68 to 0.18)	**-1.85 (-3.33 to -0.38)**	**0.90 (0.18 to 1.64)**	-0.59 (-1.40 to 0.23)

5 Summary and conclusions

As a summary of several published and unpublished studies, this D6.1 deliverable shows that the effects of “smart” participatory working time scheduling software including the FIOH traffic light recommendations resulted in 6-7% less ward-level short (1-3 days) sickness absence days in comparison to continuing with traditional scheduling. The individual-level study investigating the age-group differences showed that the participatory shift scheduling software had statistically significant decreasing effect on sickness absence days for those aged ≥50 years. The effect on the sickness absence days for younger (≤49 years of age) employees was smaller and statistically insignificant.

On ward-level, a conservative estimate suggests that using participatory shift scheduling software produces annual savings of 37€ per an employee. Cost-benefit ratios show benefits to outweigh costs by a ratio of 4. Preliminary results from the individual-level effect show beneficial effects on sickness absence days for older (≥50 years) employees, of 190€ per employee. For the older group, benefits outweigh the costs by a ratio of 20. However, these preliminary results will be further explored during the preparation of the manuscript.

The effects of utilizing the software on well-being were more modest in the first study with smaller sample but clearer and more consistent in the subsequent study with triple sample size and more sophisticated statistical methods. The use of participatory working time scheduling software decreased the risk of poor perceived work ability and short sleep in addition to improving control over scheduling of shifts compared to those who used traditional scheduling. The positive effects of the software of the same magnitude both among younger and older employees. In the age-group of ≥55 years of age employees, the risk of poor work ability was 42% lower among users of participatory working time scheduling software compared with non-users of the software.

To sum up, it is concluded that participatory working time scheduling software is a promising tool to support shift work management for the reduction of sickness absences and promoting well-being among hospital employees. 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.

The overall aim of the Smart Shift Scheduling -related CO-ADAPT tasks and deliverables was to support age-friendly shift systems by considering the specific needs of ageing employees during the shift scheduling process. In the D1.1 we concluded that that based on previous research and the new studies conducted as part of CO-ADAPT, older employees are in increased risk for sickness absence (Larsen et al., 2020), poor work ability and disturbed sleep (Tucker et al., 2021) compared to younger employees. On the other hand, we found that changes towards shorter working hours and lower work tempo (with decreased workload) among ageing workers were associated with decrease in retirement intentions (D1.1). Earlier we have found that work-time control helped to reduce sickness absence due to musculoskeletal disorders among the older employees (Albrecht et al., 2020), and night work was associated with the increased need for recovery of older employees, indicated by changes towards long sleeping (Harma et al., 2018). Our results are also in line with the earlier findings from the Finnish Pubic Sector study that work-time control increases the likelihood for less disability pensions and longer working lives through later retirement (Vahtera et al., 2010; Virtanen et al., 2014).

Based on this deliverable, it can be concluded that the use of participatory working time scheduling was associated with beneficial effects, i.e., improvements in work ability and sleep, and savings due to higher work participation among the ageing hospital employees. Due to increased risks for poor work ability and sickness absence with older age, good work time control and proper shift ergonomics in the form of using smart shift scheduling tools developed in CO-ADAPT can be recommended.

In addition to following the general shift ergonomic recommendations applied in this project (see Table 1), we recommend that with older age special emphasis should be put on not only the good control over working hours, but the possibility to select shorter average working hours (i.e., work part-time), more recovery time between the shifts, and having less night shifts. These age-specific recommendations are possible to be implemented to the new versions of the *Titania®* shift scheduling software to disseminate the good practises developed by the CO-ADAPT project.

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