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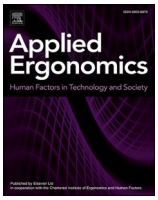

# Effects of the use of a shift schedule evaluation tool with ergonomic recommendations on employee wellbeing - a quasi-experiment in the Finnish healthcare sector

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ABSTRACT

We investigated the effects of a shift schedule evaluation tool with ergonomics recommendations on employee wellbeing. The study sample was from the Finnish Public Sector study (n = 7002 employees). The shift planners' use of the shift schedule evaluation tool was linked to employees' self-reported wellbeing outcomes. Inverse probability weights, reflecting the likelihood of the evaluation tool's use by the shift planner, were calculated using multilevel mixed-effects logistic regression for each participant and logistic regression for each ward. Wards using the tool (intervention group) were compared to those not using it (control group) with a generalized linear model. No association was found between the tool's use and wellbeing at the ward level. In the individual level, lower psychological distress was found in the intervention group (Risk ratio 0.92, 95 % Confidence interval 0.85–0.99). More rigorous use of the tool may be necessary to achieve significant benefits for wellbeing.

## 1. Introduction

Shift work is a necessity in many safety-critical professions, and the proportion of shift workers in the healthcare is amongst the highest of all occupational sectors (Eurofound & ILO, 2019). Shift work increases the risk of various chronic diseases, such as type II diabetes (Gao et al., 2020), cardiovascular diseases (Torquati et al., 2018), ischemic stroke (Brown et al., 2009), and certain types of cancer (IARC, 2020), such as breast cancer (Cordina-Duverger et al., 2018). The high number of health risks in shift work emphasizes the importance of how the adverse effects can be mitigated (Härmä et al., 2024).

An ergonomic shift schedule is designed to optimize the health and safety of employees and minimize negative effects associated with shift work. Previous studies among small and selected samples of primary healthcare staff and municipal hospitals have indicated that developing ergonomic, i.e., safe and health-promoting shift schedules, can have several positive effects on shift-working nurses' wellbeing (Hakola et al., 2010; Jarvelin-Pasanen et al., 2013). Especially reduction of quick returns (i.e., shift intervals of ≤11 h) has been found to have beneficial psychological and psychophysiological effects on wellbeing (Hakola et al., 2010). In a cross-sectional setting, shorter shift length (7 h regardless of the time of the day) was associated with fewer work-related burdens and health risk behaviours than longer shift lengths among nurses and nursing assistants (Fond et al., 2023). On the contrary, self-rostering studies point out that safe shift work patterns seem to be overruled by other priorities, such as staff preferences and entitlements (Booker et al., 2024), even though especially priorities of wishes and issues of fairness are difficult to objectify (Heydrich et al., 2020). It is important to note that these findings are based on studies using small and selected samples (Hakola et al., 2010; Jarvelin-Pasanen et al., 2013; Booker et al., 2024), cross-sectional (Fond et al., 2023), or theoretical approaches (Heydrich et al., 2020). These may lead to issues such as sampling bias, limited generalizability, reduced statistical power, and a lack of causal inference.

There is robust evidence that insufficient sleep causes adverse metabolic and immunological changes as well as cognitive impairments (Irwin, 2015). Thus, it has been suggested that short sleep or impaired sleep quality could be a mediator of the relation between shift work and

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adverse health effects (Kecklund and Axelsson, 2016). In our earlier studies in the social and healthcare sector, we found that decreasing the proportion of night shifts and quick returns (<11 h) and giving preference to quickly forwarding rotating shift systems were associated with reduced fatigue (Härmä et al., 2018). Interventions promoting sufficient sleep and recovery by improving shift schedules are rare, however. Our previous natural intervention study among ageing social and healthcare sector employees showed that implementing binding ergonomic shift scheduling rules on the organizational level had a buffering effect against worsening of sleep by age (Karhula et al., 2021).

It is also important to note that appropriate shift scheduling that respects ergonomic criteria is not only important to protect the healthcare workers but also for the quality of care and patient safety (Costa et al., 2021). For example, nurses working long shifts (≥12 h) and those working overtime reported lower care quality and patient safety (Griffiths et al., 2014).

While the changes in certain characteristics of shift schedules are associated with changes in perceived wellbeing (Härmä et al., 2018, 2019), it is not clear whether perceived wellbeing can be improved with the use of the shift scheduling recommendations that are implemented in the shift scheduling software. Based on follow-up studies, the use of the shift ergonomics tool was associated with several, albeit modest, favourable changes in shift characteristics (Härmä et al., 2022) and with a reduced risk of occupational injuries in a prospective cohort study (Shiri et al., 2023). We had the unique opportunity to quantitatively assess the use of the shift ergonomics tool and link this information to the employees' perceived wellbeing using a quasi-experimental natural intervention design. In this study, we aimed to investigate whether the use of a shift schedule evaluation tool with ergonomic recommendations influences wellbeing of social and healthcare workers.

## 2. Methods

### 2.1. Study design

This was a quasi-experimental natural intervention study based on the Finnish Public Sector (FPS) study. The FPS study is an ongoing cohort study that has investigated working conditions, health, and wellbeing among Finnish public sector employees since 1997 (Härmä et al., 2023). The study covers approximately 30 % of Finnish public sector employees.

### 2.2. Study population

The study population was derived from seven municipalities and three hospital districts participating in the FPS study (Ervasti et al., 2023). The social and healthcare workers of the municipalities were responsible for primary healthcare, including, e.g., the operation of health centres, and hospitals for elderly and chronically ill patients who need 24/7 care. In addition, the social and healthcare workers of the municipalities provided home care to elderly and disabled citizens. The hospital districts were responsible for special healthcare services and had both outpatient clinics and inpatient hospital wards.

The study population consisted of the following FPS study waves: 1) 7233 employees who had 2015/2016 survey responses, a period-based working time arrangement (114:45h in 3 weeks), and realized working hour data, 2) 9522 employees with 2017/2018 FPS surveys responses and the period-based working time arrangement and working hour data, and 3) 6784 employees with 2019/2020 FPS survey response and period-based working time arrangement and working hour data.

After excluding day workers due to the lack of most of the studied working hour characteristics we formed two cohorts of shift workers having the FPS survey response in two consecutive survey waves; Cohort I comprised shift working social and healthcare employees from the 2015/2016 and 2017/2018 surveys (n = 5,877, 44.4 % nursing assistants, 30.9 % nurses and 8.8 % social workers) and Cohort II included participants from the 2017/2018 and 2019/2020 surveys (n = 1,667, 43.0 % nursing assistants, 32.0 % nurses and 8.9 social workers). Thereafter, we excluded those employees who had worked less than 31 shifts in a year to exclude employees with very long absences or very low actual working hours. We also excluded underweight (BMI <18.5 kg/m$^2$) and morbidly obese (BMI >40.0 kg/m$^2$) participants to minimize the likelihood of having undiagnosed health issues, such as sleep apnoea, among the study participants. The combined analytical sample was 7002 employees, who were from 1171 wards (Fig. 1.).

### 2.3. Intervention

The Finnish Institute of Occupational Health (FIOH) has developed national shift ergonomics recommendations integrated into a shift scheduling tool used in the public healthcare sector (Härmä et al., 2022). The use of the shift schedule evaluation tool, following the shift ergonomics recommendations, was investigated with a quasi-experimental study design. The evaluation tool is integrated to a shift scheduling software (Titania®, CGI Finland Ltd) with a four-colour traffic-light analogy (red, orange, yellow, and green to indicate the level of workload) and one-click access to the explanation for the colouring in each work shift. The purpose of the evaluation tool was to give feedback to the ward level shift planner on the optimization of the shift schedules according to the FIOH shift ergonomics recommendations (Härmä et al., 2022). The tool requests the shift planner to primarily remove the very high overload (i.e., red), and secondly, the high overload (i.e., orange) from the shift schedule draft (Härmä et al., 2022). To remove the possible red and orange warnings, each of the shift characteristic had to be handled separately. The reduction of "increased load" (i.e., yellow) depends more on ward and organization level practices and organization-specific prioritization in scheduling.

The evaluation and possible schedule modifications were done individually, but the information on the use of the tool (in minutes) was based on the ward level use of the tool by the shift planner. Only the use time of the evaluation tool, including simultaneously at least one modification during the same scheduling session, were calculated for the annual use of the tool.

We defined two distinct interventions: 1) utilizing the tool for at least 1 minute and 2) utilizing the tool for at least 10 minutes. Employees of a ward were included in the intervention group (IG) if the shift planner had utilized the shift schedule evaluation tool with ergonomics recommendations during a year. To be classified as utilization of the tool, actual changes needed to be made to the shift plan in the same session. The control group (CG) was formed from the wards where the shift planner had not used the shift schedule evaluation tool with ergonomics recommendations (intervention 1) or had used it for 0–9 minutes (intervention 2).

### 2.4. Outcome variables

The average 24-h sleep duration was surveyed with the question "How many hours do you normally sleep during 24 h?" (Vahtera et al., 2006). Long sleepers (>9h, n = 290) were excluded. We defined short sleep as sleep with a duration of 6.5 h or less (Shiri et al., 2023). Sleep difficulties were surveyed with four questions from the Jenkins Sleep Scale (difficulties falling asleep, waking up several times per night, difficulties staying asleep, and feeling tired and worn out after waking up after the usual amount of sleep) with six response options from "not at all" to "every day" (Jenkins et al., 1988). The answers were dichotomized as having sleep difficulties if the frequency of any of the sleep difficulties was at least 2–4 times per week. Psychological distress was assessed with the General Health Questionnaire-12 (Goldberg and Williams, 1988) and utilized both as a continuous and binary variable, the latter with a cut point at GHQ-12 score above three (Cheng et al., 2021). Poor work ability was assessed with a single item compared to lifetime best work ability (Tuomi et al., 2001) and defined as a current work

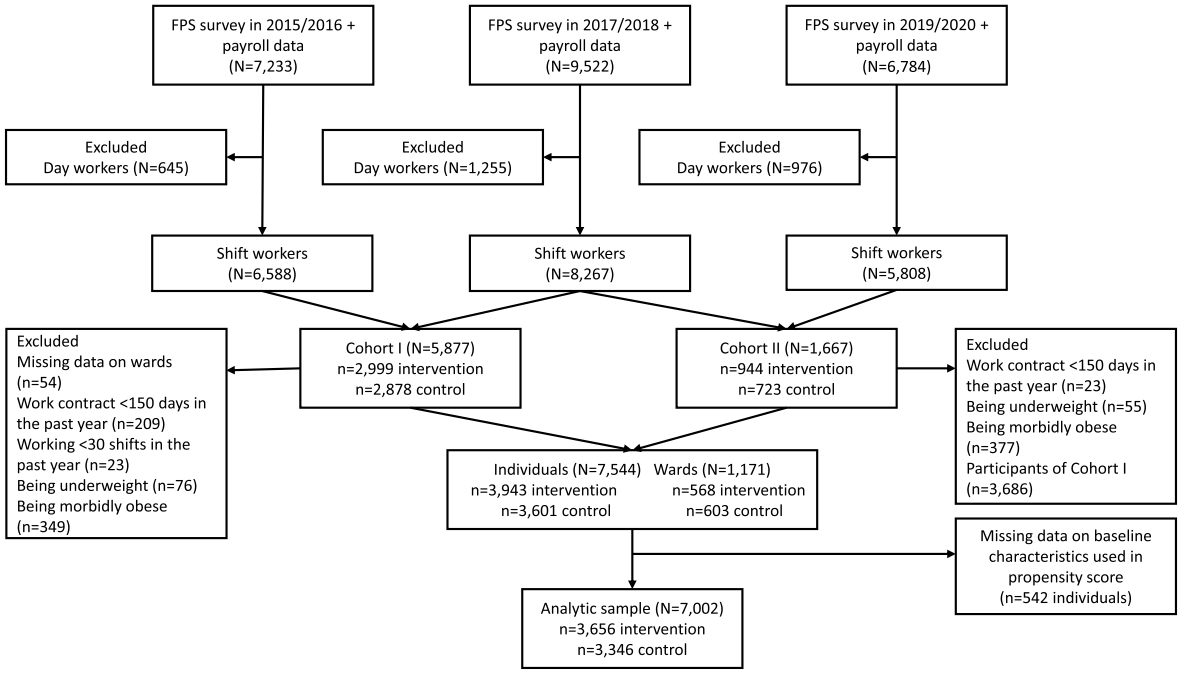


**Fig. 1.** Flow chart of the study.

ability score of 5 or less (Kinnunen and Nätti, 2018). Perceived health was rated on a five-point scale from good to poor (Blaxter, 1987) and was defined as poor when rated as "rather poor" or "poor" (Shiri et al., 2021). Both the perceived health and work ability were also included as continuous variables.

### 2.5. Covariates

We assessed the following work-related factors as covariates: type of work contract (full-time or part-time), tenure at the current job (years as a continuous variable), supervisory role, participation in professional training in the past two years, unpredictable and excessive amounts of workloads that exceed one's capacity and being a victim workplace bullying or mental violence (Ervasti et al., 2022). Worktime control was assessed as a continuous variable from the Ala-Mursula scale (Ala-Mursula et al., 2002). Job demands were measured using three items in the 2015/2016 surveys and five items in the 2017/2018 surveys (Ervasti et al., 2023). To standardize the scores, we divided the 2017/2018 scores by 1.67 to achieve a similar mean and range. Job control was measured using nine items (Karasek et al., 1998).

The following baseline working hour characteristics were included as covariates in the propensity score for balancing: proportion of >6 consecutive daily work shifts (continuous), the average number of consecutive night shifts (continuous), % of >2 consecutive night shift spells (continuous), the average number of consecutive evening shifts (continuous), % of >4 consecutive evening shift spells (continuous), the average time between work shifts (hour, continuous), % of shift intervals of <11 h (continuous), % of the maximum of the weekly recovery period (<48h, continuous), % of single free days (continuous), average weekly working hours during the year (continuous), the average length of all shifts during the year in hours (continuous), % of >12 h shifts (continuous), % of >10-h night shifts (continuous), % of realized shift wishes (continuous), and time (cohort I vs. cohort II).

We utilized various demographic and lifestyle factors as covariates, including age (both as categorized into five groups and as a continuous variable in years), sex, body mass index (continuous), marital status, having a child/children under seven years old or 7–18 years old living in the same household. Smoking status was categorized into never-smokers, former smokers, and current smokers (Heikkilä et al., 2012). We also inquired about alcohol consumption, including the weekly frequency of beer and wine intake, and the monthly frequency of spirit intake, and converted that as alcohol portions equivalent to 12 g of alcohol per week (Ervasti et al., 2018). Information on passing out after drinking alcohol in the past 12 month was also inquired. Additionally, we assessed leisure-time physical activity over the past year, considering four intensity levels: 1) walking, 2) brisk walking, 3) jogging, and 4) running. To quantify overall physical activity, we calculated a metabolic equivalent (MET) index by multiplying the MET value of each activity intensity by the time spent on that activity and summing up the METs across the four activities (Shiri et al., 2020a).

### 2.6. Ethical issues

All the municipalities and hospital districts made a co-operation contract with the FIOH which enabled the use of employers' register data for research. The working time data containing personal data was transferred to the FIOH data manager using password-protected Share-File file-sharing software. All data was pseudonymized before analysis. The study was approved by the ethics committee of the Helsinki and Uusimaa hospital district (HUS/1210/2016), and international ethical standards were conformed. The study was not preregistered with an analysis plan in an independent institutional registry.

### 2.7. Statistical analysis

Data on worktime control, number of years of shift work, alcohol intake, job demands, job control, and percentage of weekend work had a few missing values, ranging from 2 % to 5 %. The payroll data on the annual average length of weekly working hours had a higher rate of missing values at 15 %. All missing values for these continuous variables were replaced with the sample mean values.

We employed logistic regression to calculate the propensity score for each ward and multilevel mixed-effects logistic regression to calculate the propensity score for each participant applying the intention-to-treat approach. Multilevel mixed-effects logistic regression accounted for employees clustered within wards. The propensity score represented the probability of receiving an intervention, defined as using the shift schedule evaluation tool. Our regression models incorporated the

outcome variables (sleep duration, sleep difficulties, psychological distress, perceived health, and work ability), the above-mentioned work-related, demographic, and lifestyle factors, cohort (I vs. II), and hospital districts/municipalities. Because of multicollinearity (the variance inflation factor >5), the number of consecutive night shifts, length of night shifts (hours), percentage of long spells of consecutive night shifts, and shift length (hours) were excluded from the propensity scores. For each ward, we calculated the mean values of the participants' characteristics.

We employed the inverse probability of treatment weight (IPTW), calculated using the propensity score, and assigned weights based on the likelihood of an employee using the shift schedule evaluation tool. To enhance stability and minimize bias, we stabilized the IPTW (Xu et al., 2010). Extreme weights (>3.0) were excluded from the analysis (Chesnaye et al., 2022). We removed the seven participants with extreme IPTW from the total sample, resulting in IPTW values between 0.53 and 3.0. We also removed the 16 participants with extreme IPTW from the municipal employees, resulting in IPTW values between 0.49 and 3.0, and 4 wards with extreme IPTW.

We also computed propensity scores and weights separately for hospital and municipal employees, as well as for two age groups divided by the median distribution. For comparing outcomes of interest between the intervention and control groups, we employed a generalized linear model. For binary outcomes, we used a binomial distribution and a log link function, applying the inverse probability of treatment weight as a weighting factor. To assess the baseline characteristics balance between the groups, we compared unweighted and weighted prevalence rates and mean values of these variables (Austin and Stuart, 2015). All analyses were conducted using Stata (StataCorp LLC, Texas, USA), version 18.0.

## 3. Results

### 3.1. Use of the shift schedule evaluation tool

The shift schedule evaluation tool was used for at least a minute by a ward shift planner in 568 (48.5 %) of 1171 wards with 7544 employees (52.3 % in the wards in the IG) for whom we had data on both the tool and the wellbeing outcomes. The tool was used for at least 10 minutes in 200 wards (17.1 %) with 1306 employees (17.3 % in the wards in the IG). Of the participants, 43 % were 50 years or older, 88 % were female, and 70 % worked for the municipalities.

We observed a statistically significant difference in the use of the tool between cohort I and cohort II ($P < 0.001$). The tool was used by 51 % of Cohort I and 57 % of Cohort II. We also observed a statistically significant difference in the use of the tool between shift planners in the municipalities and hospital districts (54 % vs. 48 %, $P < 0.001$). The tool was used by the shift planners in the municipal wards for an average duration of 92 minutes (SD = 367), whereas the shift planners in the hospital districts s used it for an average duration of 7 minutes (SD = 22). The tool was used in all the annual three-week periods in 97 % of the cases.

### 3.2. Associations between the use of the shift schedule evaluation tool and outcomes

We analysed data from the 7002 employees who had complete information on the shift schedule evaluation tool, baseline covariates, and outcomes at both the baseline and the follow-up. The IPTW method balanced the baseline characteristics of employees in the intervention group (IG) and employees in the control group (CG), defined using the shift schedule evaluation tool by the shift planner of the ward (Table 1).

At the ward level, we observed no associations between use of the shift schedule evaluation tool for at least 1 minute and perceived health, work ability, sleep problems, and psychological distress as compared to no use. The results were similar in intervention 2, where the use was defined as at least 10 minutes (Table 2).

At the individual level (Table 3), in the total sample, the proportion of employees who had psychological distress at the follow-up was 26 % among those in the IG and 28 % among those in the CG. The relative risk was 8 % lower in the IG than the CG (risk ratio [RR] = 0.92, 95 % confidence interval [CI] 0.85−0.99, Table 3). Among the municipal employees in the IG, the relative risk was 9 % lower for psychological distress than the CG (RR = 0.91, 95 % CI 0.83–0.99, as shown in Table 3). No other differences between the IG and the CG were observed. The results were similar for employees <47 years of age and those aged ≥47 years, i.e., in neither of these two groups the use of the shift

**Table 1**
Comparison of the baseline characteristics according to the shift planners' shift schedule evaluation tool use (no vs. yes) in the weighted samples, proportions (%) and means ± SD.

| Characteristic | Intervention group (N = 3656) | | Control group (N = 3346) | |
|---|---|---|---|---|
| | % | | % | |
| Female sex | 88.3 | | 88.4 | |
| Age (years) | | | | |
| 20-29 | 11.7 | | 11.8 | |
| 30-39 | 20.4 | | 20.2 | |
| 40-49 | 25.3 | | 25.5 | |
| 50-59 | 33.7 | | 33.6 | |
| ≥60 | 8.9 | | 8.9 | |
| Marital status | | | | |
| Unmarried | 19.7 | | 19.6 | |
| Married or cohabiting | 59.6 | | 59.8 | |
| Divorced or separated | 17.0 | | 17.0 | |
| Widowed | 3.7 | | 3.6 | |
| Smoking | | | | |
| Past | 25.3 | | 25.3 | |
| Current | 22.1 | | 22.0 | |
| Part-time work contract | 6.7 | | 6.9 | |
| Working time arrangement | | | | |
| Shift work without night shifts | 44.4 | | 44.4 | |
| Shift work including night work | 51.6 | | 51.6 | |
| Permanent night work | 2.1 | | 2.1 | |
| Other irregular shift schedule | 1.9 | | 1.9 | |
| Perceived health | | | | |
| Good | 38.3 | | 38.3 | |
| Rather good | 38.3 | | 38.4 | |
| Average | 19.5 | | 19.5 | |
| Rather poor or poor | 3.9 | | 3.8 | |
| Current work ability | | | | |
| Good (score ≥8) | 73.4 | | 73.3 | |
| Poor (score ≥5) | 6.8 | | 6.8 | |
| Sleep duration (hours) | | | | |
| <6.0 | 14.0 | | 13.9 | |
| 6.5 | 15.1 | | 15.0 | |
| 7.0 | 28.4 | | 28.6 | |
| 7.5 | 16.5 | | 16.5 | |
| 8.0 | 17.6 | | 17.6 | |
| ≥8.5 | 8.4 | | 8.4 | |
| Psychological distress (GHQ-12) | 24.4 | | 24.6 | |
| | **Mean** | **SD** | **Mean** | **± SD** |
| Age (years) | 45.23 | (±11.12) | 45.23 | (±11.20) |
| Body mass index | 26.36 | (±4.46) | 26.36 | (±4.47) |
| Physical activity (MET) | 37.36 | (±31.32) | 37.50 | (±32.21) |
| Weekly working hours | 28.85 | (±9.34) | 28.87 | (±9.25) |
| Number of years working at the current job | 12.17 | (±9.87) | 12.12 | ±9.62) |
| Work ability | 8.07 | (±1.53) | 8.07 | (±1.53) |
| Sleep difficulties (Jenkins Sleep scale) | 2.72 | (±1.22) | 2.72 | (±1.22) |
| Psychological distress (GHQ-12) | 2.27 | (±3.08) | 2.28 | (±3.07) |
| Job demands | 10.23 | (±2.41) | 10.22 | (±2.40) |
| Job control | 31.78 | (±4.46) | 31.81 | (±4.61) |
| Worktime control (Ala-Mursula scale) | 18.54 | (±4.58) | 18.53 | (±4.52) |
| Average shift length (hours) | 8.31 | (±0.70) | 8.31 | (±0.72) |
| Average time between work shifts (hours) | 15.51 | (±0.83) | 15.52 | (±0.85) |
| Average number of consecutive night shifts | 1.40 | (±1.38) | 1.39 | (±1.36) |

**Table 2**
The effects of utilizing a shift schedule assessment tool on perceived health, work ability, sleep problems, and psychological distress (continuous outcomes) at the ward-level.

| Outcome | Intervention group wards | | Control group wards | | Difference | 95 % CI | P |
|---|---|---|---|---|---|---|---|
| | N | Mean ± SD | N | Mean ± SD | | | |
| *The tool use for ≥1 min* | | | | | | | |
| *Total sample* | | | | | | | |
| Perceived health | 559 | 1.98 ± 0.43 | 575 | 1.99 ± 0.45 | −0.01 | −0.06, 0.04 | 0.63 |
| Work ability | 559 | 7.87 ± 0.82 | 575 | 7.86 ± 0.84 | 0.01 | −0.08, 0.11 | 0.78 |
| Psychological distress | 559 | 2.44 ± 1.63 | 575 | 2.57 ± 1.75 | −0.13 | −0.33, 0.06 | 0.18 |
| Sleep difficulties | 559 | 2.81 ± 0.63 | 575 | 2.80 ± 0.63 | 0.01 | −0.06, 0.09 | 0.70 |
| *Municipalities* | | | | | | | |
| Perceived health | 474 | 1.98 ± 0.45 | 457 | 1.99 ± 0.46 | −0.01 | −0.07, 0.05 | 0.68 |
| Work ability | 474 | 7.88 ± 0.82 | 457 | 7.87 ± 0.84 | 0.01 | −0.10, 0.11 | 0.90 |
| Psychological distress | 474 | 2.43 ± 1.63 | 457 | 2.57 ± 1.80 | −0.14 | −0.36, 0.08 | 0.21 |
| Sleep difficulties | 474 | 2.81 ± 0.65 | 457 | 2.81 ± 0.65 | 0.00 | −0.09, 0.08 | 0.92 |
| *The tool use for ≥10 min* | | | | | | | |
| *Total sample* | | | | | | | |
| Perceived health | 198 | 2.00 ± 0.39 | 953 | 1.99 ± 0.48 | 0.01 | −0.06, 0.09 | 0.68 |
| Work ability | 198 | 7.85 ± 0.75 | 953 | 7.87 ± 0.91 | −0.02 | −0.16, 0.12 | 0.79 |
| Psychological distress | 198 | 2.47 ± 1.57 | 953 | 2.56 ± 1.87 | −0.09 | −0.37, 0.19 | 0.53 |
| Sleep difficulties | 198 | 2.82 ± 0.59 | 953 | 2.81 ± 0.66 | 0.01 | −0.09, 0.11 | 0.89 |
| *Municipalities* | | | | | | | |
| Perceived health | 180 | 1.98 ± 0.39 | 765 | 1.98 ± 0.49 | −0.00 | −0.08, 0.08 | 0.92 |
| Work ability | 180 | 7.88 ± 0.78 | 765 | 7.89 ± 0.91 | −0.01 | −0.16, 0.14 | 0.87 |
| Psychological distress | 180 | 2.34 ± 1.60 | 765 | 2.54 ± 1.85 | −0.20 | −0.50, 0.10 | 0.19 |
| Sleep difficulties | 180 | 2.77 ± 0.61 | 765 | 2.81 ± 0.67 | −0.03 | −0.14, 0.07 | 0.53 |

schedule evaluation tool was related to the perceived wellbeing outcomes.

## 4. Discussion

We aimed to investigate whether the use of a shift schedule evaluation tool with ergonomic recommendations influences the wellbeing of the public sector's social and healthcare workers. We observed no associations between the use of the shift schedule evaluation tool and employee wellbeing at the ward level. On the individual level, there was, however, a slightly smaller risk of psychological distress among the employees in the IG, whose shift planner had used the shift schedule evaluation tool, compared to the CG, with no use. The result remained the same in the stratified analysis, including municipal employees only.

To the best of our knowledge, this is among the first studies that have investigated the effects of a shift schedule evaluation tool with ergonomics recommendations embedded in a shift scheduling software on perceived wellbeing. An earlier study based on the same data but focusing on occupational accidents found that the incidence of dislocations, sprains, and strains was lower among employees whose schedules had been checked with the evaluation tool (Shiri et al., 2023). Moreover, among the municipal employees, whose shift planner had used the shift schedule evaluation tool three times longer than the hospital employees, the use of the tool was associated with a reduction in the incidence of all workplace injuries.

Previously, good shift ergonomics in the healthcare sector has been implemented and studied via the use of binding ergonomic shift scheduling rules (Karhula et al., 2021) and different types of working time interventions in the workplaces (Hakola et al., 2010; Järvelin-Pasanen et al., 2013). These studies have found positive results on sleep, alertness, and perceived health (Hakola et al., 2010) and increased parasympathetic tone in heart rate variability (Järvelin-Pasanen et al., 2013) or a buffering effect on worsening of sleep by increasing age (Karhula et al., 2021). In our earlier studies based on the FPS cohort, employee-level changes in sleep, fatigue, and work-life interaction were associated with several changes in the working hour characteristics (Härmä et al., 2018; Karhula et al., 2018).

The fact that we found only weak associations between the use of the tool and wellbeing measures in this study might be associated with the insufficient use of the shift schedule evaluation tool and an insufficient sample size. Even though the average time of using the tool during a year was 69 minutes, the distribution of the use in minutes was skewed, and therefore, the IG needed to be defined by the minimum of at least 1 min or at least 10 minutes of use of the tool by the shift planner. The IG thus represents a higher use than the CG but not necessarily a sufficiently long use of the tool.

At the higher level (at least ten minutes) of the use of the tool, the sample size dropped, giving lower power than at the level of at least 1 minute of use of the evaluation tool. On the other hand, the tool preserves information on the use of the evaluation tool only if changes were made to the shift schedule. Thus, in practice, if there was no need for changes in the shift schedule, no information was saved on the evaluation even if the evaluation tool had been used. Furthermore, a possibility is that even if the shift planner uses the tool, he/she may have made only minor changes to the shift schedules. This is likely especially in the hospital districts, where the changes in working hour characteristics were minor in our earlier study (Härmä et al., 2022). Some of the shift scheduling recommendations were also unpopular with a part of the employees, such as the avoidance of long shifts (Härmä et al., 2022), as it reduces longer spells of time off that employees themselves often prioritize (Barnes-Farrell et al., 2008). Having good worktime control is also positively associated with employee wellbeing, namely perceived health (Beckers et al., 2012).

The shift planners' use of the shift scheduling evaluation tool was based on evaluating and possibly correcting the shift schedule draft if the employees' planned schedule did not fulfil the FIOH recommendations. The focus was targeted on the correction of the most hazardous shift characteristics, providing "a red-light signal" for the shift and the employee. Since the information on the use of the tool was based on the ward level cumulative time of the shift planner, but the evaluation itself was done on an individual level, we analysed the results on both the ward and individual levels. Since the percentage of the employees and shifts with the hazardous (red) shifts had been normally low in the FPS data (<5 %) (Härmä, 2019), the possible modifications during the shift schedule evaluation sessions have focused, in practise, on few persons. This could possible explain why the ward level results, summarizing the changes in wellbeing over all employees, were more insignificant than the individual level results. Further on, whether the shift recommendations and instructions for the removal of the hazardous shift characteristics after the evaluation are followed in practise, may depend on the

**Table 3**
The effects of utilizing the shift schedule evaluation tool with ergonomics recommendations at individual level. The two age groups were divided by the median. Perceived poor health, poor work ability, short sleep, sleep problems, and psychological distress, with binary outcomes. Risk ratios and their 95 % Confidence intervals are presented.

| Outcome | Intervention group participants | | Control group participants | | RR | 95 % CI |
|---|---|---|---|---|---|---|
| | N | % of outcome | N | % of outcome | | |
| *The tool use for ≥1 min* | | | | | | |
| *All participants* | | | | | | |
| Poor perceived health | 3634 | 4.8 | 3327 | 5.6 | 0.87 | 0.71–1.06 |
| Poor work ability | 3629 | 8.0 | 3324 | 8.9 | 0.89 | 0.76–1.04 |
| Short sleep (≤6.5h) | 3461 | 13.8 | 3196 | 13.4 | 1.03 | 0.91–1.17 |
| Sleep difficulties | 3607 | 58.5 | 3302 | 59.2 | 0.99 | 0.95–1.03 |
| Psychological distress | 3636 | 25.9 | 3330 | 28.2 | 0.92 | 0.85–0.99 |
| *<47 years* | | | | | | |
| Poor perceived health | 1825 | 5.0 | 1613 | 6.4 | 0.77 | 0.59–1.02 |
| Poor work ability | 1824 | 8.1 | 1610 | 9.3 | 0.87 | 0.70–1.08 |
| Short sleep (≤6.5h) | 1741 | 14.7 | 1544 | 14.0 | 1.06 | 0.89–1.25 |
| Sleep difficulties | 1810 | 60.0 | 1602 | 58.3 | 1.03 | 0.97–1.09 |
| Psychological distress | 1829 | 26.6 | 1614 | 28.8 | 0.92 | 0.83–1.03 |
| *≥47 years* | | | | | | |
| Poor perceived health | 1807 | 4.8 | 1712 | 4.7 | 1.02 | 0.76–1.37 |
| Poor work ability | 1803 | 7.9 | 1712 | 8.7 | 0.91 | 0.73–1.14 |
| Short sleep (≤6.5h) | 1718 | 13.0 | 1651 | 13.3 | 0.98 | 0.82–1.16 |
| Sleep difficulties | 1795 | 57.6 | 1698 | 60.3 | 0.96 | 0.90–1.01 |
| Psychological distress | 1805 | 25.1 | 1714 | 27.4 | 0.92 | 0.82–1.02 |
| *Municipalities* | | | | | | |
| Poor perceived health | 2693 | 4.4 | 2274 | 5.4 | 0.81 | 0.63–1.04 |
| Poor work ability | 2686 | 8.0 | 2273 | 8.8 | 0.91 | 0.76–1.10 |
| Short sleep (≤6.5h) | 2568 | 13.3 | 2184 | 13.9 | 0.95 | 0.83–1.10 |
| Sleep difficulties | 2670 | 58.8 | 2259 | 59.5 | 0.99 | 0.94–1.04 |
| Psychological distress | 2694 | 25.6 | 2277 | 28.2 | 0.91 | 0.83–0.99 |
| *The tool use for ≥10 min* | | | | | | |
| *All participants* | | | | | | |
| Poor perceived health | 1215 | 4.5 | 5798 | 5.2 | 0.87 | 0.65–1.15 |
| Poor work ability | 1214 | 7.5 | 5791 | 8.6 | 0.88 | 0.71–1.09 |
| Short sleep (≤6.5h) | 1162 | 13.4 | 5545 | 13.4 | 1.00 | 0.85–1.18 |
| Sleep difficulties | 1201 | 59.3 | 5760 | 58.8 | 1.01 | 0.96–1.06 |
| Psychological distress | 1212 | 25.7 | 5806 | 27.3 | 0.94 | 0.85–1.05 |

internal administrative decisions, coaching, and other intra-organizational practises (Härmä et al., 2022).

A strength of this study is its analysis of the longitudinal data as a quasi-experiment. This statistical approach helped balance the distribution of measured baseline covariates between users and non-users of the shift scheduling ergonomics tool, making the two groups more comparable, like a randomized controlled trial (Shiri et al., 2020b). Utilizing propensity score weighting reduced confounding and selection bias, resulting in a less biased comparison between the intervention and control groups. This rigorous methodology significantly enhanced the internal validity of the study compared to previous observational studies.

Further on, we utilized objective data from the shift scheduling software, including the data on the use of the shift schedule evaluation tool with ergonomic recommendations by the shift planner and each employee's objective working hour data. We were also able to utilize a comprehensive survey data on demographic, lifestyle, and work-related factors. Finally, the large sample of social and health care workers and the relatively long follow-up time were a strength of this study.

There are also limitations to be discussed. Even though we had data on the use of the evaluation tool and the realized shift schedules, we did not have exact information on which changes to which schedule were made to the shift schedule drafts based on the evaluation tool. Due to this reason and the fact that a shift planner needs to consider several operational factors as well, including, e.g., having more senior employees and required competencies, e.g., authorisation to administer IV (intravenous) medication in each shift, the analysis on ward level sought to answer the research question at the ward level.

Additionally, there was a difference between the municipalities and hospital districts in the average time used using the tool, a difference that we have indicated previously (Härmä et al., 2019). In the municipalities, the wards and employees were largely from other municipalities than the intervention wards and employees. Therefore, there may have been differences in the working conditions that our comprehensive survey questions have not addressed. In the hospital districts, both the controls and the intervention participants were from the same organizations. Due to the smaller number of employees in the intervention 2, stratification by age was not feasible. The limited number of users would have resulted in low statistical power, thus making age-based subgroup analysis unreliable.

Further studies should investigate whether the shift planners' more rigorous use of the shift schedule evaluation tool, combined with proper organizational support for good shift ergonomics, would change the perceived wellbeing more systematically. It would also be relevant to study age-group-specific effects, as large age-related differences in working hour characteristics are detected in the FPS data (Ropponen et al., 2020), and it could be assumed that the older employees with increased need for recovery and risk for sleep difficulties would likely benefit more from having schedules that follow ergonomic shift scheduling.

## 5. Conclusion

Although the use of the shift schedule evaluation tool with ergonomic recommendations by shift planners was not associated with perceived wellbeing at the ward level, an association was observed with lower psychological distress at the individual level. More rigorous use of the tool may be needed to achieve significant wellbeing effects, especially at the ward level.

## CRediT authorship contribution statement

**Kati Karhula:** Writing – original draft, Methodology, Investigation, Funding acquisition, Conceptualization. **Rahman Shiri:** Writing – original draft, Formal analysis, Data curation. **Jenni Ervasti:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Aki Koskinen:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Annina Ropponen:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Mikael Sallinen:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization. **Jarno Turunen:** Writing – review & editing, Methodology, Investigation, Funding acquisition,

Conceptualization. **Mikko Härmä:** Writing – review & editing, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

## Data availability statement

The research data are not publicly available due to privacy and ethical restrictions. Research data are not available on request from the authors or FIOH due to written agreements with the register data owners (the hospital districts and municipalities) not to forward any data to third parties.

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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