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National recommendations for shift scheduling in healthcare: A 5-year prospective cohort study on working hour characteristics

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ABSTRACT

Background: National recommendations to decrease the health and safety risks of working hours are often given based on the increasing knowledge of the associations between working hour characteristics and health. However, the utilization of the recommendations, and their potential to change the actual working time patterns in healthcare sector is unclear.
Objective: We investigated the extent to which the national recommendations are utilized in shift scheduling, when they are integrated as a shift schedule evaluation tool into the shift scheduling software. Second, we examined whether the use of the tool results in changes that are in line with the recommendations.
Design: A prospective cohort study with a 5-year follow-up.
Participants: A total of 36,663 healthcare workers with objective data on daily working hours in 10 hospital districts and 6 large cities.
Methods: We investigated the annual use of the evaluation tool, and the effects of using the tool on annual changes in working hour characteristics from 2015 to 2019 while adjusting for the hierarchical structure of the data, age, sex, shift work, night work, work contract days and the type of shift scheduling software. Utilizing intention-to-treat principle, the employees in wards using the tool were compared to non-users by multi-level generalized linear models.
Results: Continuous use (during at least 10 scheduling periods) of the evaluation tool increased from 2% in 2015 to 20% in 2018. In the fully adjusted model, the use of the evaluation tool was associated with the decrease of >6 consecutive workdays (OR 0.73, 95% CI 0.66, 0.81), >4 consecutive night shifts (OR 0.86, 95% CI 0.77, 0.95), and proportion of <11-hour shift intervals (difference 0.63, 95% CI 0.43, 0.83). The proportion of single days off (difference 0.33, 95% CI 0.15, 0.51), and >40-hour work weeks (OR 1.16, 95% CI 1.10, 1.22), as well as the proportion of ≥12-hour work shifts (OR 1.22, 95% CI 1.07, 1.38) increased. Realized shift wishes decreased (difference 0.76, 95% CI 0.12, 1.41). The use of the tool was associated with more frequent changes towards the recommendations in the cities compared to the hospital districts, and among the older age groups compared to the ≤30-year-old employees.
Conclusions: National recommendations embedded in the shift schedule evaluation tool were used continuously by one fifth of the employees, and were associated with several, albeit modest changes towards the given recommendations. Changes in working hour characteristics depended on organization indicating for differences in the implementation of the recommendations.
Tweetable abstract: The national recommendations for safer working hour characteristics embedded in a shift schedule evaluation tool are associated with several, albeit modest changes in working hour characteristics.

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What is already known

- Several strenuous working hour characteristics such as night work, excessive working hours, and insufficient recovery time between the shifts are associated with increased safety and health risks in healthcare sector.

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- Based on existing knowledge, recommendations for safer working hours are often given but their use or effects have not been studied.

What this paper adds

- During the five-year follow-up, national recommendations for safer working hours patterns embedded in a shift schedule evaluation tool were used continuously by one fifth of the employees.
- The use of the tool was associated with several, albeit modest changes towards the given recommendations.

1. Background

In Europe, over 20% of employees are shift workers and 19% work at night-time at least once a month. Shift work is defined by the ILO and the European Directive 2003/88/EC as "a method of organizing working time in which workers succeed one another so that the establishment can operate longer than the hours of work of individual workers". The number of shifts (intensity), type of shifts (e.g., morning, evening and night), and the organization of consecutive work shifts (e.g., rapidly or slowly rotating shift work) can vary between or within different shift systems (Härmä et al., 2015; IARC, 2020; Kecklund and Axelsson, 2016; Neil-Sztramko et al., 2014). Regulatory approaches related to national working time acts and collective or local agreements are often used to protect employees from the potential health hazards of strenuous working hours (Gärtner et al., 2019; Ropponen et al., 2017). In addition to legal regulations, recommendations are often given to decrease the health and safety risks (Garde et al., 2020; Neil-Sztramko et al., 2014; Wong et al., 2019). However, the use or effects of voluntary recommendations has not been studied.

Shift work has well-known associations with disturbed sleep and fatigue, and an increased risk for several acute and chronic health impairments. Research has been active among healthcare workers (Bigert et al., 2021; Dall'Ora et al., 2016; Garde et al., 2020; Griffiths et al., 2014; Härmä et al., 2018; Kader et al., 2022; Karhula et al., 2017; Nielsen et al., 2019; Tucker et al., 2021). The established risks include both safety, i.e., occupational injuries (Dembe et al., 2006; Nielsen et al., 2019; Wagstaff and Sigstad Lie, 2011), and health, e.g. miscarriage (Begtrup et al., 2019; Kader et al., 2022), cardiovascular diseases (Bigert et al., 2021; Vyas et al., 2012) and cancer (Cordina-Duverger et al., 2018; IARC, 2020). Individual factors, such as current work-life situation, age, gender and chronotype can modify the health effects of shift work among nurses (Härmä, 1993; López-Soto et al., 2019). Female nurses with an evening-oriented chronotype and aging employees seem to suffer more on insomnia and fatigue at work (Cheng et al., 2021; López-Soto et al., 2019; Tucker et al., 2021).

The current knowledge on the association of specific working hour characteristics and health status among the healthcare workers has increased due to the use of detailed payroll data of working hours (Bigert et al., 2021; Garde et al., 2020; Griffiths et al., 2014; Härmä et al., 2018; Kader et al., 2022; Tucker et al., 2021). The growing evidence suggests that, e.g., the number of several consecutive night shifts and short recovery between the shifts should be limited, and very long work shifts should be avoided to prevent the health and safety risks (Garde et al., 2020; Griffiths et al., 2014; Kecklund and Axelsson, 2016). While the knowledge on the association of specific working hour characteristics with health risks is yet on inadequate level, the existence of potential associations in some serious risks, like breast cancer (IARC, 2020), emphasize the demand on initialization of preventive actions (Bonde et al., 2012). Based on this need, and in addition to the legislative limitations for excessive working hours, voluntary recommendations have been given to prevent the health and safety risks of shift work and long working hours (Bonde et al., 2012; Garde et al., 2020; Wong et al., 2019). Since aging is more frequently associated with insomnia, chronic health problems and increased need for recovery, the improvement of working hours among the aging employees has often been highlighted (Ritonja et al., 2019; Tucker et al., 2021).

Whether the given recommendations on working hours, without legal obligations, are possible to modify the work schedules in practice, is not yet clear and not much studied. In our previous study, implementing binding ergonomic shift scheduling rules resulted in reduction in, e.g., short shift intervals (Karhula et al., 2021). Any recommendations on work scheduling probably should be sufficiently precise, and accessible during the shift scheduling process to facilitate their application.

In hospitals, the shift planner, often the nurse manager of the ward, faces a demanding task while aiming to fit sufficient staffing and their required qualifications into a work schedule following simultaneously the legislative restrictions and possible personal and other preferences. One option to support shift scheduling process towards the available recommendations to decrease the health risks of shift work and excessive working hours is to place the recommendations in the daily work scheduling process.

We investigated the extent to which the national recommendations are utilized in shift scheduling when they are integrated as an evaluation tool into the shift scheduling software. Second, we examined whether the use of the evaluation tool resulted in changes that are in line with the given recommendations. Our hypothesis was that an active use of the evaluation tool against the given recommendations will change the work schedules towards the given recommendations. Third, we analyzed whether the type of organization and age of employees played a role in the use of the recommendations. All these questions were examined utilizing daily working hours in a national prospective cohort of healthcare workers.

2. Methods

2.1. Study population

The study population is based on the ongoing Working Hours in the Finnish Public Sector (WHFPS) study (Härmä et al., 2015; Karhula et al., 2020; Shiri et al., 2021) with payroll data of working hours at earliest since 2000. The current sample of employees comprises of a dynamic cohort of the WHFPS healthcare workers who worked in one of the 10 hospital districts or 11 cities and used Titania® shift scheduling software during 2015 (baseline, n = 80,364) (Fig. 1). At baseline, 61% (76% in hospital districts and 45% in cities) of the population were registered nurses. The sample included also many other healthcare occupations (e.g. practical nurses, laboratory nurses, department secretaries and hospital cleaners), the practical nurses being the second largest group. Hospital districts were responsible for special healthcare services and have both out-patient clinics and in-patient hospital wards. The healthcare workers of the cities were responsible of the primary healthcare, including, e.g., the operation of health centers, and hospitals for elderly and chronically ill citizens needing 24/7 care. In addition, the healthcare workers of the cities provided home care to disabled citizens.

We excluded administrative employees and physicians without period-based work used by the healthcare workers (n = 11,438). Secondly, we excluded employees without information on the use of the specific work schedule evaluation tool including national recommendations and embedded into the Titania® shift scheduling software (see later, n = 36,776, five cities). These employees did not use the tool, or information on the use of the tool or adherence to the national recommendations for shift scheduling was not available. Finally, we excluded employees with less than 31 work shifts (n = 2185) during each year to get sufficient information on the average annual working hour characteristics. The final sample of this open cohort included 29,968 workers in 16 organizations (Table 1) in 2015 and increased to 35,663 in 2018 and 10,464 lost to follow in 2019 (N = 25,199 in 2019). Altogether 56% of the sample worked at baseline in hospital districts and 44% in cities, 88% were women and 12% men.

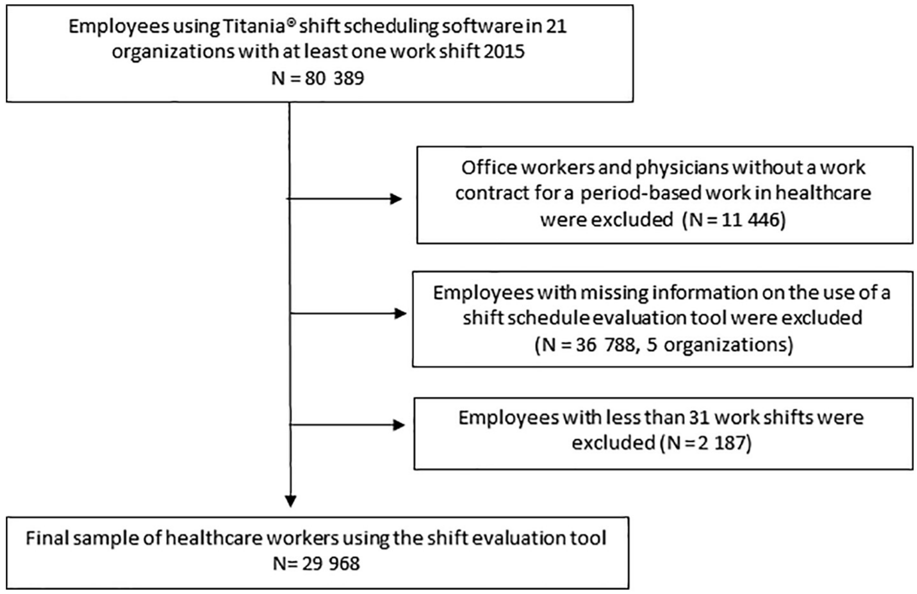

Fig. 1. The flow chart of the selection of the study participants.

2.2. Study design

We analyzed this 5-year prospective cohort study like a stepped wedge randomized controlled trial design (Hughes et al., 2015) to investigate the effects of embedding national recommendations in the shift schedule evaluation tool on the changes of working hour characteristics during the years 2015–2019. For each year (2015, 2016, 2017, 2018 and 2019) the users of the shift schedule evaluation tool of the shift scheduling software were defined as the intervention group and non-users of the tool in that year as the control group. The working hour characteristics (see below) of users were compared with those of non-users. When the evaluation tool including the recommendations was used during at least 10 different 3-week scheduling periods of the year, the employees of that ward were included in the intervention group in the upcoming years irrespective of the amount of future use of the evaluation tool.

2.3. Data sources

The retrieval of daily payroll-based registry data of working hours and the use of the shift evaluation tool were based on the use of the shift scheduling program Titania ® (CGI Finland Ltd) in all the 16 organizations. The data included the daily starting and ending times of all work shifts, and the minutes and timing of the used shift evaluation tool. The data were available from all organizations to the end of 2018, but only from the hospital districts to the end of 2019.

Based on the information on the starting and ending times of the work shifts, working hours were classified as early morning, morning, evening, and night shifts. Night shifts were defined as ≥3 h between 23:00–06:00 h; early morning shifts as work starting 03:00–05:59 and ending before 18:00 h and not categorized as night shifts; morning shifts as work starting 06:00–08.00 and ending by 18:00 h; evening shifts as any time between 18:00–23:00 and not categorized to night shifts. If time between two shifts was less than 1 h, the two shifts were combined. Based on the classified work shifts, annual working hour characteristics associated with the length, time of the day, shift intensity/recovery and social aspects of working hours were calculated as described earlier (Härmä et al., 2015). A full description of the data retrieval process, data cleaning, reliability, validity, and the obtained data accuracy has been reported earlier (Härmä et al., 2015).

The healthcare workers in the study sample had so-called period-based work contracts where working hours are planned and balanced for every 3 weeks (total planned working hours 114 h and 45 min). The period of 3 weeks for total working hours allows larger variability in the distribution and length of the work shifts or work spells compared to regular day work from Monday to Friday (Ropponen et al., 2017). Period-based work can be organized as daywork or shift work. In general, working hours in the period-based work are mostly irregular. The description of the average working hour characteristics at baseline according to the main dimensions of working hour characteristics (Härmä et al., 2015) is presented in Table 1.

This study is based on employer-owned register data. Pseudonymized identification numbers for each employee were applied for research purposes. Research using register data does not need to undergo review by an ethics committee according to Finnish legislation (Data Protection Act 1050/2018). The consent to participate was not applicable since the data comprised employer-owned information on working hours. All organizations gave written permissions to utilize the data for research purposes.

2.4. Work schedule evaluation tool including the recommendations

Working hours were scheduled during the years 2015–2019 utilizing the work schedule evaluating tool including the national recommendations (Appendix 1) to decrease the health and safety risks of shift work and excessive working hours.

CGI Finland Ltd. published the work schedule evaluation tool with the national recommendations to decrease the health and safety risks (see below) in 2014 and added it as a specific evaluation tool into their Titania® shift scheduling software. The idea of the new evaluation tool was to give feedback to the ward-level shift planner to evaluate and optimize the work schedules according to the national recommendations. The software was available in both the standard Titania® shift scheduling software and in a separate participatory shift scheduling software intended for collective shift scheduling. In the standard Titania® software, the evaluation tool can be used only by the shift planner of the ward. In the participatory shift scheduling software, the tool can be used by both the shift planner and the employees. The use of the evaluation tool by employees was very rare. In this study, we investigated only the effects of the use of the tool by the shift planner but

Table 1
Description of the sample and working hours characteristics at baseline in 2015, healthcare workers with a periodic-type work contract with the minimum of 31 work shifts during each year, (N = 29,968).

		N	%	Mean	SD
Organizations	Hospital districts (10)	16,746	55.9		
	Cities (6)	13,222	44.1		
	All	29,968	100		
Shift work status	Day work	5768	19.3		
	Shift work	24,200	80.7		
Gender	Women	26,371	88.0		
	Men	3597	12.0		
Age	<30	6219	20.8		
	30–39	7302	24.4		
	40–49	6720	22.4		
	50–59	7766	25.9		
	≥60	1961	6.5		
The length of working hours	Weekly working hours			34.23	3.97
	% of long working weeks				
	>40 h			23.19	14.90
	>48 h			4.41	6.61
	Shift length (hours)			8.34	0.88
	% of long shifts (≥12 h)			3.63	8.75
	% of long night shifts in those with a night shift				
	>10 h			18.23	19.25
	>12 h			1.57	5.49
	Number of consecutive working days			3.72	0.63
	% of long spells of work shifts			2.91	5.74
Timing of working hours	At least one night shift	14,565	48.6		
	% of night shifts in those with a night shift			23.89	20.36
	Number of consecutive night shifts in those with a night shift			2.24	0.86
	% of 5 or more consecutive night shifts in those with a night shift			0.34	0.34
	% of evening shifts			26.88	18.97
	Number of consecutive evening shifts			1.22	0.65
	% of morning shifts			57.38	27.35
	% of early morning shifts			0.04	1.52
Recovery	Time between shifts (h)			14.99	3.26
	% of short shift intervals (<11 h)			12.31	12.22
	% of short recovery periods after the last night shifts				
	<48 h			14.23	21.52
	<28 h			5.88	15.46
	Maximum weekly recovery period				
	<35 h			16.44	11.89
	<48 h			4.75	4.56
Social aspects of working hours	% of week-end work			31.89	23.00
	% of single days off			14.08	9.63
	Variability of shift starting times			2.67	1.74
	Variability of shift lengths			0.87	0.55
Individual possibilities to control working hours	Having shift wishes	15,816	52.8		
	% of realized shift wishes			81.79	19.81

controlled for the use of the participatory shift scheduling tool allowing the use of the tool by both the shift planner and the employees.

The utilization rate of the evaluation tool for each 3-week scheduling period during the years 2015–2019 was calculated. Utilization was acknowledged if the evaluation tool was used during an active session leaving modifications to the work shift tables. Based on the annual use of the tool, the number of new employees whose 3-week shift plans were evaluated using the tool for at least the 1st, 2nd and 10th time during each year was calculated. Only the evaluations leading to modifications of the working hour schedule during the same scheduling session were calculated to the annual use of the tool. When an employee used the shift scheduling tool continuously (during at least 10 different 3-week scheduling periods, i.e., the 10th time), she/he was included in the intervention group in the upcoming years irrespective of amount of future use of the evaluation tool. The reason for this was that shift planners learned the result of the evaluation soon, and even if they continued to use the tool, made less modifications to the schedules.

The national recommendations to decrease the health and safety risks of shift work and long working hours were given by an expert group of the Finnish Institute of Occupational Health (FIOH) based on earlier research on the association of working hours characteristics with health (Supplementary data, Table 1). The recommendations included 14 items within five main dimensions of the characteristics of working hours and were based on earlier published algorithms (Härmä et al., 2015) for the assessment of working time patterns, and their suggested safety categories for digital shift scheduling. The recommendations included a list of working hour characteristics attached to recommended safety levels. Green level indicated the optimal value for the working hour characteristic while yellow indicated being on the level of increased workload. Orange indicated an overload situation, and red for high overload that should be removed. Three key characteristics were highlighted in the national and organizational level dissemination of the recommendations: the avoidance of several consecutive work shifts, especially consecutive nights shifts, and the avoidance of short shift intervals (<11 h), supporting together the use of "quickly forward rotating" work schedules. Thirdly, possibilities for shift wishes to control individual working hours was highlighted.

2.5. Working hour characteristics

The working hour characteristics studied in relation to the use of the evaluation tool were the working hour characteristics included in the recommendations embedded into the evaluation tool. They were associated with five dimensions of working hours (Härmä et al., 2015): 1. *The length of the working hours*: the length of average weekly working hours (Mon 00:00-Sun 24:00), all shifts, night shifts, and the number of consecutive workdays; 2. *Timing of working hours*: The number of consecutive early morning, evening and night shifts; 3. *Recovery*: Number of <11-hour shift intervals, the length of free time after the last night shift and the weekly rest time (during Mon 00:00-Sun 23:59). 4. *Social aspects of working hours*: Number of free weekends and single days off; 5. *Individual possibilities to control working hours*: realized shift wishes.

In addition to annual means, proportions for specific category levels were used as recommended earlier for the assessment of working hour patterns of payroll data (Härmä et al., 2015), and utilized as a part of the given national recommendations (Supplementary data, Table 1). Split shifts were not calculated separately due to their rarity. However, they were included in the calculation of the "number of <11-hour shift intervals". Early morning shifts were very rare (n = 126) and could thus be calculated only for the whole group.

2.6. Statistical methods

We used intention-to-treat principle and defined the intervention as using the evaluation tool within the shift scheduling tool for the 10th time or more. We analyzed the data using the stepped wedge clinical trial design. Multi-level generalized linear model was used to study the effects of using the evaluation tool on changes in working hour characteristics during the follow-up and to control for hierarchical structure of the data (individuals nested within units and units nested within organizations). The estimates were controlled for age, sex, shift work (day work contract vs shift work contract of the period-based work), night work, number of contract days and the use of participatory shift scheduling software. Subgroup analyses were performed for age, organization (hospital districts/cities), and shift work status. No subgroup analysis was conducted for gender as only 12% of the study population were men. We performed two sensitivity analyses: First, we analyzed the effects of the use of the evaluation tool by excluding employees in day work based on work contract. Second, we analyzed the effects of the use of the evaluation tool by excluding those with the 2nd -9th use of the software, the comparison group to the continuous time users (10th time) being only the single-time users (1st time) only. Stata version 17 (StataCorp LLC, College Station, TX, USA) was used for the analyses.

A dichotomized variable for long weekly working hours >40 h was defined as working >40 h >25% of annual working weeks. Dichotomized variables for shift length of ≥12 h, night shift of ≥10 h and number of consecutive working days >6 were defined as working >10% of annual working shifts or days. Dichotomized variables for working >4 consecutive evening or night shifts were defined as working at least once within a year. These cut-off values have been described before in detail (Härmä et al., 2015).

3. Results

3.1. The annual use of the work shift evaluation tool

The annual use of the shift schedule evaluation tool including national recommendations for the 1st, 2nd, and 10th 3-week period of the year is shown in Fig. 2. During 2015, the use of the evaluation tool was started in most of the organizations. The cumulative %s of employees whose work schedules were designed with the tool for at least one 3-week scheduling period were 42% (2015), 60% (2016), 76% (2017), 88% (2018) and 96% (2019). However, the tool was used continuously (at least in 10 3-week shift scheduling periods out the maximum of 16) by only 2% of the employees during the first year 2015. By 2018, last year that included all the organizations in the data, the tool was used continuously by 20% of all employees, and the occasional use of the tool decreased compared to the years 2015–2016. The drop-out percentage of the number of continuous users of the evaluation tool was 20% in 2016, 18% in 2017 and 20% in 2018. By 2018, the highest rate in the use of the evaluation tool for at least 10 3-week periods in any single organization was 48%. Since this organization was also the largest one among the cities, 56% of the continuous users (n = 20,921) during all years, and even 91% of the continuous users among all cities (n = 13,081), came from this organization.

3.2. The effects of the use of the evaluation tool on changes in working hour characteristics

In the total sample, the annual continuous use of the evaluation tool was associated with several favorable changes towards the given recommendations in the fully adjusted models (Tables 2–3). The number of consecutive workdays decreased (difference 0.065, 95% CI 0.05, 0.08) in the fully adjusted model, Table 2), including the % of >6 consecutive workdays (OR 0.73, 95% CI 0.66, 0.81, Table 3). However, the % of occasionally long weekly working hours (>40 h) increased (OR 1.16, 95% CI 1.10, 1.22) albeit being rare (less than 2%) and the % of ≥ 12-hour shifts increased (OR 1.22, 95% CI 1.07, 1.38). The % of >4 consecutive night shifts decreased (OR 0.86, 95% CI 0.77, 0.95) while the %

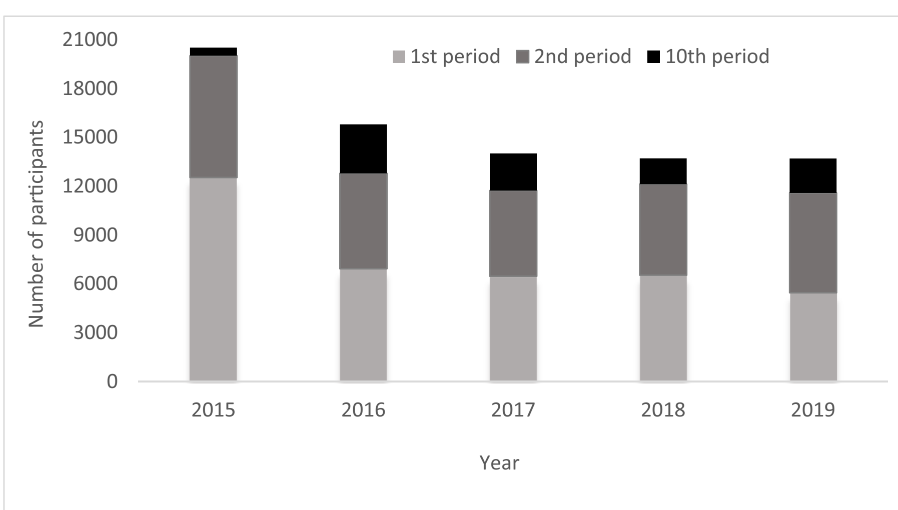

Fig. 2. The annual use of the shift schedule evaluation tool including national recommendations to reduce health and safety risks during 2015–2019. The bars indicate the number of new employees whose 3-week shift plans were evaluated by the tool for the 1st time or more, for the 2nd time or more and for the 10th time or more during each year.

Table 2
Differences in employees' working hour characteristics according to the use (yes/no) of the work schedule evaluation tool during the preceding year.

Working hour characteristic	No		Yes		Model I			Model II		
	n	Mean (SD)	n	Mean (SD)	Difference	95% CI	P	Difference	95% CI	P
Length of the working hours										
The length of weekly working hours	131,047	34.19 (4.34)	19,635	34.32 (4.34)	0.003	−0.09, 0.10	0.94	−0.056	−0.15, 0.04	0.24
The length of a night shift (h)	70,704	11.01 (1.60)	10,261	10.83 (1.32)	−0.012	−0.05, 0.03	0.55	−0.002	−0.04, 0.04	0.94
Number of consecutive workdays	131,680	3.68 (0.64)	19,773	3.65 (0.58)	−0.070	−0.08, −0.06	<0.001	−0.065	−0.08, −0.05	<0.001
Timing of working hours										
Number of early morning shifts	1989	6.09 (22.92)	126	2.08 (3.43)	−0.78	−5.71, 4.14	0.75	−1.00	−5.81, 3.80	0.68
Number of consecutive evening shifts	137,431	1.21 (0.64)	20,921	1.37 (0.65)	0.029	0.02, 0.04	<0.001	0.010	−0.001, 0.02	0.086
Number of consecutive night shifts	137,431	1.13 (1.24)	20,921	1.19 (1.34)	0.05	0.03, 0.08	<0.001	−0.007	−0.03, 0.02	0.54
Recovery										
% of short shift intervals (<11 h)	137,431	12.22 (12.05)	20,921	12.34 (10.95)	−0.43	−0.65, −0.22	<0.001	−0.63	−0.83, −0.43	<0.001
% of short recovery periods after N shifts										
<48 h	70,401	15.71 (22.25)	10,198	13.01 (21.32)	−0.60	−1.24, 0.03	0.061	−0.40	−1.03, 0.23	0.21
<28 h	70,401	6.31 (16.15)	10,198	5.09 (15.16)	−0.44	−0.91, 0.03	0.064	−0.30	−0.77, 0.16	0.20
Maximum weekly recovery period										
<48 h	131,680	4.42 (4.35)	19,773	4.95 (4.90)	−0.03	−0.13, 0.07	0.55	0.04	−0.06, 0.13	0.42
<35 h	131,680	15.31 (11.55)	19,773	19.24 (11.70)	−0.00	−0.23, 0.24	0.98	0.07	−0.14, 0.29	0.50
Social aspects of working hours										
% of single days off	127,546	13.61 (9.48)	19,334	16.80 (9.36)	0.32	0.13, 0.51	0.001	0.33	0.15, 0.51	<0.001
% of weekend work	137,405	31.23 (22.98)	20,921	36.19 (21.91)	0.68	0.26, 1.09	0.001	0.32	−0.03, 0.66	0.070
Individual possibilities to control working hours										
% of realized shift wishes	64,186	81.01 (20.69)	10,179	80.03 (20.61)	−1.01	−1.66, −0.37	0.002	−0.76	−1.41, −0.12	0.021

Model I: Adjusted for hierarchical structure of the data.
Model II. Further adjusted for age, sex, shift work, night work, number of days of work contract, and use of participatory scheduling software.

of >4 consecutive evening shifts increased. The use of the evaluation tool was also associated with the decrease in % of short intervals between the shifts (<11 h, difference 0.63, 95% CI 0.43, 0.83). The % of single days off among all days off increased (difference 0.33, 95% CI 0.15, 0.51) and the % of realized shift wishes decreased (difference 0.72, 95% CI 0.12, 1.41), opposite to the given recommendations.

The use of the evaluation tool was associated with clearly more robust changes towards the given recommendations in the cities compared to the hospital districts (Table 3 and Supplemental data, Tables 2–3). In the cities, the use of the evaluation tool decreased the average length of the weekly working hours, the % of ≥ 10-hour night shifts, and decreased the number of >6 consecutive workdays. Short

Table 3
Differences in employees' working hour characteristics according to the use (no/yes) of the work schedule evaluation tool during the preceding year. Dichotomized working hour characteristics. All organizations and according to organizational type (hospitals districts/cities).

Working hour characteristic	No		Yes		Model I		Model II	
	n	%	n	%	OR	95% CI	OR	95% CI
All organizations								
Length of the working hours								
Weekly working hours >40 h	131,047	49.87	19,635	51.50	1.20	1.13–1.26	1.16	1.10–1.22
Work shift ≥12 h	131,680	14.43	19,773	7.23	1.33	1.18–1.50	1.22	1.07–1.38
Night shift ≥10 h	137,431	32.07	20,921	24.45	1.14	1.06–1.23	1.00	0.93–1.08
Consecutive workdays >6	131,680	7.49	19,773	5.97	0.81	0.73–0.89	0.73	0.66–0.81
Timing of working hours								
Consecutive evening shifts >4	137,431	0.60	20,921	0.54	1.87	1.35–2.59	2.68	1.88–3.83
Consecutive night shifts >4	137,431	7.12	20,921	9.25	1.04	0.95–1.13	0.86	0.77–0.95
Hospital districts								
Length of the working hours								
Weekly working hours >40 h	94,232	53.96	7531	54.44	1.16	1.07–1.26	1.16	1.06–1.26
Work shift ≥12 h	94,702	18.96	7552	16.34	1.53	1.33–1.76	1.45	1.24–1.68
Night shift ≥10 h	97,842	39.15	7840	35.65	1.27	1.15–1.40	1.21	1.09–1.35
Consecutive workdays >6	94,702	7.93	7552	7.67	0.91	0.78–1.06	0.89	0.76–1.05
Timing of working hours								
Consecutive evening shifts >4	97,842	0.85	7840	1.45	1.87	1.35–2.59	2.68	1.88–3.83
Consecutive night shifts >4	97,842	6.64	7840	4.85	0.78	0.65–0.93	0.84	0.70–1.01
Cities								
Length of the working hours								
Weekly working hours >40 h	36,815	39.41	12,104	49.67	1.20	1.12–1.29	1.11	1.04–1.19
Work shift ≥12 h	36,978	2.84	12,221	1.60	0.89	0.70–1.13	0.85	0.66–1.08
Night shift ≥10 h	39,589	14.56	13,081	17.74	1.02	0.92–1.13	0.87	0.79–0.97
Consecutive workdays >6	36,978	6.36	12,221	4.92	0.74	0.65–0.84	0.66	0.57–0.75
Timing of working hours								
Consecutive evening shifts >4	39,589	0	13,081	0	–	–	–	–
Consecutive night shifts >4	39,589	8.30	13,081	11.90	1.14	1.02–1.27	0.92	0.81–1.04

Model I: Adjusted for hierarchical structure of the data.
Model II. Further adjusted for age, sex, shift work, night work, number of days of work contract, and use of participatory scheduling software.

shift intervals (<11 h), the % of <48-hour and < 24-hour recovery periods after the night shifts, consecutive evening shifts and weekend work decreased. However, the % of single days off, and the % of realized shift wishes decreased, opposite to the given recommendations. In the hospital districts, the % of short shift intervals (<11 h) decreased, but the decrease of the % of >4 consecutive night shifts was not significant. On the contrary, increases in the % of ≥12-hour work shifts and ≥10-hour nights shifts were found in addition to the increase in >4 consecutive evening shifts (Table 3 and Supplemental data, Table 2).

The use of the evaluation tool was associated with somewhat divergent changes among the older age groups (Supplemental data Tables 3–7). The % of short shift intervals (<11 h) and the number of consecutive workdays decreased, and the % of weekly working hours >40 h increased in all age groups. Among the older age groups (30–49 years and ≥50 years), the number of >4 consecutive night shifts decreased additionally but the % of >4 consecutive evening shifts increased. The % of realized shift wishes decreased significantly only in the middle-age (30–49 years) group.

3.3. Sensitivity analysis

In the main results above (Tables 2–3) we controlled for shift work status (shift work vs day work). In the first sensitivity analysis we excluded regular dayworkers based on their work contracts. Similar to the main results, and according to the fully adjusted model, the evaluation tool decreased the number of consecutive workdays (Diff. 0.07, 95% CI 0.05, 0.08, $p < 0.001$), % of short shift intervals (Diff 0.75, 95% CI 0.52, 0.98, $p < 0.001$), and the % of those with consecutive (>6) workdays (OR 0.71, 95% CI 0.64, 0.79) and consecutive (>4) night shifts (OR 0.86, 95% CI 0.77,0.95). Also, the % of those with weekly working hours >40 h (OR 1.09, 95% CI 1.04,1.15) and single days off (Diff 0.31, 95% CI 0.11, 0.51, $p = 0.002$) increased like in the main results. Being different from the main results, the mean length of the weekly working hours decreased (Diff. 0.12, 95% CI 0.02, 0.22, $p = 0.016$) and the decrease in the % of realized shift wishes was no more significant (Diff −0.64, 95% CI 0.02, −1.29, $p = 0.056$). The absolute differences between the users and non-users of the evaluation tool were of the same magnitude, even marginally larger with dayworkers excluded.

In the second sensitivity analysis we increased the contrast between the users (10th time or more) and nonusers (1st time only) by excluding those with the 2nd-9th time use of the evaluation tool. The results were again like the main results in Tables 2–3 in relation to the observed working hour characteristic with statistically significant differences. However, the absolute differences between the users and non-users of the software increased slightly. For example, the decrease in the % of short shift intervals was 1.31% (95% CI 0.98, 1.63, $p < 0.001$) while it was 0.63% (Table 2) in the main results.

4. Discussion

Based on this prospective cohort study of 36,663 healthcare workers, the integration of the national recommendations on healthy working hours into the shift scheduling software resulted in several, albeit modest changes that were in line with the given recommendations. Long spells of work shifts, several consecutive night shifts and the % of short shift intervals decreased. However, the evaluation tool was used continuously by only one fifth of the studied population and realized shift wishes decreased, being opposite to the given recommendations. An active use of the tool was associated with more robust positive changes towards the given recommendations in the cities compared to the hospital districts, and among the older age groups compared to the ≤30-year-old employees.

The obtained results add to the policy on utilizing the recommendations on shift work and excessive working hours since no earlier studies on the use or effects of recommendations on working hour characteristics are available.

The use of the evaluation tool was associated with the decrease of several working hour patterns linked to increased health and safety risks in earlier studies: excessively long work spells (Griffiths et al., 2014; Karhula et al., 2017), several consecutive night shifts (Cordina-Duverger et al., 2018; Lie et al., 2011) and short recovery times between the shifts (Härmä et al., 2018; Nielsen et al., 2019; Vedaa et al., 2016). Although the observed changes in the working hour characteristics on average level were only moderate, the use of the evaluation tool made the most hazardous working hour characteristics less frequent.

The national recommendations in Finland for healthcare sector included items to support possibilities for individual shift wishes, and the avoidance of single days off instead of longer spells of days off. However, the use of the evaluation tool was associated with opposite trends in these characteristics. Probably the need of the shift planner to avoid the most strenuous working time patterns decreased the potential for individuals to wish them. For example, having several consecutive night shifts, very long work spells and shorter times between the shifts are all associated with longer spells of days off due to more work in evenings, nights and during the weekends. However, no association was found in an earlier cross-sectional study between level of control over scheduling of work shifts and long working weeks (Karhula et al., 2019). Better worktime control in healthcare sector may be associated with lower sickness absence (Turunen et al., 2020) and higher job motivation (Nijp et al., 2015), hence further follow-up for the obtained result of decreased worktime control would be merited.

The use of the evaluation tool was associated with more frequent and favorable changes in the cities compared to the hospital districts. In the cities, the use of the evaluation tool decreased weekly working hours, long work shifts, the number of consecutive evening shifts, and the short recovery periods after the night shifts in addition to the earlier mentioned changes found in the whole sample. In the hospital districts, long work shifts increased. The main results were otherwise mostly similar in both the hospital districts and the cities. Most of the data on the continuous use of the tool in the cities came from one large organization. The active use of the evaluation tool in that city may be explained by a longer experience in applying the national working time recommendations and thus better readiness to apply the evaluation tool when it became available in 2015. During 2011, an administrative decision was made in this city to avoid long weekly working hours, several and long consecutive night shifts and short recovery periods between the shifts (Karhula et al., 2021). The administrative decision was supported by coaching the nurse managers in lectures and workshops. The internal instructions were based on earlier national recommendations (Hakola et al., 2010; Karhula et al., 2021).

The evaluation tool was used continuously by one fifth of the studied population but the cumulative use of the tool during for at least one 3-week scheduling period during each year increased even up to 96% at the end of the follow-up. We acknowledge few possibilities that may limit the increase of the continuous use of the tool. First, the software saves information on the evaluation of the schedule (i.e. the use of the tool) only if changes were made to the schedule during the same session of the evaluation. If there were thus no needs for change, no information was saved on the evaluation even if it actually took place. Second, the use and recommendations included to the evaluation tool are quickly learned, and thus discontinuing the use of the tool does not indicate that the recommendations are no longer used. This suggest that our estimates for the use of evaluation tool are more likely underestimates than overestimates.

The beneficial changes in working hour patterns were somewhat clearer among the older age groups compared to employees of ≤30 years of age. Insomnia symptoms and need for recovery increase among the older population (Jansen et al., 2003; Marquiáe et al., 2012). In earlier studies, signs of age-related interactions on the association the of shift work with health are also available. The association of e.g. short shift intervals with fatigue was most evident among ≥50 years old healthcare workers (Härmä et al., 2018), and the aging nurses had the largest decrease in fatigue if changing from shift to day work (Härmä et al., 2019). In the ≥50 age group, no decrease in the percentage of realized shift wishes in the current study was seen. It is possible that the more robust changes towards the given recommendations among the aging employees could be associated with more acknowledged priority for utilizing the recommendations. However, this can be associated with the transfer of some strenuous work shifts to younger employees. We found, for example, that the % of >4 consecutive night shifts decreased significantly only in the two older age groups.

5. Strengths and limitations

A strength of the study is its analysis as the stepped wedge randomized controlled trial with a large sample size and long follow-up and time span of using the evaluation tool. To reduce bias, we used multilevel generalized linear models and controlled for the hierarchical structure of the data and several individual and working time -related factors. Information on the use of the intervention and outcomes were based on precise daily data and earlier published method for the assessment of working time patterns for epidemiological studies (Härmä et al., 2015).

The study has also limitations. We used a stepped wedge randomized trial analysis for prospective data where the intervention and control group could not be randomized before the use of the evaluation software. Since we had limited information on the individual and work-related factors of the employees, we cannot exclude the possibility that some unmeasured factors were not controlled in the analysis. The studied work schedules were mostly irregular limiting the generalization of the results to regular work schedules and occupational groups outside healthcare sector. Additional research is needed on the observed large organizational differences in the use of the evaluation tool, and on effects to health and safety.

6. Conclusions

National recommendations embedded in a shift schedule evaluation tool were associated with several, albeit modest changes towards the given recommendations. The present study suggests that having a technically easy-to-use solution for utilizing recommendations in work scheduling results in reductions of unhealthy shift characteristics.

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CRediT authorship contribution statement

All authors have joined the design of the study and contributed to writing and revising the manuscript. MH applied for funding and drafted the manuscript. RS analyzed the data All the authors approved the final version submitted for publication.

Declaration of Competing Interest

The authors of the enclosed paper (National recommendations for shift scheduling in healthcare: A 5-year prospective cohort study on working hour characteristics by Mikko Härmä, Rahman Shiri, Jenni Ervasti, Kati Karhula, Jarno Turunen, Aki Koskinen, Annina Ropponen and Mikael Sallinen) disclose no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnurstu.2022.104321.

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