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A Longitudinal Study of Nursing Staffs' Shift Schedules during the COVID-19 Pandemic[1]

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ABSTRACT

Working conditions among healthcare workers became more demanding during the COVID-19 pandemic, and new types of work hour schedules emerged. The aim of the study was to investigate how working hours in the Swedish healthcare sector were affected by the COVID-19 pandemic. Payroll data were extracted from one mid-size Swedish region, including 1,130,391 shifts worked by 3392 individuals between December 2018 and September 2023. Paired t-tests were used to compare working hours before and after the onset of COVID-19. There were few changes to the working hours during COVID-19. A new schedule (4 workdays, 2 days off) increased weekend work and decreased the proportion of quick returns and single free days. Exploratory analyses showed that overtime increased. In conclusion, the pandemic had few and weak effects on the ergonomic qualities of work hour schedules. More research is needed to explore whether the findings are representative of other contexts.

KEYWORDS

COVID-19 / healthcare / nursing / recovery / working hours

The COVID-19 pandemic contributed to increased strain on the healthcare sector and findings from the Swedish healthcare sector show that new ways of scheduling work hours emerged (Hernandez et al. 2024a). Several studies have found associations between demanding work hours [e.g., long working hours, night work, quick returns (<11 hours between shifts), few days of between work periods] and negative health- and performance-related consequences among healthcare workers during the pandemic (Britt et al. 2021; Djupedal et al. 2022; Jarrar et al. 2023). For example, it has

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been reported that overtime increased following the onset of the COVID-19 pandemic (Carrière et al. 2020; Nymark et al. 2022).

Long working hours increase the exposure to job-related stressors and leave less time for recovery, which has been deemed an important factor in preventing stress-related ill-health (Geurts & Sonnentag 2006). Meta-analytic and multi-cohort findings suggest that long weekly working hours (in most cases >55 h/week) are related to an array of negative health consequences (Ervasti et al. 2021; Kivimäki et al. 2015; Wong et al. 2019) as well as increased risk of safety incidents (Matre et al. 2021). Long shifts (>12 h) have also been associated with more safety incidents and occupational injuries, with some findings suggesting that the risk increases exponentially after 9 hours on duty (Fischer et al. 2017; Härmä et al. 2020; Matre et al. 2021). Scheduling characteristics such as quick returns, night work, overtime, and rotating shift work have also been related to unfavorable outcomes including burnout, poor sleep, fatigue, and impaired performance (Dall'Ora et al. 2016; Fischer et al. 2017; Vedaa et al. 2016).

In recent years, payroll data have been used as a more precise measure of work hours in large epidemiological studies (Härmä et al. 2024), and a standardized framework for analyzing work hour characteristics/patterns in objective work hour data, such as payroll data, has been proposed (Härmä et al. 2015). The characteristics relate to the ergonomic qualities of the working hours (i.e., characteristics that determine how sustainable the work hours are). These characteristics include the length of working hours (e.g., weekly working hours, shift length, proportion of long (>48 h) work weeks), time of the day (e.g., day/evening/night shifts), shift intensity (e.g., time between shifts, number of consecutive workdays, proportion of quick returns), and social aspects of working hours (e.g., weekend work, annual free days) (Härmä et al. 2015). Several studies have followed this framework when investigating work hour schedules within healthcare settings, using objective work hour data from payroll systems (Garde et al. 2018; Karhula et al. 2017; Vanttola et al. 2020). However, few such studies have been conducted in the Swedish healthcare sector, especially within the context of the COVID-19 pandemic.

Qualitative findings from the Swedish healthcare sector have shown that the working hours and new schedules, which emerged during the pandemic were demanding, left little room for recovery, and in some cases resulted in dissatisfaction as they removed employee influence over working hours, according to Swedish nursing staff (Hernandez et al. 2024b). One example of the new scheduling practices was moving away from participatory work time scheduling (PWTS) to the crisis agreement which increased weekly working hours to 48 h, with 12-h shifts. Another scheduling solution was 4-2 schedules, which were comprised of two-day shifts, followed by two evening shifts and two days off, later changed in some units to a counterclockwise rotation with a short inter-shift interval (<11 h; a 'quick return') in the middle of each block of shifts (Hernandez et al. 2024a). According to HR-representatives in the Swedish healthcare sector, the 4-2 schedules eased staffing, while nursing staff reported that a positive aspect of the 4-2 schedules was that they rarely entailed having to work overtime and extra shifts (Hernandez et al. 2024a, 2024b). Nursing staff also described that working on PWTS during the pandemic resulted in demanding work hours with unplanned changes in the schedules (Hernandez et al. 2024b). Findings from the Norwegian healthcare sector suggest that nurses who reported that they had changes in their work hour schedules during the COVID-19 pandemic were more likely to report sleep disturbances, as well as higher turnover intention, with increased quick returns being identified as a particularly strong predictor of the negative outcomes (Djupedal et al. 2022).

Previous studies investigating working hours during COVID-19 pandemic have used subjective measures of work hours. Little is known about how the different work hour solutions used in the Swedish healthcare sector during the COVID-19 pandemic impacted the ergonomic qualities of work hour schedules (i.e., aspects which may be important in relation to health and safety, such as the length of working hours, shift intensity, night work, weekend work, and free days). Thus, the aim of the present study was to investigate how working hours in the Swedish healthcare sector were affected by the COVID-19 pandemic, using objective work hour data from hospital payroll systems before and after the onset of the pandemic. The following hypotheses were formulated:

H1: The length of working hours increased during the COVID-19 pandemic.

H2: The proportion of night shifts increased during the COVID-19 pandemic.

H3: Shift intensity increased during the COVID-19 pandemic.

H4: The proportion of weekend work and single free days increased during the COVID-19 pandemic.

H5: The number of free days decreased during the COVID-19 pandemic.

H6: Working on PWTS during the COVID-19 pandemic was associated with more demanding working hours, for example, longer working hours and higher shift intensity.

In addition to these hypotheses, the study also included exploratory research questions, namely if overtime work, very long working weeks (>48 h), very long work shifts (>12 h), and number of sick leave days increased during the pandemic, as well as if there was a difference between wards where COVID-19 patients were most commonly treated and other wards.

Methods

Participants

The participants were nursing staff working in 24/7-hour healthcare across 45 units in four hospitals in one Swedish region. The participants held positions such as registered nurses, certified nursing assistants, care assistants, specialist nurses, and midwives. Individuals who had worked in employment positions such as managers, laboratory staff, and coordinators at some point during the study period were excluded, as switching out of or into a nursing position could have impacted the work hours. Physicians were excluded due to insufficient information on working hours and on-call time which was recorded in a separate system. To investigate changes in working hours over time, those who had worked <31 shifts over a three-month period were removed according to cut-offs identified from previous studies (Karhula et al. 2017; Vanttola et al. 2020).

Furthermore, participants working <17 h per week were removed (17 hours is equivalent to approximately 50% of full-time for shift workers in the Swedish public healthcare sector (Swedish Association of Local Authorities and Regions 2024). Lastly, those who had worked exclusively between 06.00 and 18.00 were excluded as it was not considered a shift working schedule, keeping only those who had worked at least 10% non-day shifts during the pandemic. Thus, the final data set included 1,130,391 work shifts from 3392 individuals. Approximately 38% were registered nurses, while 62% worked in other nursing positions.

Context

The region was mid-sized and located in the middle of Sweden, with one relatively large city with over 100,000 residents. The hospitals within the region utilized 4-2 schedules between March and August 2020. The scheduling pattern followed a clockwise rotation where employees worked two day shifts, two evening shifts, and then had two days off. Night shifts were covered by permanent night workers, where the schedules followed a pattern of two night shifts and three days off. In some wards, the pattern was changed after approximately two months to a counterclockwise pattern (two evening shifts, two day shifts, two days off), which meant that there was a quick return in the middle of each block of shifts (Hernandez et al. 2024a).

Data collection

Data were retrieved through the hospital payroll system Heroma with assistance from the region under study, including all shifts worked by nursing staff in 24/7 healthcare units between December 2018 and September 2023. The data included unique ID numbers for each employee, job title and ward of employment, as well as the date and the number of minutes worked each hour over a 24-h period (Table 1). A total of four files were retrieved, one with the ordinary shifts worked, one with overtime/extra shifts, one with shifts compensated by the hour, and one with shifts where employees had been absent. Overtime/extra shifts and shifts compensated by the hour were added to the ordinary working hours to get the total hours worked. The study was approved by the Swedish Ethical Review Authority (dnr. 2020-04230). Upon retrieval, data were pseudonymized, and the research group did not have access to a code key.

Table 1 Example of the data structure

DATE	ID	POSITION	WARD	Minutes	HOUR1	HOUR2	HOUR3	HOUR4
2018-12-01	1234	Registered nurse	Intensive care unit	415	60	60	60	60
2018-12-01	5678	Midwife	Maternity ward	453	0	0	0	0

Note: The Minutes column represents the total minutes worked, HOUR1 represents 00.00–00.59, HOUR2 represents 01.00–01.59, etc.

Definition of variables

The variables used in the present study were defined and calculated according to the parameters described by Härmä et al. (2015). The parameters were each calculated over three-month periods (December–February, March–May, June–August, September–November). The reason for choosing this classification was that the three-month periods enabled more accurate estimations of fluctuations in working hours over time, while also taking seasonality into account. A total of 11 work hour variables were included in the study. Variables related to the length of working hours (H1) included *average weekly working hours* which were calculated as the average number of hours worked per week (weeks with no worked shifts, e.g., due to sick leave or vacation, were excluded), as well as the *average shift length* and *length of night shifts*, which were calculated as the average number of hours worked per shift and per night shift, respectively. The *average proportion of night shifts* (H2) was calculated as the average proportion (%) of night shifts out of all shifts worked, night shifts being defined as having worked ≥3 hours between 23.00 and 06.00. Variables which related to shift intensity (H3) included the *average number of consecutive work shifts/night shifts*, which were calculated as the average number of consecutive shifts of any sort and the average number of consecutive night shifts, respectively; the *proportion of quick returns* which was calculated as the proportion (%) of rest periods between shifts that are <11 hours, out of all rest periods between shifts; and the *proportion of short recovery after last night shift* which was calculated as the proportion (%) of rest periods after the last night shift that were <28 hours, out of all rest periods after the last night shift. Variables related to the social aspects of working hours were the *proportion of weekend work*, which was calculated as the number of weekends with a shift on a Saturday and/or Sunday as a proportion (%) of all weekends occurring in the reference period; and the *proportion of single free days*, which was calculated as the number of single days off from work as a proportion (%) of all days off from work (H4). Lastly, a parameter which was adapted from 'Annual free days' described by (Härmä et al. 2015) was added: The *number of free days* (H5) was calculated as the total number of free days over each three-month period. Shifts where participants had been absent due to sick leave, parental leave, military duty, and union representative duty were not considered free days.

Data analysis

An analysis plan was established and pre-registered prior to analyzing the objective work hour data (https://doi.org/10.17605/OSF.IO/6BCMJ). The data set was first run through a software, which had been specifically developed for the purpose of creating clock start- and end times (hours, minutes) for each work hour entry in the data set. The data output was then run in a second analysis software, which had previously been developed for summarizing working hour entries in objective work hour data into shifts, joining multiple shifts by the earliest start-time and latest end time, and identified working hour patterns according to the parameters described above. Overlapping shift entries (e.g., an overtime shift entry which overlapped with the ordinary working hours) were combined to one shift using the earliest start-time and the latest end-time (Härmä et al. 2015). In cases when there were two registered shifts on one day, these were combined into one shift if there was an hour or less between them, otherwise they were considered two separate shifts (Garde et al. 2018). Shifts <3 h were removed unless they were within an hour from another shift, as they were considered unreliable short entries (Rosenström et al. 2021).

Descriptives (means and standard deviations) were collected and reported for each period. The means reflect the work hours of all individuals meeting the inclusion criteria (having worked at least 31 shifts, 17 h per week, and 10% non-day shifts), for each period. To analyze differences in working hours before and after the onset of the pandemic, data from each three-month period of 2020, 2021, 2022, and 2023 were compared to baseline (2018–2019). Paired *t*-tests were performed between each three-month period at baseline and the same period in each of the following years. Given the large number of tests conducted in the present study, a Benjamini-Hochberg correction was performed to adjust for multiple comparisons. Effect sizes were calculated using Cohen's d average (d_{av}), which is suitable for calculating effect sizes for within-subject designs (Lakens, 2013). The paired *t*-tests are based on a subset of individuals who had data available in both 2018 and 2019 and in some or all of the equivalent periods of the years 2020–2023.

Several exploratory analyses were conducted. Comparisons were made, using paired *t*-tests adjusted for multiple comparisons with the Benjamini-Hochberg correction, between pre- and post-pandemic levels of overtime, very long work weeks (>48 h) and very long shifts (>12 h). Overtime data were separated from the total working hours and divided into the same three-month periods to determine average overtime hours among participants who had worked overtime, as well as the distribution of overtime hours (i.e., the proportions of individuals who had worked <25, 25–50, 51–75, or >75 overtime hours per period). The prevalences of very long work weeks and very long shifts were calculated as a proportion of the number of weeks worked/shifts worked within a three-month period, for each participant. To investigate potential differences between wards in the prevalence of demanding work hours, a distinction was drawn between wards where COVID-19 patients were primarily treated (i.e., intensive care units, emergency room, infection clinic, medical emergency ward) and control-wards where COVID-19 patients were not primarily treated (e.g., surgery-, gynecological-, diabetes-, and urology wards) to see if there were any differences in weekly working hours and shift length between these different work contexts.

Rates of sick leave for each of the three-month period were calculated to examine whether there was an increase during the pandemic, as this could have implications for the number of hours worked. These data were plotted alongside the numbers of newly admitted patients who had tested positive for COVID-19 in each three-month period, which served both as an indicator of workload related to COVID-19 and of COVID-19 transmission rates within the general population.

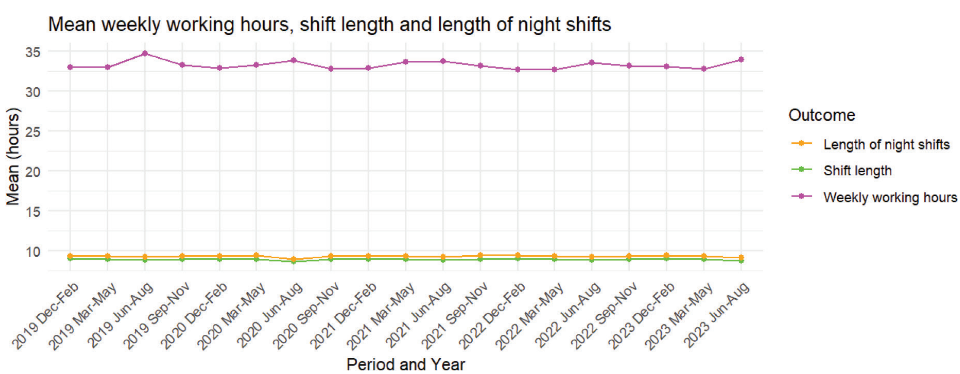
Results

Comparisons between the three-month periods at baseline (2018–2019) and their equivalent periods in 2020–2023 are summarized below. See Tables A1–A12 in appendix A for full results, including descriptives with means (M), standard deviations (SD) for all participants in each given period, as well as results from paired *t*-tests and *t*-values (t), adjusted p-values (p), mean differences (MD) with confidence intervals (CI upr, CI lwr), and effect sizes (d_{av}).

Length of working hours

No major differences in the length of working hours were found between 2020 and 2023 compared to baseline (Figure 1). With regards to weekly working hours, out of the 15 paired *t*-tests conducted, 11 tests showed a significant *decrease* in working hours in the years following the onset of the COVID-19 pandemic. The differences were in most cases very small (d_{av} = 0.10 to 0.17) with mean differences equivalent to less than an hour per week on average (MD = 0.49 to 0.82). During the summer periods (June–August) following the onset of the pandemic, there were small significant decreases in weekly working hours (d_{av} = 0.22–0.34) compared to 2019, where weekly working hours were 1–1.5 h shorter on average (MD = 0.99–1.50). When it came to average shift length, four of the 15 tests were significant. A small decrease in shift length was found during summer 2020 compared to 2019 (d_{av} = 0.21), while the other tests showed very small differences (d_{av} = 0.07–0.11), equivalent to only a few minutes per shift. When it came to the length of night shifts, four out of the 15 tests were significant. For the winter periods of 2022 and 2023, the night shifts were longer than during winter 2018–2019, but the differences were very small (d_{av} = 0.09 and 0.10). During summer 2020 and spring 2023, the night shifts were significantly shorter compared to 2019, however the differences were also very small (d_{av} = 0.19 and 0.09).

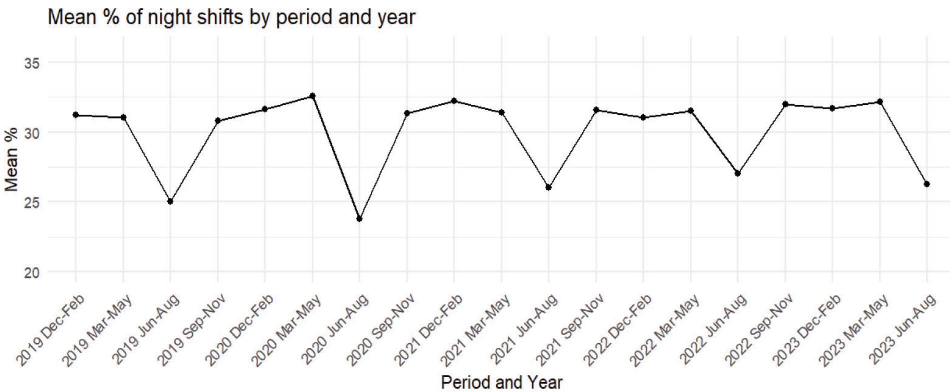
Figure 1 Average weekly work hours, shift length, and length of night shifts across all periods.



Proportion of night shifts

The proportion of night shifts varied across the year, with less night shifts during summer periods (Figure 2). Out of the 15 paired *t*-tests performed to investigate changes in the proportion of night shifts for each three-month period, 12 showed that there was a significant increase in the proportion of night shifts during 2020–2023 compared to baseline, but the differences were very small (d_{av} = 0.05–0.13). The significant mean differences ranged between MD = 1.39 and 3.51, meaning that on average, the proportion of night shifts was between 1.39 and 3.51 percentage points higher across 2020–2023 compared to baseline.

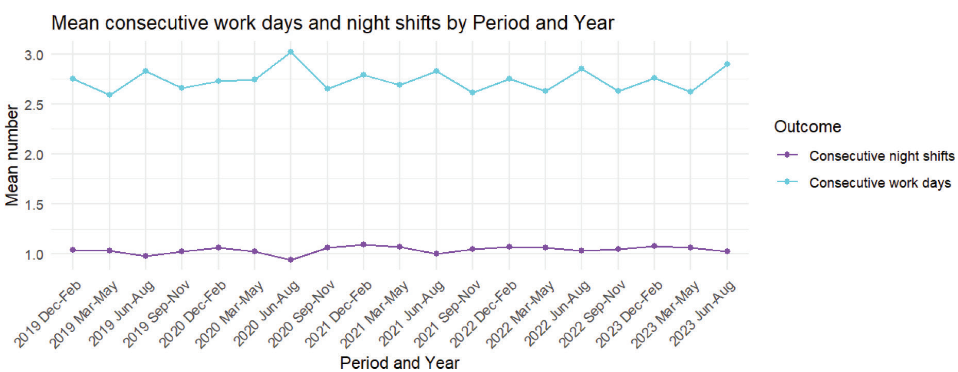
Figure 2 Average proportion of night shifts across all three-month periods.



Shift intensity

There were no major changes in the number of consecutive workdays and night shifts (Figure 3). Analyses of the number of consecutive workdays showed that four out of 15 tests were significant. During spring and summer 2020, which is when 4-2 schedules were used, there were significant increases in the average number of consecutive workdays compared to the same period in 2019. The differences were small (d_{av} = 0.20, 0.32, MD = 0.13, 0.18). In the other two significant tests, the differences were very small (d_{av} = 0.06, 0.08). When it came to the number of consecutive nights shifts, 12 out of 15 tests showed a significant increase in the number of consecutive night shifts. However, the differences were very small (d_{av} = 0.06 to 0.16), equal to only a fraction of a workday on average (MD = 0.04 to 0.09).

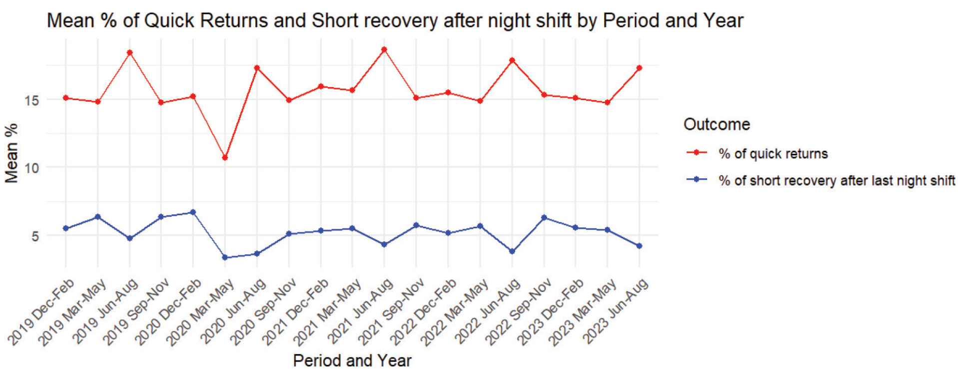
Figure 3 Average number of consecutive workdays and night shifts across all periods.



Quick returns were more common during summer periods, while short recovery after the last night shift was less common during summer periods (Figure 4). The proportion of quick returns was significantly lower over the years 2020–2023 compared to baseline in seven out of the 15 tests. However, among these, six showed very small differences (d_{av} = 0.06–0.17). A more pronounced decrease (d_{av} = 0.44) in quick returns was found during spring 2020 compared to 2019, which is during the time that 4-2 schedules were used within the region. In this case, the proportion of quick returns was on average 4.34 percentage points lower (MD = 4.34).

Analyses of the proportion of short recovery after the last night shift showed that two out of the 15 tests were significant. There was a small significant decrease (d_{av} = 0.26) during spring 2020 compared to spring 2019, where the proportion of short recovery after the last night shift was 3.20 percentage points lower on average (MD = 3.20). This is during the period in which 4-2 schedules were used. Furthermore, the proportion of short recovery after the last night shift was also significantly lower during autumn 2020 compared to the same period in 2019, but the difference was very small (d_{av} = 0.16).

Figure 4 Average proportion of quick returns and short recovery (<28 h) after the last night shift across all periods.

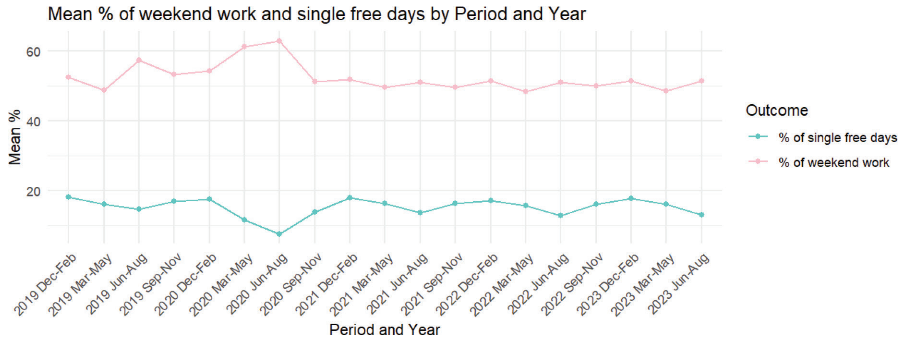


Weekend work and free days

In the analyses of the proportion of weekend work, 13 out of the 15 tests showed significant differences. The most prominent changes were seen during the period where 4-2 schedules were used in March–August 2020 (Figure 5). There was a moderate increase in spring 2020 (d_{av} = 0.68), where the proportion of weekend work was over 12 percentage points higher on average (MD = 12.25) compared to spring 2019. During summer 2020, the proportion of weekend work was also significantly higher than in 2019 (d_{av} = 0.25, MD = 4.73). Aside from these two periods of increased weekend work, the differences were mostly in the opposite direction. Small decreases were found during the summer periods of 2021–2023 (d_{av} = 0.34–0.41) compared to 2019 (MD = 6.63–7.67). Small significant differences were also found for the autumn periods in 2021 and 2022, where the proportions of weekend work were also significantly lower than during the same period in 2019 (d_{av} = 0.22, 0.26). The remaining six significant tests showed very small differences, with five decreases and one increase (d_{av} = 0.08–0.13).

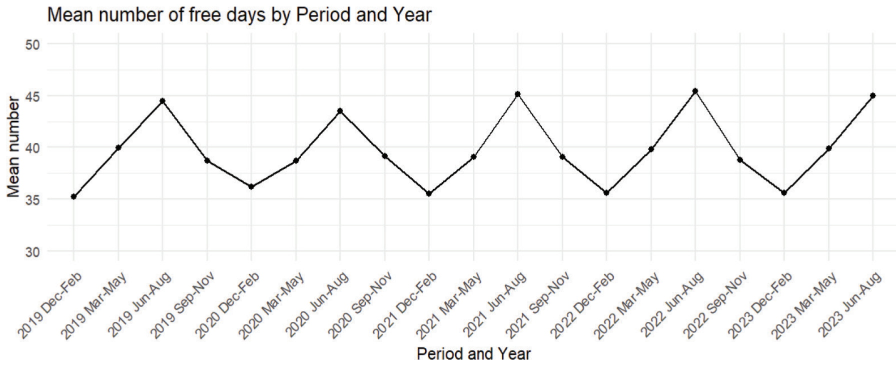
Analyses of the number of single free days as a proportion of all free days showed that 14 out of the 15 tests were significant, and in all cases, the proportion of single free days was lower compared to 2019. Two tests showed moderate effect sizes, which were during spring (d_{av} = 0.50, MD = 4.96) and summer (d_{av} = 0.85, MD = 7.63) 2020, which was when 4-2 schedules were used. Five tests showed that there was a small decrease (d_{av} = 0.20–0.34) and seven tests showed very small decreases (d_{av} = 0.07–0.19).

Figure 5 Average proportion of weekend work and single free days across all periods.



Overall, the number of free days (Figure 6) was higher during the years 2020–2023 compared to baseline, and 13 out of the 15 tests showed that the increase was significant. The number of free days was significantly higher in all years for the winter and autumn periods compared to the same periods at baseline, but the differences were small or very small (d_{av} = 0.12–0.23). The number of free days was also significantly higher during summer of 2021–2023, and these differences were also small (d_{av} = 0.29–0.32). Two very small increases in the number of free days were also found in spring 2022 and 2023 (d_{av} = 0.13, 0.16). A very small significant decrease in the number of free days was found in spring 2020 (d_{av} = 0.07, MD = 0.63). Among the tests that were significant and showed that the number of free days were higher during the years 2020–2023, the average increase was between approximately 1–3 more free days per three-month period (MD = 0.96–3.35).

Figure 6 Average number of free days across all periods.



Differences between 4-2 schedules and PWTS

Analyses of differences in working hours between March–May in 2020 and 2021 (when 4-2 schedules and PWTS were used, respectively) showed that 7 out of the 11 paired *t*-tests were significant. There were no significant differences in weekly working hours, shift length, length of night shifts, or the proportion of night shifts. A very small (d_{av} = 0.16) significant decrease (MD = 0.10) in the average number of consecutive workdays was found in 2021 compared to 2020, while there was a very small significant increase in the average number of consecutive night shifts (d_{av} = 0.11, MD = 0.07). There was a small increase in the average proportion of quick returns during spring 2021 compared to 2020 (d_{av} = 0.39, MD = 3.94), and a very small increase in the average proportion of short recovery after the last night shift (d_{av} = 0.17, MD = 2.05). There was a moderate decrease in the average proportion of weekend work in 2021 compared to 2020 (d_{av} = 0.69, MD = 12.11). There was a small increase in the average proportion of single free days (d_{av} = 0.42, MD = 4.34) during spring 2021 compared to 2020, as well as a very small significant increase in the number of free days (d_{av} = 0.12, MD = 1.09).

Exploratory analyses

For full results, including means (M), standard deviations (SD), t-values (t), and p-values (p), mean differences (MD) with confidence intervals (CI upr, CI lwr) and effect sizes (d_{av}), see Tables A13–A15 in appendix A.

Overtime hours

The mean number of overtime hours in each three-month period was higher during the pandemic compared to before. Not all participants in our sample worked overtime. The calculations below are based only on participants who had worked overtime, which was between 70% and 86% of the entire sample during different periods (M = 79). The proportion of participants who worked overtime prior to the pandemic was on average 76.6%, while in the periods following the onset of the pandemic (March–May 2020 and onward), the average proportion of participants who worked overtime was 79.9%. When conducting *t*-tests on those who had worked overtime, all tests for the periods from spring 2020 and onward were significant compared to baseline (d_{av} = 0.15–0.46, MD = 3.40–11.99), suggesting that overtime hours increased by around 1–4 hours per month on average following the onset of the pandemic. A clear peak in average overtime hours was visible in December 2021–February 2022 (Figure B1, appendix B). Among those who had worked overtime, a clear majority had worked <25 hours of overtime in each three-month period. However, during the pandemic, a larger proportion of these participants had worked >25 hours of overtime in each period (see figure B2, appendix B).

Very long work weeks (>48 h) and very long shifts (>12 h)

Having a very long work week (>48 h/week) was fairly common, with between 62% and 82% of the participants having worked very long weeks during the study period

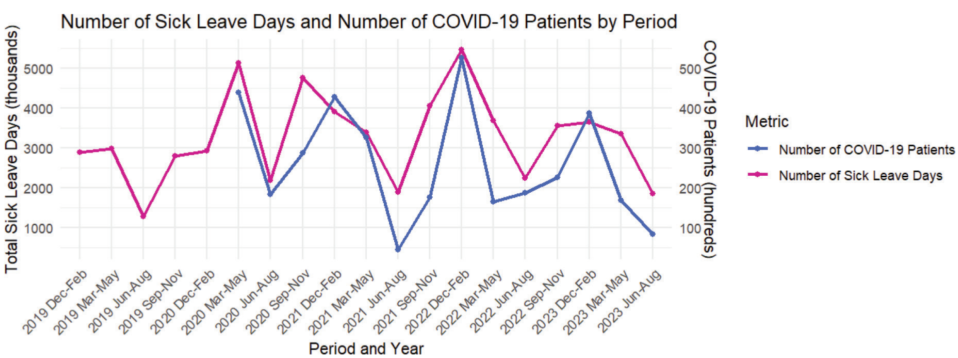
(M = 70) (See figure B3, appendix B). Between 7% and 22% (M = 13) of participants had at least 25% very long work weeks over a three-month period, equivalent to one week per month. The proportion of participants who worked >25% long work weeks was higher during the summer periods, and the lowest in spring 2020 when 4-2 schedules were used (see Figure B4, appendix B). When conducting paired *t*-tests to compare the prevalence of very long work weeks, five of the tests showed a significant decrease for the periods following the onset of the pandemic compared to baseline (d_{av} = 0.12–0.38). The largest decrease (d_{av} = 0.38) was during spring 2020 when 4-2 schedules were used.

Less than half of the participants had worked very long (>12 h) work shifts, while the prevalence appeared to increase slightly following the onset of the pandemic (see figure B5, appendix B). However, it was almost exclusively ambulance personnel who worked a high proportion (>25%) of very long shifts. When removing ambulance personnel, it appeared that the proportion of participants who had worked any very long shifts over a three-month period was slightly higher following the onset of the pandemic, and most prevalent during summer and winter periods (see figure B6, appendix B). When conducting paired *t*-tests on the prevalence of very long shifts, four out of the 15 tests were significant, of which three showed a significant decrease, and one showed an increase. The differences were however very small (d_{av} = 0.05–0.07).

Sick leave

The number of sick leave days was, on average, higher following the onset of the pandemic and followed a pattern very similar to the number of patients with confirmed COVID-19 infection admitted to inpatient care within the region (Figure 7).

Figure 7 Total number of sick leave days and the number of patients with confirmed COVID-19 admitted to inpatient care within the region.



Differences between wards

There were fluctuations in the number of nursing staff who worked in wards where COVID-19 patients were primarily treated, versus in the control wards. The number of nursing staff working in wards where COVID-19 patients were treated was higher during the pandemic than before (see figure B7 in appendix B). The mean average weekly working hours were slightly higher in the wards where COVID-19 patients were treated compared to the control wards during the pandemic (see figure B8, appendix B). There were no major differences in average shift length between COVID- and control-wards (see figure B9, appendix B). The proportion of long work weeks was slightly higher in the COVID-wards than in the Control-wards, prior to the pandemic as well. The proportion of long work weeks was lowest overall (irrespective of ward type) in 2020, when 4-2 schedules were used (see figure B10, appendix B).

Discussion

We found little support for our hypotheses, with little change observed in objective working hours following the onset of the COVID-19 pandemic. There was minor variation in objective working hours, for example, proportion of night shifts showed a weak increase, whereas proportion of quick returns showed a weak decrease during COVID-19 pandemic. Overall, this suggests that the ergonomic qualities of work schedules were only marginally affected during the pandemic as compared to before the onset (2018–2019), when looking at the group level. However, there were some indications that work hours changed initially. Below follows a detailed discussion of the results including possible consequences for health, safety, and well-being.

Changes in the length of working hours following the onset of the pandemic

There were no major changes observed in either weekly working hours, shift length, or length of night shifts. Thus, the results do not support H1, which was that the length of working hours increased during the COVID-19 pandemic. Some tests showed significant differences, mostly trending toward decreases in the length of working hours following the onset of the pandemic. The differences were extremely small and likely lack relevance in terms of health and safety at the group level. However, it is important to note that the weekly working hours could be impacted by sickness absence, which increased during the pandemic. While weeks where participants had been completely absent from work were omitted in the calculations, being absent for part of a week would decrease the weekly working hours. This could partially explain why the weekly working hours did not increase despite that there was an increase in overtime hours.

Most literature focusing on adverse health and safety consequences highlights increasing risks for working hours exceeding 55 h per week or 10–12 h per shift (Fischer et al. 2017; Matre et al. 2021). The results in the present study show that the mean weekly working hours and shift length were well below those thresholds on average, and that very long shifts were uncommon outside of ambulance operations. However, it should be noted that increased patient safety risks have been found in healthcare settings when exceeding 40 weekly working hours (Olds & Clarke 2010). While thresholds may vary, it is important to take the context of the pandemic into consideration, and findings from the pandemic have highlighted that nurses working >40 hours per week reported higher levels of fatigue (Sagherian et al. 2023). Nurses have also been subjected to stressors such as high workload, uncertainty and lack of knowledge on how to treat patients, and limited opportunities for rest breaks during the workday (Escher et al. 2023; Sagherian et al. 2023). Thus, it is possible that thresholds for sustainable work hours identified in previous studies (Härmä et al. 2020) do not transfer well to the context of a crisis, such as a pandemic. More research is needed to further identify relevant thresholds for working hours in relation to health and safety during a crisis.

Effects on the proportion of night shifts

Our results provide tentative support for H2, that the proportion of night shifts increased following the onset of the COVID-19 pandemic. Most tests showed a significant increase in the proportion of night shifts, but the differences were equivalent to only a few percentage points on average. At the group level, these findings likely lack relevance in terms of health and safety; however, it is possible that some participants had a larger increase in night work, driving the differences at group level. Qualitative findings from the region under study suggest that some individuals who started working night shifts, or worked more night shifts, during the pandemic experienced sleep problems as a result (Hernandez et al. 2024b).

Effects on shift intensity

There was little evidence in support of H3, that shift intensity increased during the pandemic. On the contrary, we found that shift intensity, in terms of quick returns and short recovery after the last night shift, decreased. The most prominent decrease in the proportion of quick returns was in spring 2020 when 4-2 schedules were used with a clockwise pattern. The mean proportion of quick returns also remained lower during the summer of 2020 compared to 2019, after a counterclockwise pattern was introduced in some wards. This could be considered positive, as quick returns have been associated with an increased risk for short sleep and fatigue (Öster et al. 2024; Vedaa et al. 2016).

Analyses of the other measures of shift intensity showed some support for H3, albeit weak. There were only a few significant differences in the number of consecutive workdays, mostly during the spring and summer period of 2020, when 4-2 schedules were used. This was expected as the 4-2 schedules entailed regularly working four days in a row, while there may be more variation in the number of consecutive shifts in PWTS. Analysis of the number of consecutive night shifts showed that for most periods, there were significant increases. These were, however, very small, equivalent to only a fraction of a shift, with the average number of consecutive night shifts remaining around one across all periods. Thus, at the group level, it does not appear that multiple consecutive night shifts were common. There were participants who rarely worked night shifts which likely impacted the means.

There was a small decrease in the proportion of short recovery after the last night shifts when 4-2 schedules were used. Otherwise, most tests were non-significant, with the results suggesting that short recovery periods after the last night shift remained uncommon despite the pandemic. This could be considered positive, as previous research has highlighted the importance of having more than one night off after having worked night shifts, to promote good sleep and support sufficient recovery between work periods (Totterdell et al. 1995).

Effects on weekend work and free days

We found some support for our hypothesis that weekend work increased during the pandemic (H4), but only when 4-2 schedules were used. This is in line with qualitative findings showing that a negative aspect of 4-2 schedules was that increased weekend work limited possibilities for social activities, such as spending time with family and friends (Hernandez et al. 2024a, 2024b). Other findings have suggested that weekend work is associated with increased work-family conflict (Laß & Wooden 2022). A study of nurses showed that having two days off during weekends as compared to the middle of the week was associated with higher vigor and lower emotional exhaustion upon returning to work (Drach-Zahavy & Marzuq 2013). Thus, increased weekend work could be considered a negative aspect of 4-2 scheduling.

The proportion of single free days decreased during the pandemic which does not support H4, suggesting that participants were more likely to have two or more consecutive days off work following the onset of the pandemic. It is however important to note that participants in a previous study described two days off as too little during the pandemic, given the demanding work environment (Hernandez et al. 2024b). We found no evidence for H5, that the total number of free days decreased during the pandemic, after correcting for absence due to sick leave, parental leave, military duty, etc.

The different scheduling solutions

We found some support for H6, with results showing that working on PWTS compared to the 4-2 schedules was associated with higher shift intensity in terms of increased quick returns and short recovery after the last night shift. However, to put this into perspective, these parameters did not differ significantly from baseline levels. Thus, the findings appear to be more related to the 4-2 schedules than to the pandemic itself. At the same time, the number of consecutive workdays and proportion of weekend work was lower when using PWTS, which implies that some aspects of shift intensity decreased compared to when 4-2 schedules were used. There was no difference between the schedules with respect to the length of working hours.

It appears that the factor that had the most impact on working hours overall was the use of 4-2 schedules. The largest effect sizes found across all tests were for the increase in weekend work in spring 2020 (d_{av} = 0.68) and a decrease in single free days during summer 2020 (d_{av} = 0.85), highlighting the impact of these schedules. As mentioned, increased weekend work has been described as problematic by nursing staff due to its impact on non-work life (Hernandez et al. 2024b). Thus, perhaps the most significant practical implication of the present study may be to pay special attention to weekends when scheduling working hours during a crisis. The proportion of weekends worked was around 50% during most of the periods. Not exceeding this level could be important to minimize the risk of negative consequences on the private lives of nursing staff and to support recovery (Drach-Zahavy & Marzuq 2013; Laß & Wooden 2022).

Exploratory findings

Following the onset of the COVID-19 pandemic, the average number of overtime hours increased by around 1–4 hours per month. While this may be a relatively small increase at group level, results also show that more individuals worked >50 h overtime. Overtime has been associated with higher risks of making mistakes, as well as reporting poor quality of care and patient safety, but is often enmeshed with long working hours in the literature (Dall'Ora et al. 2016). A study of nurses concluded that an onset of high overtime during the pandemic (i.e. transitioning from <1 h to >2 h of overtime per day) was associated with increased symptoms of burnout (Giusti et al. 2024). Thus, at least some of the participants may have been at risk of negative consequences due to increasing overtime.

There were no apparent differences in work hours between the different types of wards over the course of study period. Very long work weeks were slightly more common in 'COVID-wards' (e.g., intensive care units, infection clinics). However, this difference was also visible prior to the pandemic, suggesting that nursing staff in wards such as intensive care are always more exposed to very long work weeks.

Lastly, there was an increase in sick leave days during the pandemic. As previously discussed, this may have affected our measure of weekly working hours, and therefore also the proportion of very long working weeks, which did not increase either.

Trends across the study period

There were no clear trends in working hours across the years examined. It does not appear that the working hours were more affected in the early phases of the pandemic (aside from when 4-2 schedules were used) than later on, when it could be assumed that the most acute phases of the pandemic were over. The proportion of night shifts, number of consecutive night shifts, and overtime remained higher compared to baseline across the entirety of the study. While it is likely that some aspects, such as treatment options for COVID-19 patients and planning of staff, improved in the latter phases of the pandemic, there may have been care queues to catch up with which maintained pressure on the healthcare system (Hernandez et al. 2024a). Sickness absence due to COVID-19 infection could also be a contributing factor, as sickness absence remained high throughout the pandemic and afterwards.

A notable finding, although outside the scope of the present study, was that there were more consecutive workdays, quick returns, and very long work weeks during the summer periods. This is consistent with previous findings, which found that vacation was offered at the expense of employees having to work more demanding schedules during summer (Hernandez et al. 2024a). The potential implications that this may have for health and safety should be addressed in future research. The current findings also indicated a lower proportion of night shifts, which could be due to some types of care (e.g., surgeries) being reduced during summer/vacation periods.

Summary

The findings indicate that there were no major changes in working hours during the COVID-19 pandemic in this region, at least not at group level. The use of 4-2 schedules appears to have had the most impact on the working hours. When comparing results from the present study with the previous paper by Härmä and colleagues (2015), it is evident that our sample means are in many cases similar to theirs. This suggests that our results reflect working hours that are rather common for this occupational group. However, it does not necessarily mean that the working hours were ideal but rather highlights that some aspects of working hours in the healthcare sector may be suboptimal irrespective of whether there is a pandemic or not.

Limitations

There are several limitations of the current study that should be noted. First, there are limitations regarding the analysis and processing of the data, as well as the data structure itself. Second, objective work hour data are limited in its ability to capture key factors that determine the ergonomic qualities of work schedules.

Perhaps the most important limitation of the current study is the large number of paired *t*-tests performed, posing a risk for type I error. While a Benjamini-Hochberg correction was applied to adjust for multiple comparisons, somewhat reducing that risk, significant test results were obtained even when the differences were very small. This suggests that there may be false positive results due to extensive testing and relatively large sample sizes, and that the significant differences in working hours should be interpreted cautiously. There are also many significant tests which likely lack practical relevance.

Objective work hour data are very complex, and it was sometimes necessary to make assumptions about data due to lack of information. For example, participants were included according to the number of weekly hours and shifts they worked in each period, but the data did not specify if the participants were full-time, part-time, or hourly based employees. Consequently, the sample may include hourly based employees who worked many hours during some periods, but who otherwise would not meet the study's inclusion criteria. However, due to lack of contractual information on the participants, it was necessary to make this assumption.

The working hour data were obtained from a payroll system that is designed with the primary purpose of providing employees with the right pay, rather than for registering work hours in accordance with the purposes of the current research. For example, the datafile of hourly based compensation did not differentiate between shifts worked by hourly employees and extra shifts worked by permanent employees. As there was insufficient information to tell these shifts apart, the shifts recorded in this datafile were not included when looking at overtime, likely resulting in an underestimation of overtime. Thus, the structure of the data itself should be considered a limitation.

While it is evident that the average overtime hours increased among those who worked overtime, which was around 80% of the total sample, this increase is not visible in other parameters which should also reflect overtime (e.g., shift length, weekly working hours, proportion of long weeks). One limitation in this regard is that overtime hours were analyzed separately, making it impossible to account for potential compensatory time off at another timepoint. Thus, one possibility is that the increase in overtime to some extent reflects reorganization of shifts, rather than increased work hours.

The large standard deviations observed in the work hour data suggest large variations in the data, and some individuals may have experienced substantial changes in their working hours during the pandemic, which are not detectable when looking at the results at the group level. Thus, an implication for future studies could be to take a more person-centered approach or focus on identifying different patterns or profiles of work hour characteristics (Garde et al. 2018; Rosenström et al. 2021).

The work hour data were derived from only one Swedish region. Thus, the results regarding how working hours were (or were not) impacted by the pandemic should be generalized cautiously. Qualitative findings suggest that the working hours in the region under study were less negatively affected than in other regions, such as those utilizing the crisis agreement which extended shifts to 12 h and weekly hours up to 48 h (Hernandez et al. 2024b). Instead of adopting the crisis agreement, the region under study opted for a scheduling solution which changed the scheduling pattern rather than increasing the working hours (Hernandez et al. 2024a). This is confirmed by the present findings, both in terms of lack of changes in working hours at group level, along with the observed changes in weekend work, quick returns, and free days during the periods when 4-2 schedules were used. This is in line with other qualitative findings (Hernandez et al. 2024b). Thus, the absence of changes in working hours may reflect the region having been less affected by the pandemic compared to other regions, thereby limiting the need to increase the working hours.

The apparent lack of changes following the onset of the pandemic may reflect the presence of ergonomically poor schedules during the year preceding the pandemic, for example, due to lack of staffing and periods of very high workload (e.g., caused by peaks in seasonal flu) in 2018–2019. To this end, the design of the current study would have been strengthened by explicitly comparing periods before, during and after the pandemic. However, while it can reasonably be argued that the current data includes the 'post-pandemic era', it is less easy to specify the point of transition from pandemic to post-pandemic. Hence, the decision was taken to restrict the current analyses to comparing before and after the onset of the pandemic.

Lastly, the absence of substantial effects observed in the current results may reflect a key shortcoming of objective work hour data. By its very nature, such data do not capture subjective factors that may negatively impact individuals, such as influence and volition in relation to working hours. For example, previous findings have suggested that mandatory overtime is more strongly related negative consequences than voluntary overtime (Beckers et al. 2008; Watanabe & Yamauchi 2018), and influence over working hours may serve as a buffer against work-related stress by improving balance between work and leisure (Nijp et al. 2012). Qualitative findings from the pandemic indicated that reduced work time control, unpredictable work hours, and blurred boundaries between work and leisure negatively impacted the health and well-being of nursing staff (Hernandez et al. 2024b).

Objective work hours are also limited in terms of capturing contextual factors, such as how demands in the work environment may increase the need for recovery between shifts. It has previously been highlighted that shift work research often fails to include such factors, which could be a reason why there are inconsistent results in literature, for example, when it comes to negative consequences of working 8 vs. 12-h shifts (Ferguson & Dawson 2012). It is important to note that previous qualitative findings in this setting have indicated that the working hours were perceived as too demanding, given the increasingly challenging work environment during the pandemic (Hernandez et al. 2024b). It has also been previously reported that staff working with patients with infectious diseases preferred working shorter shifts (Gao et al. 2020; Lehmann et al. 2015; Zhang et al. 2021). This could indicate that individuals' tolerance toward working demanding working hours is affected by the work context and stressors in the work environment. As a result, a demanding work situation may create greater needs for recovery. The interaction between working hours and work environmental demands should be examined further. Previous research around working hours has mostly been conducted outside of contexts such as the pandemic. The thresholds described in previous studies, regarding the length of working hours or the number of free days (Härmä et al. 2015), may not be directly transferrable to a crisis situation.

Conclusion

Overall, it appears that the ergonomic qualities of the work hour schedules in one Swedish mid-size region were relatively unaffected by the COVID-19 pandemic, when looking at data on group level. However, the initial use of 4-2 scheduling during the pandemic had a significant impact on some aspects of working hours of nursing staff, by substantially increasing weekend work and decreasing the proportion of quick returns and single free days. The analyses in the present study may not have been an optimal approach to evaluate changes in working hours over time, as they do not account for variations between individuals or how employees perceive their work hours. Objective work hour measures do not account for other important aspects which can also contribute to negative outcomes, such as the level of influence, volition, and work demands. Taking these aspects into account may be important when investigating working hours.

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