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Research Article

Working Conditions and Fatigue in Japanese Shift Work Nurses: A Cross-sectional Survey

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SUMMARY

Purpose: This study aimed to identify the working conditions (working hours, overtime work, number of night shifts, number of holidays, and work intervals) associated with fatigue, based on the shift patterns, and determine their thresholds.

Methods: From January to February 2020, a web-based questionnaire was sent to 4601 shift work nurses at 47 hospitals in Japan. The multivariate logistic analysis was conducted to predict high- and low-fatigue groups by working conditions, and receiver operating characteristic analysis was performed to clarify the high-fatigue thresholds by shift pattern.

Results: A total of 386 shift work nurses participated in this study. The threshold (fatigue was 3.0 or higher) of the two-shift rotation was 9 hours 50 minutes for daily working hours during day shifts (Odds ratio [OR] = 1.57, $p < .01$), 17 hours 15 minutes for daily working hours during night shifts (OR = 1.20, $p < .01$), and 8.0 days for the number of night shifts (OR = 1.09, $p = .02$). The threshold of the three-shift rotation was 9 hours 45 minutes (OR = 1.59, $p < .01$), 2.9 days for the number of midnight shifts (OR = 1.53, $p < .01$), and 2.0 times for the interval between day-shift and night-shifts within 12 hours (OR = 1.39, $p < .01$).

Conclusion: Working hours and the number of night shifts are important for two-shift rotation, and working hours for the assignment of midnight shift are important for three-shift rotations. Nurse managers should manage shifts according to nurses' shift patterns.

Introduction

Fatigue is defined as a condition in which individuals experience a decreased ability to perform activities at the desired level due to mental and/or physical lassitude or exhaustion [1,2]. Fatigue in nurses has a negative impact on them and patient care. According to prior research, fatigue in nurses is related to their performance [3,4], wellness [5], care outcomes related to nurses' satisfaction [6,7], health [8,9], quality of care [10], and patient safety [11,12]. Moreover, long-term fatigue leads to severe physical and mental health problems [2]. Shift work disrupts circadian rhythms and leads to fatigue [13]. Therefore, the prevention of fatigue is important for both health care of the nurses and sustaining high-quality care.

There have been many reports on working conditions that induce fatigue in shift-work nurses. Recent reviews by Gifkins et al. [14] and Min et al. [15] identified shift work arrangement (consecutive and night shifts), length of shifts, overtime, rotating shifts, quick returns, high work demands, and the number of night or evening shifts as work conditions that cause fatigue. It has also been reported that night shifts are associated with sleepiness and that counterclockwise shift rotation lowers sleep quality [16,17]. In other words, working hours per shift, overtime, the number of night shifts, inadequate recovery period, and counterclockwise shift rotation are important factors of fatigue among shift nurses.

Meanwhile, the results of previous studies on the length of shifts are not consistent. Generally, longer working hours are associated with higher fatigue levels [14,15], but there have also been reports of lower fatigue in 12-hour shifts than in 8-hour shifts [17]. A review of studies of Japanese nurses found that the length of working hours was associated with fatigue, but that two-shift workers who

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worked 16-hour night shifts reported less fatigue than three-shift workers [18]. Thus, the findings on the length of working hours are not consistent. This is because the number of hours worked in each shift varies across countries (e.g. 12 hours in European countries, 8 and 16 hours in Japan) [19–21]. Furthermore, if the number of hours worked per month is held constant, the length of each shift is a trade-off between the number of hours worked and the number of days off or intervals between work [20]. That is, each element of work conditions depends on the rotation type and is interrelated. In addition, factors such as quick return and counterclockwise shift rotation are more characteristic of three-shift rotation than of two-shift rotation [22–24]. Recovery from fatigue requires sufficient holidays, but the factors causing fatigue and their corresponding effects may differ between nurses who work without sufficient holidays and those who are given sufficient holidays. Therefore, the work conditions that lead to fatigue may differ depending on the rotation pattern and the number of holidays. In addition, the threshold values of these factors are unknown.

The Japan Nursing Association has published guidelines for shift work nurses in Japan [25]. The guidelines provide recommendations on appropriate working hours, the number of night shifts per month, and enough holidays, but due to insufficient nurse staffing, it is difficult to implement all of these recommendations. Nonetheless, nurse managers must assign adequate shift work to nurses to protect their health and ensure stable and high-quality care. For more specific and efficient work environment management, evidence for accurate reference points (thresholds) that link shift work to fatigue, which in turn affects nurses' physical and mental health, is needed. Therefore, the purpose of this study was to identify the working conditions (i.e., working hours, overtime work, number of night shifts, and number of holidays) associated with fatigue, based on the shift patterns (two or three rotations) and the number of holidays (more or less groups), and determine the threshold of the associated working conditions.

Methods

Study design

This study is a cross-sectional study.

Survey setting and period

To conduct the logistic analysis accurately, the sample size needs to be ten times more than the events [26]. Since we presumed that five independent variables were to be entered this time, at least 50 samples were required. However, to reflect nationwide work conditions and fatigue and minimize sampling bias (e.g., location, bed size, and hospital function), we requested more target hospitals to participate in this study.

Through convenience sampling, 11 hospitals consented to participate; however, due to the bias related to bed size and region, additional hospitals were randomly selected from the list of hospitals nationwide. Using random sampling to include staff nurses working in hospitals of various bed sizes, we categorized the target hospitals as follows: under 99 beds, 100–199 beds, 200–299 beds, 300–399 beds, and over 400 beds. To avoid bias related to the number of nurses included in each bed size category, extractions and requests were repeated until the number of documents distributed in each bed size category reached 1000 shift work nurses. We sent the informed consent documents to the nurse administrators at the selected 338 hospitals, of which, 47 hospitals were ultimately included in this study, as they provided consent. The login information (explanation documents, URL, and QR code for login) for the online survey was distributed to participants via the nurse administrators of these hospitals, and the participants logged in at their discretion and answered the web-based anonymous self-report questionnaire. The survey was conducted from January to February 2020.

Participants

The participants to whom the questionnaires were distributed were 4601 nurses working in the target hospital. The inclusion criteria were full-time or part-time nurses who worked in shifts. The exclusion criteria were nursing managers, schedulers, and newcomers within 6 months.

Measurements

Fatigue

Fatigue was assessed by the Brief Job Stress Questionnaire developed by Shimomitsu et al. [27]. It comprehensively measures workplace stressors and stress reactions, and is widely used to conveniently measure job stress among Japanese workers including nurses, because of its use being recommended by the Ministry of Health, Labor and Welfare [28]. In this study, we used the "fatigue" subscale. It comprises three items, assessed on a 4-point Likert scale ranging from 1 = '*almost never*' to 4 = '*almost always*' Item examples include 'I am very tired,' 'I feel exhausted,' and 'I feel languid.' The reliability and validity of the overall scale and its subscales were previously verified by Shimomitsu et al. [27]. The average score of this scale is expressed as a value between 1.0 and 4.0. Those with an average score of 3 or more always perceive at least two items as high fatigue, which suggests that they are in a state of fatigue on a daily basis. The manual for this scale recommends that 3.0 or 4.0 be judged as having a stress reaction as a simple measure of stress response [27]. Therefore, in this study, 3.0 was set as a cutoff and used to divide participants with either high or low fatigue categories. The Cronbach's α of this subscale was 0.912 in this study.

Work conditions

To measure daily working hours, participants were asked their daily start and end time for each shift pattern (day, night, evening, and midnight shifts)—an example of the item regarding this is '*At what time did you start/end [day shift] in the past month?*' In addition to measuring daily overtime working hours, we asked for the start and end times set by their facilities for each shift pattern—an example of an item regarding this is '*According to the rules of your hospital, what time does the shift [day shift] have to start/end?*'. In this study, the difference between daily working hours and working hours set by their facilities was considered daily overtime work.

To confirm the number of days of night shifts (including evening and midnight shifts) and holidays (including a day off and requested rest days) per month, participants were asked the number of days of night shifts and holidays in their latest schedule—an example of the item regarding this is '*How many days have you been assigned [day shift] in the past month?*'. In Japan, in the two-shift rotation, the night shift is generally from approximately 17:00 to 9:00 the following morning. However, in the three-shift rotation, the evening shift is from 16:00 to 0:00, and the night shift is from 0:00 to 8:00. In other words, the night shift of the two-shift rotation is equivalent to two days when converted to the three-shift rotation. Therefore, for the two-shift rotation, one night shift was counted as two days. We converted them into days per 30 days

since the schedule span was different for each participant. A short interval between work hours hinders recovery from fatigue and leads to a stress response. According to the Japan nursing association's guidelines [25], for two-shift rotations, it is recommended to have an interval of 24 hours or more after the night shift, and for three-shift rotations, it is recommended to have an interval of 12 hours or more for inter-working intervals. Therefore, we asked the number of times of inter-working intervals in the latest schedule that were less than 24 hours for the two-shift rotation or 12 hours for the three-shift rotation—an example of an item regarding this is '*How many quick returns have you experienced within 24/12 hours in the past month?*'

Additionally, we asked participants to provide their age, sex, nursing experience (years), and marital status as demographic characteristics.

Statistical analysis

We calculated descriptive statistics to verify the relationship between work conditions and fatigue. The bivariate logistic analysis was conducted with each work condition variable as the independent variable and the fatigue group (high or low) as the dependent variable. The multivariate logistic regression analysis (stepwise method) was performed to identify the work conditions associated with high-level fatigue in each rotation type (two- or three-shift rotation) and the number of holidays (fewer than 10 holidays per month and 10 or more holidays per month; this is because Japanese nurses are assigned approximately 10 holidays per month [21]). At each step of the analysis, socio-demographic variables (age, sex, and marital status) and work conditions were entered. Variables entered in the two-shift rotation model included daily working hours per day shift, daily working hours per night shift, daily overtime work per day and night shift, number of night shifts and holidays per month, and interval between workdays within 24 hours. Variables entered in the three-shift rotation model included daily working hours during the day, evening, and midnight shifts, daily overtime work during day, evening, and midnight shifts, number of evening and midnight shifts holidays per month, and interval between workdays within 12 hours (evening shift to day shift, and day shift to midnight shift). The variables entered in less than 10 holidays model and 10 or more holidays model included daily working hours during day and night shifts, daily overtime work per day and night shift, and number of night shifts and holidays per month. In the stepwise method, the inclusion criteria were $p < 0.05$, and the exclusion criteria were $p > 0.1$. After that, to determine the threshold of the working conditions associated with high fatigue, predictive probabilities were calculated for each variable. The points with maximum sensitivity and specificity were searched by a receiver operating characteristics (ROC) analysis for each rotation type or the number of holidays. Missing data were excluded from all analyses.

Ethical considerations

The questionnaire was completed anonymously. Participants were provided with documents that explained the ethical considerations of this survey, and they were informed that participation was voluntary, and nonparticipation would not cause them any disadvantages. After reading the documents, if participants agreed to complete the survey, they logged in to the survey screen on the web and checked a box at the top of the questionnaire to confirm their consent. Those who did not agree were not shown the survey screen and were not asked to respond. This study was approved by the Research Ethics Committee of the Graduate School of Medicine, the University of Tokyo (No. 2019142NI).

Results

Participants' characteristics

Table 1 shows participant characteristics. Of the 4601 shift work nurses, 640 logged onto the website for the survey. After excluding those who declined to participate or were managers or schedulers (74 people), 566 nurses were included. Finally, after excluding newcomers (e.g., recently arrived nurses or nurses transferred within six months) and surveys with missing data (180 surveys), the data of 386 nurses were analyzed (Figure 1).

The average age of participants was 36.5 years and approximately 90% were female. The average number of years of nursing experience was 13.1. There were 58, 66, 89, 86, and 87 nurses for under 99 (15.1%), 100–199 (17.1%), 200–299 (23.1%), 300–399 (22.3%), and 400 beds (22.5%), respectively. Approximately half of all the participants were in the high-fatigue group, and the proportion was high in the three-shift rotation group. The start and end times of each shift varied according to the rules of their hospital, but the mode of two-shift rotation was 8:30 (63.2%) for the start time and 17:00 (30.5%) for the end time of the day shift. The mode of the night shift was 16:30 (39.9%) at the start time and 9:00 (29.8%) at the end time. The mode of the three-shift rotation is 8:30 (98.5%) for the start time of the day shift, 17:15 (64.6%) for the end time, and 16:30 (80.0%) for the start time of the evening shift. The end time was 1:00 (55.4%), the start time of the midnight shift was 0:30 (75.4%), and the end time was 9:15 (43.1%). Daily working hours during day shifts were 9 hours 53 minutes for the two-shift rotation and 9 hours 40 minutes for the three-shift rotation. Daily working hours during the night shifts of the two-shift rotation were 17 hours 08 minutes, and that of the evening and midnight shifts for the three-shift rotation were approximately 9 hours 30 minutes. Overtime hours were approximately one hour for each working shift for both shift rotations. The average number of days of night shifts per 30-day period was 8.5, with two-shift rotations slightly higher. The average number of days of holidays per month was 10.3.

Multivariate logistic analysis

The results of the multivariate logistic analysis have been presented in Table 2. In all models, the variance inflation factor for all variables was less than 2.0; thus, there was no problem of multicollinearity. Variables associated with high fatigue were selected via the inclusion and exclusion criteria for a stepwise method. The controls and socio-demographic variables were excluded from all models.

For the two-shift rotation, daily working hours during day shifts, daily working hours during night shifts, and the number of days of night shifts were significantly associated with high fatigue (OR = 1.57, $p < .01$; OR = 1.20, $p < .01$; OR = 1.09, $p = .02$, respectively). For the three-shift rotation, daily working hours during midnight shifts, number of days of midnight shifts, and the interval between workdays within 12 hours (day shift to midnight shift) were significantly associated with high fatigue (OR = 1.59, $p < .01$; OR = 1.53, $p < .01$; OR = 1.39, $p < .01$, respectively).

For the group with fewer than 10 days of holidays per month, daily working hours during day shifts, daily working hours during night shifts, and the number of days of night shifts were significantly associated with high fatigue (OR = 1.41, $p < .01$; OR = 1.21, $p < .01$; OR = 1.11, $p < .01$, respectively). For the group with 10 or

Table 1 *Participant Characteristics and Descriptive Statistics.*

	Two-shift rotation (n = 321)			Three-shift rotation (n = 65)		
	Mean or n	*SD* or %		Mean or n	*SD* or %	
Age	35.67	10.07		40.35	9.41	
Gender						
Women	285	88.8		56	86.2	
Men	36	11.2		9	13.8	
Nursing experience (years)	12.35	9.45		16.60	9.04	
Marital status						
Unmarried	168	52.3		23	35.4	
Married	134	41.7		35	53.8	
Other	19	5.9		7	10.8	
Number of beds at unit	40.99	12.20		40.60	11.70	
Fatigue						
Low	178	55.5		26	40	
High	143	44.5		39	60	
	Mean	(Min–Max)	*SD* or %	Mean	(Min–Max)	*SD* or %
Work conditions						
Working hours (per shift)						
Day shift	9:53	(8:15–13:20)	0:56	9:40	(8:30–12:00)	0:41
Night shift[a]	17:08	(10:30–19:45)	1:28	–	–	–
Evening shift[b]	–	–	–	9:25	(7:00–11:30)	0:44
Midnight shift[b]	–	–	–	9:46	(8:30–14:45)	0:57
Overtime work (per shift)						
Day shift	1:13	(0:00–4:34)	0:53	1:00	(0:00–3:15)	0:42
Night shift[a]	0:57	(0:00–3:15)	0:38	–	–	–
Evening shift[b]	–	–	–	0:52	(0:00–3:00)	0:38
Midnight shift[b]	–	–	–	0:51	(0:00–2:39)	0:37
Number of night shifts (days per month)						
Night shift[a]	8.69	(0.94–18.95)	3.09	–	–	–
Evening shift[b]	–	–	–	4.19	(0.00–10.65)	2.11
Midnight shift[b]	–	–	–	3.49	(0.00–7.74)	1.78
Number of holidays (days per month)	10.30	(1.50–17.14)	2.26	10.09	(1.50–14.52)	2.55
Interval between workdays (times per month)						
Within 24 hours[a]	0.38	(0.00–4.74)	0.80	–	–	–
Evening shift to day shift within 12 hours[b]	–	–	–	0.34	(0.00–5.00)	0.83
Day shift to midnight shift within 12 hours[b]	–	–	–	2.00	(0.00–6.00)	1.88

Note: SD: standard deviation, Min: minimum.
[a] Only two-shift rotation. For "Number of night shifts (days per month)," one night shift was counted as two days because the shift is spread across two days, from evening to the following morning.
[b] Only three-shift rotation.

more days of holidays per month, daily working hours during day shifts and daily working hours during night shifts were significantly associated with high fatigue (OR = 1.49, $p < .01$; OR = 1.25, $p < .01$, respectively).

ROC analysis

The ROC analysis was performed for variables that were significant in the logistic regression analysis; the results have been presented in Table 3.

The thresholds of daily working hours for day shifts, daily working hours for night shifts, and the number of night shifts for two-shift rotations were 9 hours 50 minutes, 17 hours 15 minutes, and 8.0 days, respectively. The thresholds of daily working hours for midnight shifts, number of midnight shifts, and the interval between workdays within 12 hours (day shift to midnight shift) for three-shift rotations were 9 hours 45 minutes, 2.9 days, and 2.0 days, respectively.

For the group with less than 10 holidays per month, the daily working hours for day shifts, daily working hours for night shifts, and the number of night shifts were 9 hours 20 minutes, 17 hours, and 8.0 days, respectively. For the group with 10 or more days of holidays per month, the daily working hours during day shifts and daily working hours during night shifts were 9 hours 10 minutes and 17 hours 50 minutes, respectively.

Discussion

Approximately 83.0% of the participants in this study had a two-shift rotation, and their daily working hours were 9 hours 52 minutes during day shifts and 17 hours 08 minutes during night shifts. In a European survey, 12-hour rotations were common [19]; however, in a two-shift rotation, which is mainly used in Japan, day shifts are shorter and night shifts are longer than European countries. Moreover, half of the study samples experienced high fatigue, and the ratio was high in the three-shift rotation group. In three-shift rotations, circadian rhythms are easily disturbed by evening shifts and midnight shifts, and recovery time is often required [13]; thus, this may be a type of shift work in which fatigue tends to accumulate despite the short working hours of the night shift.

This study revealed that the work conditions that are associated with high fatigue differ depending on the rotation pattern. A review article [14,15] showed that overtime and night shifts lead to fatigue. However, our study provides further insight as it identified the different factors that differ based on the shift patterns and influence fatigue in shift work nurses. In addition, our findings provided the threshold for each important work condition.

In the two-shift rotation, the number of night shifts per month and total working hours in the day and night shifts were significantly associated with high fatigue. Although some reports

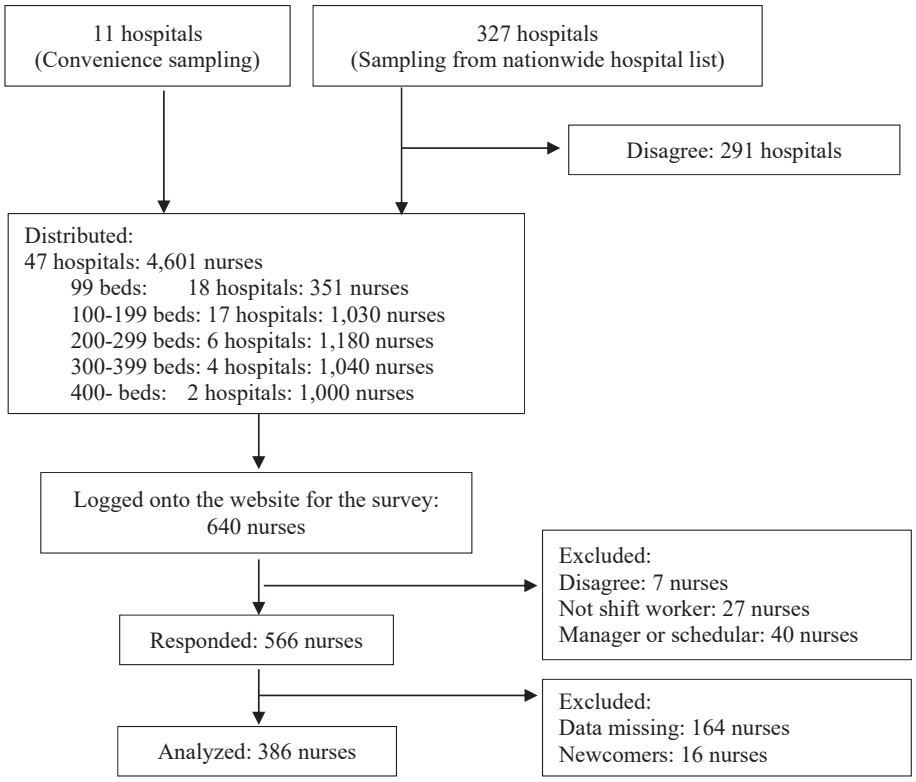

Figure 1. The process of participants selection.

indicate that nurses who work two-shift rotation shifts are more likely to recover from fatigue [29], the results of this study were consistent with the inferences of review articles [14,15], and indicated that long working hours could cause fatigue and health problems in nurses. In addition, the findings of this study imply that, in the two-shift rotation, day shifts should not exceed 9 hours and 50 minutes and night shifts should not exceed 17 hours and 15 minutes to prevent fatigue. Long day shifts to compensate for night shift hours—for example, 12-hour day shifts—might be inappropriate. Nursing organizations should adopt shift patterns other than the traditional day and night shifts to avoid long working hours. Additionally, nurse managers should monitor the total working hours rather than overtime hours and restrain nurses' night shift to no more than eight per month to prevent fatigue.

In three-shift rotation, the working hours and number of night shifts for midnight shifts were associated with high fatigue. This finding suggests that working hours and frequency of shifts—especially for midnight shifts—are important factors for consideration in three-shift rotations. A three-shift rotation consists of a diverse combination of three patterns: day, evening, and midnight, which is more likely to disrupt nurses' internal rhythm [13]. Working long hours at midnight, when they should be resting, and working frequent midnight shifts can easily cause fatigue, which in turn also affects their recovery. In addition, the number of short intervals from day shift to midnight shift being associated with high fatigue is the characteristic of three-shift rotations. Night shift and quick return negatively affect the circadian rhythm and subsequent recovery from fatigue [29–32], and day shift to midnight shift work involves a counterclockwise shift rotation, which does not follow circadian rhythms [33]. Quick returns from day shift to midnight should be more tightly restricted. Nurse managers in departments with three-shift rotations should pay particular attention to the working hours and frequency of midnight shifts and provide sufficient rest periods before and after midnight shifts to avoid fatigue among nurses.

For both groups with few and many holidays, daily working hours during day and night shifts were associated with fatigue. However, in the group with many holidays, there was no association between the number of days of night shifts and fatigue, but in the group with few holidays, this association was found. Furthermore, daily working hours during night shifts for the group with few holidays were shorter than those for the group with many holidays. It is important that nurses with fewer holidays manage their time by working shorter hours and fewer night shifts. Alternatively, it should be to secure enough personnel for everyone to take a holiday of 10 days or more a month.

Limitations

This study had some limitations. First, in the ROC analysis' results, both the area under the curve (AUC) and discrimination performance were low. The items related to work conditions are single items created for this study and were collected using a self-report questionnaire. Therefore, their reliability and validity are not verified. Real working hours data (e.g., time clock data) should be used to improve the results' accuracy. Second, a multivariate analysis for the other organizational factors was not conducted in this study. Therefore, the results did not consider the effects of other confounding factors associated with fatigue. Other organizational factors (e.g., quantitative/qualitative workload, job control, social support, and leadership) have been shown to influence stress responses, including fatigue. Future research may need to consider

Table 2 *Steps in the Multivariate Logistic Regression Analysis.*

	Odds ratio	95% CI	*P* value
Two-shift rotation			
Daily working hours (per shift)			
Day shift	1.57	1.21–2.04	<.01
Night shift	1.20	1.01–1.40	<.01
Number of night shifts (days per month)	1.09	1.00–1.18	.02
Three-shift rotation			
Daily working hours (per shift)			
Midnight shift	1.59	1.03–2.16	<.01
Number of night shifts (days per month)			
Midnight shift	1.53	1.28–1.78	<.01
Interval between workdays (per month)			
Day shift and midnight shift within 12 hours	1.39	1.05–1.72	<.01
Less than 10 holidays per month			
Daily working hours (per shift)			
Day shift	1.41	1.16–1.72	<.01
Night shift[a]	1.21	1.09–1.47	<.01
Number of day night shifts (per month)[b]	1.11	1.09–1.23	<.01
10 or more holidays per month			
Daily working hours (per shift)			
Day shift	1.49	1.05–2.10	<.01
Night shift[a]	1.25	1.03–1.51	<.01

Note: The dependent variable is fatigue (low fatigue = 0, high fatigue = 1). Independent variables were entered in the models using a stepwise method. The following variables were excluded by the stepwise method: Daily overtime work, number of holidays per month, and interval between workdays were excluded from the two-shift rotation model. Daily work hours per day and evening shift, daily overtime work, number of evening shifts and holidays per month, and interval between evening shift and day shift within 12 hours were excluded from three-shift rotation model. Daily overtime work and number of holidays were excluded from the group with fewer than 10 holidays model. Daily overtime work, and number of night shifts and holidays per month were excluded from the 10 or more holidays per month model. The control variables were excluded from all models. CI: confidence interval.

[a] For the three-shift rotation, the values used the sum of the evening and the midnight shift value.

[b] For "Number of days of night shifts (per month)" of two-shift rotation, one night shift was counted as two days because the shift is spread across two days, from evening to the next morning.

Table 3 *Receiver Operative Characteristics Analysis.*

	AUC	Threshold
Two-shift rotation		
Daily working hours (per shift)		
Day shift	0.63	09:50
Night shift	0.63	17:15
Number of night shifts (days per month)	0.65	8.00
Three-shift rotation		
Daily working hours (per shift)		
Midnight shift	0.60	9:45
Number of night shifts (days per month)		
Midnight shift	0.64	2.90
Interval between workdays (per month)		
Day shift and midnight shift within 12 hours	0.62	2.00
Less than 10 holidays per month		
Daily working hours (per shift)		
Day shift	0.62	09:20
Night shift[a]	0.59	17:00
Number of day night shifts (per month)[b]	0.64	8.00
10 or more holidays per month		
Daily working hours (per shift)		
Day shift	0.63	09:10
Night shift[a]	0.66	17:50

Note: The dependent variable is fatigue (low fatigue = 0, high fatigue = 1). In the notation "XX:YY," XX stands for hours and YY stands for minutes. Only those variables that were significant in the logistic regression analysis have been listed. AUC: area under the curve.

[a] The values for the three-shift rotation comprise the sum of the evening and the midnight shift values.

[b] With respect to the "number of days of night shifts (per month)" in the two-shift rotation, one night shift was counted as two days because the shift was spread across two days (from evening to the next morning).

these factors. Third, the response rate was low and there were a lot of missing data. This may be because there were many items, many nurses dropped out, and the survey was conducted during the year-end and New Year holidays, which are busy periods.

Conclusion

Our study clarified the relationship between work conditions and fatigue and presented the thresholds for each work condition related to fatigue in shift work nurses. For two-shift rotations, long working hours on both day and night shifts were associated with high fatigue. For three-shift rotations, daily working hours during midnight shifts, the number of days of midnight shifts, and quick returns from day shift to midnight were associated with high fatigue. Additionally, our study identified the difference in threshold between the group with few holidays and the group with many holidays. The results of our study provide specific reference points in labor management when assigning shifts on different wards and when adjusting nursing staff schedules.

Our study showed that each shift rotation pattern has different working conditions necessary to avoid fatigue. In addition, their thresholds were identified. Based on our findings, nurse managers should mainly pay attention to total working hours in two-shift rotations, protect the health of shift work nurses. In three-shift rotations, they should mainly consider the working hours, frequency, and assignment of midnight shifts. In addition, being aware of these factors and thresholds related to nurses' work life for each shift pattern can help them manage and avoid fatigue.

Author contributions

Study design: Ryohei Kida, Yukie Takemura, Data collection: Ryohei Kida, Yukie Takemura, Data analysis: Ryohei Kida, Manuscript writing: Ryohei Kida, Yukie Takemura.

Conflict of interest

There are no conflicts of interest to declare.

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