Latent Classes of Circadian Type and Presenteeism and Work-Related Flow Differences Among Clinical Nurses: A Cross-Sectional Study

Xiaofei Kang[1], Lijuan Yang[2], Linjing Xu[1], Yang Yue[1], and Min Ding[1] ✉

[1]Department of Critical Care Medicine, Shandong Provincial Hospital Affiliated to Shandong First Medical University, Jinan, China
[2]Department of Nursing, Shandong Provincial Hospital Affiliated to Shandong First Medical University, Jinan, China

Objective   To classify the characteristics of circadian type among clinical nurses and examine their relationships with presenteeism and work-related flow.

Methods   Using a cross-sectional design, 568 nurses were recruited through convenience sampling in January 2021 from three hospitals in Shandong Province, China. The data were collected using self-report measures, including the 11-item Circadian Type Inventory, Stanford Presenteeism Scale-6, and Work-Related Flow Inventory. Latent class analysis was performed to identify any clustering of circadian types. One-way analysis was performed to compare the differences between presenteeism and work-related flow in different circadian types.

Results   Four latent classes were identified, including high response class (14.4%), high flexible class (20.1%), high languid class (51.1%), and low response class (14.4%). Regarding presenteeism, the high languid class had higher scores than others. Regarding work-related flow, the scores of high flexible class were higher than those of high languid class, while the differences in all three dimensions were statistically significant.

Conclusion   Although the shift work mode is not expected to change, nursing managers could use circadian type as a predictive index to select and employ individuals for shift work to enhance work performance and provide sufficient support to staff who are intolerant to shift work.   **Psychiatry Investig 2022;19(4):311-319**

Keywords   Circadian type; Latent class analysis; Nurses; Presenteeism; Work-related flow.

INTRODUCTION

Considering the contradiction between the shortage of human resources and the high requirement of nursing quality, nursing managers have begun to explore how already employed nurses can improve their work performance.[1] Although the implementation of rotating shift work patterns could meet work needs, the frequent shift patterns alter the inherent circadian rhythms of nurses, consequently threatening their physical and mental health.[2-4] The circadian rhythm is a major body rhythm, where many systems in the body are active, alert, energetic at certain times of the day, and inactive at all other times.[4-6] Apparently, people perform best when arousal and internal physical activity are high, and worst when arousal and activity are low.[4,7,8] The desynchronization of circadian rhythms is often associated with impairments in cognitive performance, such as selective attention and executive function, which may significantly affect work performance.[9,10] Nevertheless, most clinical nurses continue to work and live well, as individual differences resulting from circadian rhythms may help resist the hazards of desynchronization of the circadian rhythm.[6,11,12] The recognition of endogenous differences in human biology has contributed to the concept of circadian type, which can relatively reflect the individual differences in adaptability and tolerance to shift work.[13,14] The theory of Folkard et al.[15] describes circadian type based on two characteristics: stability and amplitude, which were evaluated as flexible/rigid (FR) and languid/vigorous (LV), respectively. Under such shift work mode, managers should explore the

circadian type that could help clinical nurses adjust their circadian rhythms better, adapt to work time, and maximize work performance.

According to Meijman and Mulder's effort-recovery theory,[16] individuals' physical and emotional states remain activated if there is insufficient time for them to recover from work. Thus, they have poor work performance owing to the lack of emotional and physical recovery. Indeed, the quality of recovery of clinical nurses after work may be endangered because of poor circadian patterns. For example, Jafari Roodbandi et al.[17] found that shift nurses whose circadian rhythm amplitude was languid suffered more from sleepiness and working errors, whereas those whose circadian rhythm stability was flexible had better sleep quality. Moreover, sleeplessness and exhaustion might make it difficult to stay alert when the circadian rhythm is low.[4,18] Circadian type is especially important for work-related performance among clinical nurses,[19-21] although literature shows that shift workers that experienced disturbances in the sleep-wake cycle (deficits in sleep quality and daytime functioning,[2,8,20] fatigue at work,[11,18,22] psychological distress,[18,19,23] or any integration of these) were more likely to have poor work performance. To date, the relationship between circadian type and work performance (e.g., presenteeism or work-related flow) is still uncertain.

Presenteeism, as opposed to absenteeism, is regarded as a condition in which professionals are present at work but perform their activities in a nonproductive way.[24,25] In this case, professionals usually exhibit poor performance owing to diseases and/or physical and psychological problems.[24,25] The literature highlights factors such as occupational stress, frequent night shifts, and emotional exhaustion that are closely related to presenteeism among nurses.[26-29] Specifically, presenteeism could affect the quality of nursing, as it increases errors and omissions in tasks, which consequently increases the incidence of adverse events such as falls and medication errors.[24,25] In fact, the negative impacts related to presenteeism are not only harder to track than those related to absenteeism, but might also be greater.[25,30] Compared to other populations, frequent night shift patterns might be an inevitable factor for poor performance among clinical nurses. In the context of work, the shift pattern often disrupts the circadian system. This might confer risk for consolidated nighttime sleep, which is associated with the basic capacity to be awake, alert, and engaged.[5,31] However, such a difference in the adaptability to shift work was observed among clinical nurses with different circadian types.[11,13] Therefore, this is considered, to some extent, as one of the factors affecting work performance.

It is important to not only reduce the negative elements that characterize the experience of nursing, but also to highlight the need to assume a positive psychology perspective focus-ing on the motivational aspects of work.[32] Related studies on organizational psychology describe the flow as a subjective state of consciousness where individuals are completely immersed in something to the point of forgetting time, fatigue, and everything else but the activity itself.[33,34] Work-related flow in nursing refers to the nursing staff's interests and the energy they put in their job, which can be conceptualized as three aspects: absorption, work enjoyment, and intrinsic work motivation.[34] Demerouti et al.[35] found that work-related flow is positively and negatively related to vigor and exhaustion, respectively. Furthermore, it has also been found to contribute to the development of personal resources, which might drive resilience and recovery processes, thereby protecting individuals from stressful events.[35] Demerouti et al.[35] suggested that flow occurs with a precondition that people perceive a balance between the demands and their skills or resources to manage them. From this perspective, adjusting to a circadian rhythm is a common and important balancing event for nurses.[2] Consequently, circadian type might affect their work-related flow.

To date, few studies have concurrently assessed the relationship between circadian type and presenteeism or work-related flow among clinical nurses. Most self-reported measures on circadian type focus on assessing the stability and amplitude modules separately; however, the two modules are separate and simultaneous for the individual. Therefore, studies on circadian type require a person-centered approach (e.g., latent class analysis [LCA]) that can distinguish the circadian type of different subgroups and identify the characteristics of the work performance (presenteeism or work-related flow) that corresponds to the subgroups of the clinical nurses. This study uses LCA to explore the relationship between circadian type and work performance (presenteeism or work-related flow) from a person-centered perspective, which might provide important insights into such relationships. Therefore, this study aimed to ascertain whether there are subgroups of clinical nurses with circadian types, and discuss the associations among subgroups of circadian types, presenteeism, and work-related flow.

METHODS

Design

This study used a cross-sectional design. We meticulously applied the STROBE guidelines for cross-sectional research in reporting this study

Participants

Five hundred and sixty-eight questionnaires were electronically and anonymously collected by the online questionnaire

platform from three public hospitals in Shandong Province, in January 2021. The inclusion criteria were 1) obtaining practicing nurse certificate, 2) being a registered employee in the work unit, and 3) signing an informed consent form. The exclusion criteria were 1) nurse who is not working properly (maternity leave, sick leave, standardized training not completed) and 2) nurses on regular day shifts.

Data collection

The Academic Ethics Committee of Shandong Provincial Hospital Affiliated to Shandong First Medical University approved our study (SWYX: NO. 2021-456). Participants were recruited from the nursing departments of the author's institution and two cooperative hospitals in Shandong Province, China, using convenience sampling. The survey package was distributed electronically to nurses by the nursing department through the WeChat office platform. A survey note accompanying the questionnaire informed participants of the anonymity and voluntary nature of participation in the study, and provided instructions on how to complete the questionnaire on the survey platform. The survey could only be completed when participants answered all questions; therefore, there was no missing data. Participants completed the questionnaire online through the questionnaire link and submitted it directly to the network questionnaire platform after completion. To ensure the quality of the survey, the participants were informed that questionnaires required completion within seven days, and that only one questionnaire could correspond to one IP address. It was impossible to know precisely how many questionnaires were originally distributed, therefore the response rate could not be calculated.

Measures

The 11-item Circadian Type Inventory (CTI-11) was revised by Di Milia et al.[14] from the original 30-item Circadian Type Inventory developed by Folkard et al.[15] This study used the Chinese version of the CTI-11, which was developed by translation and back translation.[36] The scale shows excellent psychometric properties to predict whether an individual is comfortable with shift work.[3,14,36] It is categorized into two subscales: 1) FR, which refers to the stability of circadian rhythms; high scores of FR indicate flexibility, or the individual's ability to adapt to shift work, which includes staying up late to get work done and working during abnormal hours of the day or night. 2) LV, which refers to the amplitude of circadian rhythms; individuals with a high LV score are referred to as languid, which indicates that they find it difficult to adjust to shift work and might show signs of being languid and having insomnia.[6] All the questionnaire items were answered based on a 5-point scale ranging from 1 (not true at all) to 5 (almost always true). The

Cronbach's alpha for the subscales was as follows: FR subscale (5 items, α=0.890) and LV subscale (6 items, α=0.729).

The Stanford Presenteeism Scale-6 (SPS-6) was extracted from the original 32-item scale, which assesses a worker's ability to concentrate and accomplish work despite having health problems.[37,38] The SPS-6 is considered a valid and reliable tool for nurses.[38] We used the Chinese version of the SPS-6 developed through translation and back-translation.[39] The response scale for the items such as "Because of my (health problem), the stresses of my job were much harder to handle" ranged from 1 (strongly disagree) to 5 (strongly agree). Items 5 and 6 were reverse-scored in accordance with negative wording. The total possible score ranges from 6 to 30 points, with higher scores indicating a stronger productivity loss. Cronbach's alpha was 0.811.

The Work-Related Flow Inventory (WOLF), developed by Bakker,[34] is the most widely used scale for evaluating flow in employees.[33] The 13-item scale is categorized into three domains: absorption (four items, referring to an individual's concentration on the work), work enjoyment (four items, referring to an individual's happy feeling and positive view on the quality of his/her work), and intrinsic work motivation (five items, referring to the tendency of an individual to work for pleasure and satisfaction).[33] The Chinese version of the WOLF scale was developed after the localization revision by Lilian Zhu. All the items had a response scale with 5-points ranging from 1 (not true at all) to 5 (almost always true). The Cronbach's alphas for the subscales were as follows: absorption subscale (α=0.859), work enjoyment (α=0.957), and intrinsic work motivation (α=0.803).

We gathered basic demographic information through a self-report questionnaire, including age, sex, highest educational degree, marital status, years of work, and department.

Statistical analysis

LCA is a person-centered approach that can identify subgroups of people with similar characteristics; that is, people within the subgroups have common features regarding the study variables, while the features between the subgroups differ as much as possible.[7] We used the LCA to assign class membership of the circadian type using the Mplus 7.0 software (Los Angeles, CA, USA) and explore the specific types of circadian. The items of the circadian type served as indicators of class membership. The optimal number of classes was determined based on a combination of model fit indices,[8] including: 1) Akaike information criterion (AIC), Bayesian information criterion (BIC), and sample size-adjusted BIC (aBIC), where smaller values indicate better model fit; 2) bootstrapped likelihood ratio test (BLRT) and Vuong-Lo-Mendell-Rubin likelihood-ratio test (LMR), where significant p-values (p<

0.05) indicate that the current model is preferable to the model with one less class; 3) entropy, where the values above 0.80 were acceptable and indicated a greater distinction between the classes[12]; and 4) class probability, where a class should be no less than 1% of the total sample. In fact, the model needs to be met such that the AIC, BIC, and aBIC are lower, the LMR and BLRT are significant, and the entropy is higher.[40] In this study, the best model was chosen by balancing parsimony, theoretical interpretability, and the goodness of fit.

There is controversy regarding how to determine the appropriate sample size and number of items to yield sufficient power to determine latent classes.[41] Dziak et al.[41] proposed that Cohen's w measure be modified to determine the power for LCA. According to the equation $n=m_{80}^{(w2)}/(W^2)$, when we set the medium effect size w=0.3, $m_{80}^{(w2)}$ is a constant estimated at 40.4 if including 11 items with the set power as 0.80;

therefore, the minimum sample size required is 449. This method determines that 568 participants is a sufficient sample size to maintain power at 0.80 if including 11 items.

After the LCA of the circadian type was determined, we compared the scores of presenteeism and work-related flow among different subgroups of nurses. A one-way analysis was performed to compare the differences in presenteeism and work-related flow in different classes of circadian type using SPSS 22.0 (IBM Co., Armonk, NY, USA). The independent variable was the circadian type identified through the LCA; the dependent variable was presenteeism or each subdimension of work-related flow.

RESULTS

Demographic variables
The sociodemographic characteristics of participants is represented in Table 1.

Identification of the optimal latent class model
Table 2 shows the model fit statistics from a single-class model (C1) to a five-class model (C5). As anticipated, the AIC and BIC decreased sequentially when a new class was added to the model. The BIC values began rising again, however, when moving from a four-class to a five-class model compared with models with fewer classes. Meanwhile, the LMR and BLRT were not statistically significant when adding a five-class to the model. The entropy (0.845) corresponding to the four-class model was acceptable. Therefore, the four-class model of the circadian type among clinical nurses was considered the best model, within which the class-attributable probabilities of C1, C2, C3, and C4 were 0.144, 0.201, 0.511, and 0.144, respectively. Table 3 shows the average attribution probability matrix for the four latent classes. The average probability of each class attributable to each latent class was obtained for the four-class model that was between 90.4% and 92.7%.

The class descriptions
Based on the LCA, the response probability diagram of the

Table 1. Sociodemographic characteristics of the participants (N=568)

Variable	Value
Sex	
Female	537 (94.5)
Male	31 (5.5)
Marital status	
Married	464 (81.7)
Unmarried	104 (18.3)
Highest educational degree	
Less than college graduate	4 (0.7)
Bachelor's degree	535 (94.2)
Master's degree	29 (5.1)
Department	
Medical ward	208 (36.6)
Surgical ward	141 (24.8)
Intensive care unit	105 (18.5)
Others	114 (20.1)
Age (yr)	34.31±5.86 (21−55)
Years of work	12.19±6.81 (1−38)

Values are presented as number (%) or mean±standard deviation (range)

Table 2. The latent class analysis fit index of circadian type of clinical nurses

Model	K	Log(L)	AIC	BIC	aBIC	Entropy	LMR	BLRT	Class probability
1	11	-3,818.278	7,658.556	7,706.319	7,671.399	-	-	-	-
2	23	-3,366.386	6,778.772	6,878.641	6,805.626	0.890	892.063*	903.784*	0.345/0.655
3	35	-3,240.605	6,551.210	6,703.184	6,592.075	0.837	248.299*	251.562*	0.164/0.495/0.341
4	47	-3,150.209	6,394.419	6,598.499	6,449.295	0.845	178.446*	180.791*	0.144/0.201/0.511/0.144
5	59	-3,124.544	6,367.089	6,623.274	6,435.976	0.771	50.665	51.330*	0.134/0.211/0.178/0.146/0.331

*p<0.01. K, number of parameters estimated freely; Log(L), log likelihood value; AIC, Akaike information criterion; BIC, Bayesian information criterion; aBIC, sample size-adjusted BIC; LMR, Vuong-Lo-Mendell-Rubin likelihood ratio test; BLRT, bootstrap likelihood ratio test; -, not available

four latent categories on 11 items was obtained, as shown in Figure 1. According to the scoring rules of the CTI-11 scale, we drew two dotted lines (a and b), to divide the results into four sections. In other words, the 50th percentile and above of response probability in stability and amplitude scales were considered flexible and languid types, respectively. According to the position of the response probability of each category, classes one to four were given distinct titles. The classes and characteristics of LCA results are shown in Table 4. Of those, the minority (n=82, 14.4%) were placed into the first latent class (class 1), referred to as the high response class. Clinical nurses in this group demonstrated a higher conditional probability across the stability and amplitude dimensions, indicating that they were flexible and languid. Class 2 was further named the high flexible class indicating those in class 2 (n=114, 20.1%) had the highest probability of being flexible and vigorous. The majority (n=290, 51.1%) were placed into the third class (class 3), named the high languid class, which was characterized by a high probability of being rigid and languid. The remaining participants (n=82, 14.4%) were placed in the final class (class 4), Low response class, which was characterized by a lower conditional probability across the stability and amplitude dimensions; in other words, those who were

likely to be rigid and vigorous.

Comparison of the circadian type with presenteeism and work-related flow

While taking each latent category as an independent variable and the scores of presenteeism and work-related flow as dependent variables, the results indicated significant differences between presenteeism, work-related flow, absorption, work enjoyment, and intrinsic work motivation with different circadian types, as shown in Table 5. After the post hoc tests, the high languid class was found to have a higher level of presenteeism and a lower level of work-related flow compared with the other classes. Inversely, the high flexible class was found to have a higher score in work-related flow and its subdomains, but a lower score in presenteeism. Interestingly, the high response class had a higher score than the high languid class in the total score of work-related flow. Although the low response class scored higher than the high flexible class in terms of presenteeism, the low response class had higher work-related flow than the high languid class.

DISCUSSION

Shift work is a universal scheduling model for nursing staff,

Table 3. Average attributable probability of participants (rows) for each latent category (column)

Classes	Class 1 (%)	Class 2 (%)	Class 3 (%)	Class 4 (%)
Class 1	92.7	5.7	1.6	0.0
Class 2	5.5	90.4	2.2	1.8
Class 3	1.9	1.3	91.6	5.2
Class 4	0.1	0.9	7.2	91.9

Table 4. Classes and characteristics of latent class analysis results

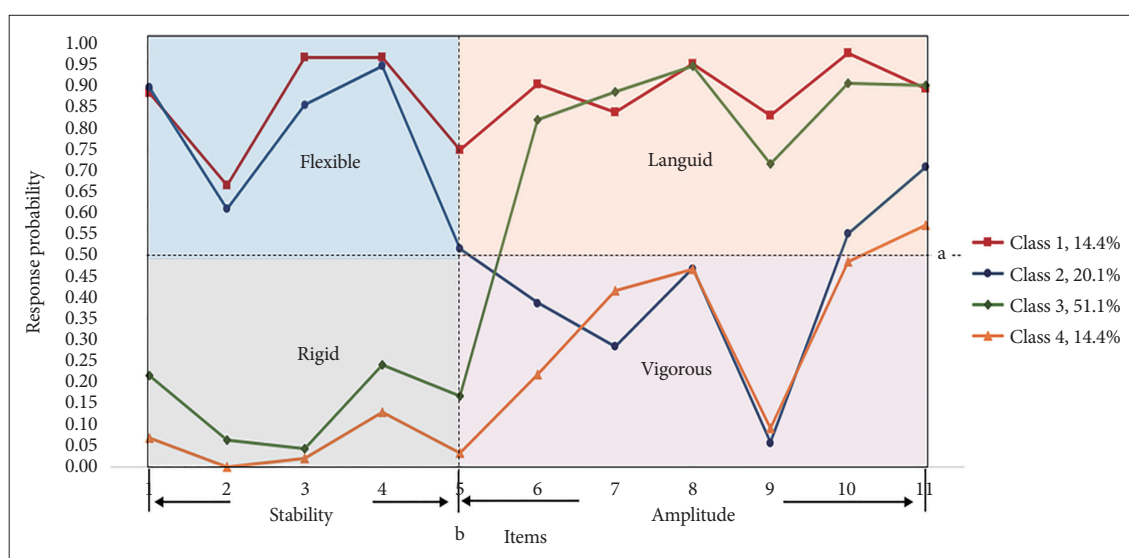| Class	Description	Characteristic
1	High response class	Flexible and languid
2	High flexible class	Flexible and vigorous
3	High languid class	Rigid and languid
4	Low response class	Rigid and vigorous

Figure 1. The response probability diagram of each latent class on all entries. In data analysis, the original scale items are rearranged according to the items included in each dimension, i,e., 1–5 is stability, 6–11 is ampitude. Dotted line a: a dotted line parallel to the X-axis at the point with 50% probibility of response. Dotted line b: a dotted line parallel to the Y-axis at the item 5.

Table 5. Comparison of presenteeism and work-related flow scores of clinical nurses with different circadian types

Variable	The circadian type of clinical nurses				Post hoc test (p)
	High response class (N=82)[a]	High flexible class (N=114)[b]	High languid class (N=290)[c]	Low response class (N=82)[d]	
Presenteeism	14.76±4.36	12.01±3.91	15.98±4.60	15.00±5.02	a>b, c>b, d>b
Work-related flow	47.37±7.11	50.31±8.12	44.77±7.72	47.72±8.68	b>c, d>c, a>c
Absorption	15.73±2.53	16.60±2.57	15.13±2.57	16.03±2.90	b>c, d>c
Work enjoyment	14.89±2.84	16.19±3.08	14.25±3.02	15.37±3.23	b>a, b>c, d>c
Intrinsic work motivation	16.74±2.92	17.52±3.77	15.39±3.35	16.32±3.84	a>c, b>c

Values are presented as mean±standard deviation

and it is important to identify the circadian type, particularly the characteristics and their possible relationship with work performance. Costa et al.[13] indicated that the characteristics of flexibility of sleeping habits and the ability to overcome drowsiness might be significant influencing factors of adaptability and tolerance to night work. Disruption of the circadian rhythm could result in a reduction in levels of attention and alertness during work, combined with poor sleep.[2] Thus, clinical nurses might have poor work performance, such as an increased likelihood of errors and omissions in tasks.[2,17] The circadian type is a significant influencing factor of work performance since it might play a key role in the regulation of the sleep/wake cycle.[6,42] In particular, the circadian type comes into play when the sleeping pattern is affected by this rhythm, and its features are disturbed by shift work.[6,42]

The latent class analysis of the circadian type of clinical nurses

The CTI-11 scale we used to identify circadian type is a two-factor scale, which adds complexity to the LCA analysis process. As the results showed, we used dotted lines to divide the category schematic into four sections based on the probability of response for each item, naming categories according to where each type falls in the sections. The results showed that the circadian type of clinical nurses had obvious classification characteristics. Further, the model fits of each of the four potential categories showed good adaptability. Among them, the response probability of the high response class was higher across all the dimensions, in which the participants whose circadian rhythm stability was flexible and circadian rhythm amplitude was languid. This indicated that nurses in the high response class had flexible schedules to perform shift work but found it difficult to overcome the sleepiness caused by shift work. The high flexible class was characterized by flexible and vigorous, which is the better and idealized circadian type, indicating that the individuals in this class are the most suitable for shift work.[14,17] However, the proportion of the idealized circadian type was relatively low; therefore, future studies should

examine people with relatively poor circadian rhythms more. The most common type in this study was the high languid class, which is the relatively bad type, characterized by rigid and languid nurses. This finding was inconsistent with those of Jafari Roodbandi et al.[17] conducted on shift nurses and healthcare workers in Iran, where the most frequent circadian rhythm is rigid and vigorous. One reasonable explanation for this is cultural differences. Given the shortage of government healthcare expenditure, public health insurance, and a tiered healthcare delivery system, nurses are at a higher risk of experiencing burnout and/or find it difficult to overcome drowsiness when they struggle to meet the expectations of patients and organizations in China.[43] The low response class, characterized as rigid and vigorous, had a low score in all the dimensions. This was a very interesting type, showing difficulty in resisting sudden circadian changes (e.g., could not go to bed early), but had a strong ability to overcome drowsiness following reduced sleep. Considering and cross-discussing the stability and amplitude of circadian rhythm types and using LCA to distinguish the different types, could have far-reaching significance in exploring the adaptability of shift workers to their jobs.

The circadian type and work performance of clinical nurses

One of the main findings of this study was the association between circadian type and presenteeism. Our results show that the risk of presenteeism was lower in the high flexible class than in the other classes, which was similar to the results of Zare et al.[6] who found that languid individuals had a higher risk for sick absence than the vigorous ones. In fact, presenteeism and absenteeism have similar characteristics, that is, physical or psychological factors that result in a decrease in productivity.[24,44] However, Taloyan et al.[30] indicated that presenteeism could have a more serious long-term impact on work than sickness absenteeism. Health impairment caused by circadian incongruence might be the main variable behind the association between circadian type and presenteeism, es-

pecially the changes in sleep patterns (waking up early, lack of sleeping at night, or inadequate sleep).[6] The nurses in the high flexible class would show flexibility toward sudden changes in circadian rhythm (such as working through the night), resisting sleepiness, and remaining vigorous.[17] As mentioned by Natvik et al.,[45] three-shift nurses whose circadian rhythm type was flexible suffered less from insomnia and could go to work or sleep at any time of the day. Clearly, this type of nurse is more suitable for night shift work. However, the proportion of this type is relatively small. Moreover, the most meaningful implication for nursing managers was to consider nurses in the high languid class more, which showed relatively high levels of presenteeism. As Di Milia et al.[46] argued, languid individuals were less alert while working during the day than vigorous individuals. This could help clarify that languid individuals were more likely to exhibit presenteeism. These fatigue and burnout measures are linked to presenteeism in a series of studies on languidness and nurse performance.[47,48] Moreover, scholars have pointed out that if a nurse was languid enough to have impaired work performance, then being absent from work might be more effective for maintaining patients' safety than presenteeism.[48]

Work-related flow has been described as the most favorable situation for individuals and organizations. Moreover, it could promote both motivation and enjoyment at work, hence reducing work-related distress.[32] Our study addresses the gaps in our knowledge about the association between circadian type and work-related flow. According to the Job Demands-Resources (JD-R) model by Demerouti et al.[35] work-related flow arises when the professional skills and available organizational resources of employees match job demands. In fact, the desynchronization of circadian rhythms could increase stressors in the work environment (e.g., relationship between vigor and tasks) and hinder their ability to focus on work.[48] Moreover, a nurse's inability to adapt to shift work might result in cognitive impairment, which consequently affects their flow at work.[3] Drawing on these arguments, one possible reason for nurses experiencing higher work flow to exhibit absorption and enjoyment in the low response class compared to the high languid class is that they have more vigor to finish work tasks. As suspected, the level of work-related flow in the high flexible class was higher than that in the high languid class, while the differences in all three dimensions were statistically significant. In this regard, we propose several explanations. Nurses with flexible sleeping habits and the ability to overcome drowsiness had a reduced risk of suffering from circadian rhythm disorders.[6] One possible reason is that they do not have to spend extra energy overcoming the fatigue and physical discomfort caused by shift work, and can therefore focus their attention on the work itself. Additionally, recent studies have shown that insomnia, which is a common public health problem resulting from desynchronization of circadian rhythms, is highly related to impaired daytime cognition mixed with attention, memory, and executive function.[49] Instead, Soh et al.[50] indicated that work engagement is a cognitive state that comprises absorption, dedication, and vigor. Therefore, in this case, nurses who were well adapted to shift work were more likely to exhibit satisfactory work-related flow than those who were not. Other psychological problems derived from shift work, such as anxiety, depression, stress, and role conflict,[13,51,52] might be possible factors of poor work-related flow, especially work motivation and work enjoyment.[32,34] All of these support existing findings where better circadian type would predict greater ability to flow at work in terms of vigor, cognition, and psychological state.

The present study has several limitations. First, we examined work performance (presenteeism and work-related flow) differences at one point in time, and future research should explore how work performance changes across years of shift work, especially considering the work performance trajectories of individuals with different circadian types using longitudinal studies. Second, the results were generated using self-report scales; thus, reporting bias could not be avoided. Future studies could further discuss the relationship between circadian type and work performance using qualitative research. Third, the data collection was based on convenience sampling; differences may exist between responders and non-responders, which could not be assessed because of the uncertain response rate. Future research is required to replicate these findings using more representative samples that are more similar to the work environment. In addition, it is necessary to focus on the distribution of the total sample size during the design stage to reduce selection bias. Finally, we found that sleep variables played an important role in exploring the relationship between circadian rhythms and productivity. Therefore, we encourage researchers to replicate this study while simultaneously discussing sleep.

Conclusion

This study discusses the classification characteristics of the circadian type of clinical nurses and the relationship between nurses' circadian rhythm and presenteeism and work-related flow. The LCA identified four latent categories of circadian type: high response (14.4%), high flexibility (20.1%), high languid (51.1%), and low response (14.4%). The high flexible class was the better and idealized circadian type; the individuals in this class were the most suitable for shift work. This class has high scores in work-related flow and low scores in presenteeism. Conversely, the high languid class was the relatively bad type, in which participants had high scores in pre-

senteeism but low scores in work-related flow.

Implications for nursing management

This study's findings have several significant theoretical implications for nursing managers. We found that clinical nurses with flexibility and vigor had less presenteeism and more work-related flow. Moreover, if rigid and languid nurses who preferred having regular sleeping and eating time, could always work in day shifts, they might also suffer from low levels of presenteeism and high work flow. It is well known that changing the shift work mode and super-nurse culture could be difficult. However, it is necessary to regard circadian type as predictive indices, to further select and employ individuals in shift work and ensure clinical nurses exhibit better work performance. Although it is impossible to transfer all the nurses in the high languid class to the day work system, it is possible to attempt identifying at least the individuals that are most susceptible to intolerance to shift work. Accordingly, nursing managers should pay attention to their physical and mental health. Additionally, although stability is not easy to change, nursing management could have ready-made solutions to reduce the fatigue of nurses, for example, the rational allocation of nurses, flexible scheduling, and necessary psychological support to help nurses recover from work induced burnout, among other effects.

Availability of Data and Material

The datasets generated or analyzed during the study are not publicly available due to privacy restriction but are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Min Ding. Data curation: Lijuan Yang. Formal analysis: Xiaofei Kang. Funding acquisition: Lijuan Yang. Investigation: Linjing Xu, Yang Yue. Methodology: Xiaofei Kang. Project administration: Min Ding. Resources: Linjing Xu, Yang Yue. Software: Xiaofei Kang. Supervision: Min Ding. Validation: Lijuan Yang. Visualization: Xiaofei Kang. Writing—original draft: Xiaofei Kang. Writing—review & editing: Min Ding.

ORCID iDs

Xiaofei Kang   https://orcid.org/0000-0002-9829-462X
Lijuan Yang   https://orcid.org/0000-0001-6889-5638
Linjing Xu   https://orcid.org/0000-0001-5675-4213
Yang Yue   https://orcid.org/0000-0002-1539-0027
Min Ding   https://orcid.org/0000-0002-6197-5376

Funding Statement

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