

Analyzing the Work Performance of Night Shift Nurses Using Clustering, Statistical Tools and Data Analytics

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Abstract

This study examined the work performance of night-shift nursing personnel in a tertiary hospital setting, focusing on how fatigue, satisfaction, and collaboration influence behavioral and physiological performance indicators. A quantitative descriptive–correlational design was employed using a 15-item Work Performance Scale rated on a four-point Likert scale. Data were analyzed using descriptive and non-parametric statistics—including medians, interquartile ranges, and Spearman’s rank correlation—to assess performance patterns and relationships among variables. Complementary data-analytics and machine-learning methods such as K-Means clustering and decision-tree modeling were applied to uncover latent performance profiles and the relative contribution of key factors. Findings revealed that the overall composite mean of 2.69 corresponds to the descriptive interpretation “Often,” signifying that nurses consistently perform their professional duties despite the physiological demands of nocturnal work. The highest-rated domains were Teamwork and Collaboration and Satisfaction and Development, demonstrating strong interpersonal cohesion and positive work engagement. Conversely, Alertness and Concentration and Physical and Mental Endurance received lower mean values, suggesting that fatigue, disrupted circadian rhythm, and limited recovery periods continue to affect performance. Correlation analysis indicated a moderate positive association ($\rho \approx 0.54$, $p < 0.05$) between concentration and physical endurance, while cluster analysis identified three behavioral profiles—Highly Engaged, Balanced, and Fatigued—reflecting varying adaptability to night-shift demands.

Keywords: Nursing; Clustering; Data Analytics; Work Performance; Statistics

1. Introduction

Nursing remains one of the most demanding professions, requiring constant vigilance and care delivery at all hours. Among the workforce, nurses assigned to night shifts experience distinct challenges compared with their daytime counterparts. Irregular sleep patterns and circadian rhythm disruption have been linked to impaired alertness, diminished concentration, and increased fatigue, which consequently reduce the quality of patient care [1], [2]. Prolonged exposure to nocturnal work patterns results in physiological disturbances, including cardiovascular strain, gastrointestinal problems, and hormonal imbalance [3]. These physiological consequences not only affect nurses’ health but also compromise patient safety. For instance, Alsharari et al. [1] found that over 85% of night-shift nurses reported patient-safety concerns, while nearly 94% experienced fatigue-related symptoms during rotations. Such evidence highlights the importance of evaluating nurses’ work performance within the night-shift context to ensure that both staff well-being and patient outcomes are maintained.

Beyond physiological strain, psychological and behavioral consequences emerge from extended exposure to night-shift work. Studies have demonstrated that fatigue accumulation over consecutive night duties leads to reduced reaction time, slower decision-making, and increased risk of clinical errors [4], [8]. Kim et al. [8] revealed that fatigue levels rise

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significantly by the third consecutive night shift, illustrating the cumulative effect of disrupted sleep cycles. Moreover, night-shift nurses frequently report isolation, decreased social participation, and emotional exhaustion, which contribute to burnout and absenteeism [5]. The compounded stress of long hours, insufficient recovery, and emotional labor diminishes professional satisfaction and organizational commitment. Understanding these multifactorial influences on nurse performance is crucial to devising evidence-based interventions that promote resilience and sustain productivity during nocturnal work.

Environmental and institutional factors also play pivotal roles in shaping night-shift nursing performance. Reduced staffing levels, limited managerial supervision, and diminished access to ancillary services during the night increase the workload and autonomy required of nurses [6]. Such conditions often demand multitasking and rapid prioritization of patient needs, intensifying both cognitive and emotional stress. Leso et al. [7] emphasized that extended working hours and high job demands are major determinants of cognitive decline and decreased psychomotor precision. Consequently, inadequate administrative support may amplify risks of fatigue-related incidents, medication errors, and communication lapses among staff. Addressing these systemic concerns through scheduling reforms, adequate staffing ratios, and institutional wellness programs can significantly mitigate the adverse impact of night-shift duties on nurse performance and patient safety.

Recent scholarship underscores the urgency of promoting adaptive coping mechanisms and restorative strategies among night-shift nurses. Studies show that brief napping, structured recovery breaks, and proper sleep hygiene improve alertness and psychomotor efficiency during long shifts [11], [12]. Iwasaki et al. [12] demonstrated that strategic naps of 20–40 minutes reduced self-reported fatigue and enhanced post-shift performance. Similarly, organizational initiatives that promote ergonomic scheduling, circadian-friendly lighting, and psychological support foster long-term health sustainability among nurses [10]. While night-shift work will remain an indispensable component of 24-hour hospital operations, optimizing these conditions is essential to maintaining nursing competence and patient safety. Therefore, the present study aims to examine the level of work performance among night-shift nurses within tertiary hospital settings, providing data to inform policies that balance service demands with staff well-being.

2. Related Studies

Night-shift assignments consistently disrupt circadian rhythms and degrade sleep, which in turn impairs vigilance and task performance. In a large cross-sectional study of Chinese nurses, those currently working consecutive night shifts showed markedly higher poor-sleep prevalence (PSQI) than former night-shift nurses, underscoring persistent circadian misalignment [1]. A predictive correlational study in public hospitals linked night-shift rotations to worse self-reported work performance and heightened patient-safety concerns among nurses [2]. Mini-review and systematic data further show that night work degrades cognitive domains (attention, memory, response inhibition) central to safe nursing practice [13], and sleep-related problems among night-shift nurses have downstream effects on error risk and workplace accidents [14]. Evidence from actigraphy and modeling also indicates measurable drops in predicted cognitive effectiveness during/after night duty [15]. Collectively, these findings establish a robust association between nocturnal schedules, sleep debt, and degraded clinical performance in nursing.

Fatigue accumulation across back-to-back nights magnifies safety risk. A prospective observational study using ecological momentary assessment showed nurses slept less and ended later-shift days with significantly higher fatigue on the second and third nights than on the first [16]. Complementary quasi-experimental data reported reduced sustained attention and increased sleepiness after three consecutive 12-hour shifts, aligning physiologic sleep loss with functional decrements [17]. At the schedule-design level, backward rotational patterns (e.g., night → evening → day) have been identified as the **strongest** predictor of poor sleep quality among nurses; avoiding backward rotations is therefore a practical mitigation [18]. Beyond schedule structure, “social jetlag” (mismatch between biological and social clocks) also predicts worse sleep quality among rotating-shift nurses, pointing to the need for chronobiology-aware rostering [19]. Together, these studies argue for limits on consecutive nights, avoidance of backward rotations, and attention to circadian alignment to protect performance.

Hospital context shapes how night duty translates into outcomes. In resource-constrained settings, nurses report higher workload, somatic symptoms, and reduced concentration during night shifts—factors tied to lower work output and satisfaction [18]. Broader reviews emphasize that the cognitive harms of night work are potentiated by long hours and insufficient recovery and can worsen progressively over successive nights [19]. Multicenter studies in Malaysia and China identify modifiable drivers of poor sleep quality—workload, irregular scheduling, and psychological stress—linking them to patient-safety risk and adverse health outcomes among night-shift nurses [20], [21]. Guidance papers and policy recommendations consistently call for systemic interventions: staffing that enables breaks, circadian-

friendly lighting, and fatigue-risk management [21]. These organizational levers are critical complements to individual coping tactics when safeguarding night-shift performance.

Evidence supports targeted countermeasures that improve alertness on nights. A longitudinal observational study in 16-hour night shifts found that **≥90-minute** total nap duration was associated with lower post-shift fatigue and drowsiness, suggesting a practical on-shift intervention [22]. Survey-based and qualitative work shows nurses employ diverse sleep strategies (timed naps, sleep hygiene, planned light exposure), and organizations can foster these practices through policy and environment (quiet rooms, protected breaks) [21], [22]. When combined with schedule redesign (limit consecutive nights, avoid backward rotations) and recovery windows, these measures can meaningfully reduce fatigue-related performance decrements. Importantly, such interventions sit on a strong physiologic rationale: improving sleep quantity/quality restores vigilance, psychomotor speed, and decision accuracy during night duty

3. Material and methods

3.1. Research Design

This study utilized a quantitative descriptive–correlational design complemented by data-analytics modeling. The quantitative approach was employed to measure and describe the level of work performance among night-shift nurses, while the correlational and analytic components explored relationships and latent patterns between demographic variables and work-performance indicators. The inclusion of non-parametric statistics ensured robust inference from ordinal data, and the integration of machine learning techniques—specifically clustering and classification—provided additional insight into hidden structures within the dataset. This mixed analytical framework aligns with recent nursing informatics research that combines inferential and predictive analytics to enhance understanding of workforce performance patterns.

3.2. Research Locale and Participants

The study was conducted among nurses working night shifts in a tertiary-level hospital in the Philippines. The hospital provides 24-hour medical, surgical, pediatric, and obstetric-gynecological services, employing both regular and contractual nursing staff. Nurses who had completed at least six months of continuous night-shift assignments were included in the sample. Participation was voluntary, and informed consent was obtained from all respondents. Convenience sampling was adopted, which is acceptable for exploratory nursing workforce studies where availability and accessibility define sampling feasibility.

3.3. Research Instrument

Data were gathered using a 15-item Work Performance Scale, designed to measure the behavioral, motivational, and physiological aspects of night-shift nursing performance. Each statement was rated on a four-point Likert scale (1 = Never, 2 = Sometimes, 3 = Often, 4 = Always).

The items assessed several domains:

- Productivity & Initiative: items 1–3
- Teamwork & Collaboration: items 4–6
- Alertness & Concentration: items 7–9
- Physical & Mental Endurance: items 10–11
- Satisfaction & Development: items 12–15

Internal reliability will be determined through Cronbach's α , with $\alpha \geq 0.70$ considered acceptable for internal consistency.

3.4. Data Gathering Procedure

Prior to data collection, authorization was sought from the hospital's Nursing Service Office and the Institutional Ethics Committee. Questionnaires were distributed personally to eligible night-shift nurses and retrieved after completion. Responses were encoded into Microsoft Excel and subsequently processed in Python (pandas, NumPy, scikit-learn) and SPSS for statistical and analytic modeling. Data cleaning involved removal of incomplete responses and verification of valid value ranges (1–4). To preserve confidentiality, all identifiers were anonymized, and only aggregate results were analyzed. Data were securely stored in an encrypted repository accessible only to the research team.

3.5. Data Analysis Plan

Descriptive analyses will summarize respondent demographics (age, sex, years of experience, ward assignment) and item-level performance indicators.

Frequency and percentage: categorical demographics

Median, mode, and interquartile range (IQR): each Likert item

Composite scores: computed as the average of all 15 items per respondent

Given the ordinal nature of Likert responses and the modest sample size ($n = 56$), non-parametric tests will be employed:

Spearman's rho (ρ) — to examine relationships between overall work performance and continuous variables such as years of experience or age group.

Mann-Whitney U test — to determine significant differences in work performance between two groups (e.g., male vs female).

Kruskal-Wallis H test — to compare median performance across more than two categorical groups (e.g., different wards or employment statuses).

All tests will use a 0.05 significance level ($\alpha = 0.05$).

The study adhered to the ethical principles of respect for persons, beneficence, and justice. Participants were informed of the study's purpose, assured of confidentiality, and given the right to withdraw without consequence. No identifying information was disclosed in any publication or presentation. Data were anonymized and retained solely for academic purposes.

4. Results and discussion

Based on all validated responses, the overall mean composite score across the fifteen (15) items of the Work Performance Scale was 2.69, interpreted as "Often." This indicates that night-shift nursing personnel generally perform their duties consistently and exhibit a satisfactory level of engagement and professional initiative despite the physiological and psychological challenges of nocturnal work. The median score of 3.00 further suggests that participants frequently carry out work responsibilities in accordance with expectations. However, moderate variability ($SD \approx 1.2$) across items reflects differences in adaptability and endurance levels—some respondents cope well with night schedules, while others demonstrate signs of fatigue or reduced concentration.

Table 1 Item-Wise Work Performance

Item	Indicator Statement	Mean	SD	Interpretation
1	I always make sure to take advantage of my work time.	2.81	1.36	Often
2	I am ready to do any additional tasks assigned to me.	2.57	1.36	Often
3	I look forward to new responsibilities in addition to my current duties.	2.76	1.22	Often
4	I communicate with my colleagues and work with a team spirit.	2.57	1.08	Often
5	I have previously submitted ideas and suggestions that were useful in developing my skills.	2.86	1.28	Often
6	I usually do more work than the expectations of my superiors.	2.81	1.25	Often
7	I am always energetic during night shift.	2.57	1.21	Often
8	I do not have difficulty concentrating or making decisions at work due to lack of sleep or rest.	2.48	1.03	Sometimes–Often

9	I do not get very tired during night shift.	2.67	1.24	Often
10	I do not experience physical symptoms such as fatigue, drowsiness, or headaches.	2.52	1.03	Sometimes–Often
11	I do not feel that my work schedule interferes with my sleep or rest.	2.60	1.19	Often
12	I feel satisfied or happy with my work environment or colleagues during night shifts.	3.00	1.34	Often
13	I receive feedback or recognition for my work performance during night shifts.	2.90	1.30	Often
14	I have opportunities for learning and development during night shifts.	2.48	1.12	Sometimes–Often
15	I feel that my work is meaningful and rewarding during night shifts.	2.71	1.19	Often
Overall Mean		2.69	1.19	Often

Items related to satisfaction, initiative, and teamwork received the highest ratings, while those involving alertness, rest, and learning opportunities were comparatively lower. These patterns reveal that most participants are highly engaged and motivated, but physical and cognitive fatigue remain evident challenges. This aligns that emphasized that job satisfaction and peer cohesion mitigate fatigue among night-duty nurses. Likewise past research reported that fatigue, sleep disruption, and reduced alertness directly affect task performance and decision-making accuracy.

Table 2 Domain Level Analysis

Domain	Items	Mean	SD	Interpretation
Productivity & Initiative	1–3	2.72	1.31	Often
Teamwork & Collaboration	4–6	2.75	1.23	Often
Alertness & Concentration	7–9	2.57	1.18	Sometimes–Often
Physical & Mental Endurance	10–11	2.56	1.11	Sometimes–Often
Satisfaction & Development	12–15	2.80	1.22	Often

Among the five domains, Teamwork and Collaboration obtained the highest average mean (2.75), indicating that nurses maintain a strong sense of professional cooperation and shared responsibility during night shifts. This reflects adaptive teamwork behaviors that support effective patient care even under limited supervision. On the other hand, Physical and Mental Endurance recorded the lowest mean (2.56), indicating that fatigue and drowsiness moderately affect overall efficiency—an observation consistent with Dires et al. (2023) [18] and Leso et al. (2021) [7], who identified fatigue and long hours as key predictors of diminished performance.

4.1. Correlation

Correlation analysis using Spearman’s rho revealed a positive moderate relationship ($\rho \approx 0.54$, $p < 0.05$) between concentration (Item 8) and physical endurance (Item 10). Participants who reported fewer difficulties in focusing also tended to experience fewer physical symptoms of fatigue.

This relationship supports the findings of Iwasaki et al. (2024), who demonstrated that structured naps and restorative rest improve both cognitive alertness and physical stamina during prolonged night shifts. The standard deviation values (≈ 1.0 – 1.3) across items reflect moderate variation among responses, highlighting the existence of different fatigue thresholds and coping strategies. These findings emphasize the importance of personalized fatigue management programs and organizational support systems to sustain high-quality night-shift performance.

4.2. Cluster analysis (data analytics)

To uncover patterns of performance behavior, a K-Means clustering model was applied using standardized Likert responses. Three optimal clusters were generated based on elbow-curve and silhouette validation:

Table 3 Cluster Table of Respondents

Cluster	Profile Description	Dominant Characteristics	Interpretation
Cluster 1 – Highly Engaged	High scores (3.2–4.0) in all items.	Energetic, proactive, highly satisfied.	Exemplifies resilience under night duty.
Cluster 2 – Balanced	Midrange scores (2.5–3.0) with moderate fatigue.	Cooperative, occasionally tired, maintains quality.	Represents the typical night-shift pattern.
Cluster 3 – Fatigued	Low scores (1.5–2.0) on alertness and physical items.	Experiences exhaustion, low concentration.	Requires targeted wellness interventions.

These groupings demonstrate that while most personnel maintain effective and balanced performance, a subset experiences notable fatigue and reduced engagement. The clustering analysis supports the assertions of Watanabe et al. (2022) [21], who emphasized that long shifts without adequate recovery intervals substantially increase fatigue and reduce alertness.

5. Conclusion

The study investigated the level of work performance among night-shift nursing personnel using a 15-item Work Performance Scale analyzed through descriptive statistics, non-parametric tests, and machine learning-assisted clustering.

Results revealed that overall work performance was rated as “Often” (Mean = 2.69), indicating that participants generally sustain effective work behavior despite the challenges inherent in nocturnal duties.

Among the domains evaluated, Teamwork and Collaboration and Satisfaction and Development emerged as the highest-performing areas, reflecting the strong interpersonal cooperation, adaptability, and intrinsic motivation of night-shift nurses.

Conversely, Alertness and Concentration and Physical and Mental Endurance registered lower mean values, suggesting that fatigue, disrupted circadian rhythms, and limited rest periods continue to affect the consistency of performance.

Correlation results underscored the interrelationship between concentration and physical endurance—demonstrating that rest quality and fatigue levels influence both cognitive and physical functioning.

The clustering analysis further identified three latent groups—*Highly Engaged*, *Balanced*, and *Fatigued*—emphasizing that while most nurses maintain resilience, a subset experiences notable fatigue that could impact patient care quality.

Overall, these findings affirm that nurses working night shifts remain competent and committed, yet their sustained performance relies on institutional efforts to address sleep adequacy, workload balance, and opportunities for learning and recognition.

In line with prior studies by Huang et al. and Alsharari [1][2], this study confirms that job satisfaction, peer support, and adaptive coping mechanisms are central to maintaining nursing excellence during night duty.

Further studies are encouraged to:

- Expand the dataset to include multiple institutions and shift types for cross-validation of findings.
- Incorporate biometric or wearable data (e.g., sleep tracking, heart rate) to quantify fatigue objectively.
- Explore predictive analytics and AI-driven scheduling systems to balance workforce efficiency with employee health outcomes.
- Employ mixed-methods research to capture qualitative narratives that contextualize quantitative findings.

Compliance with ethical standards

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