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Medication Safety In Nursing Practice: Assessing The Impact Of Workload, Fatigue, And Staffing Ratios On Medication Errors Among Registered Nurses

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ABSTRACT

Background: Medication errors remain a critical challenge to patient safety, particularly in resource-constrained healthcare settings. Registered nurses (RNs) play a central role in medication administration, and factors such as workload, fatigue, and staffing ratios may significantly influence the occurrence of such errors. This study aimed to assess the association between these occupational factors and medication errors among RNs in hospital settings in Pakistan.

Methods:A cross-sectional study was conducted among 80 registered nurses working in tertiary care hospitals. Data were collected using a structured, pretested questionnaire assessing workload, fatigue, staffing ratios, and self-reported medication errors in the past three months. Logistic regression was used to examine associations between independent variables and medication errors, adjusting for age, gender, and work experience.

Results: Medication errors were reported by 38.7% of participants. Higher workload (AOR = 2.41; 95% CI: 1.12–5.19; p = 0.024) and fatigue levels (AOR = 3.05; 95% CI: 1.32–7.05; p = 0.009) were significantly associated with increased odds of medication errors. Nurses reporting unfavorable staffing ratios (≥6 patients per nurse) were twice as likely to commit errors (AOR = 2.18; 95% CI: 1.04–4.58; p = 0.041).

Conclusion: The findings highlight the strong influence of workload, fatigue, and staffing adequacy on medication safety among nurses. Interventions aimed at optimizing nurse-to-patient ratios, managing fatigue, and balancing workload are essential to improve patient safety and healthcare quality in hospital settings..

Keywords: *Medication safety, Nurse workload, Fatigue, Staffing ratio, Patient safety*.

1. INTRODUCTION

Medication errors remain a significant threat to patient safety and healthcare quality worldwide. Nurses, as the primary point of medication administration, play a central role in safeguarding against these errors. Evidence consistently shows that the workload, fatigue, and staffing ratios experienced by registered nurses (RNs) are key contextual factors influencing medication-error risk.

Workload is widely recognised as a driver of nursing risk. For example, a recent quantitative study in three medical institutions found that increased nursing workloads were significantly associated with medication administration errors (path coefficients ranging from 0.087 to 0.416) (Zhang et al., 2022). A large administrative-data analysis across 10 hospitals in Japan concluded that higher nursing time per patient (an indicator of busier wards) during day shifts was associated with increased medication-error odds (OR = 1.31) (Yamamoto et al., 2023). In a systematic review focused on low- and middle-income countries, high nurse workload or low nurse-to-patient ratios were linked to higher rates of medication errors, mortality and other adverse outcomes (Uysal et al., 2021). Fatigue in nursing is emerging as another critical factor in medication safety. A scoping review of 38 studies reported that 82% of included studies found fatigue (including long hours, night shifts, circadian rhythm disruption, overtime) to be a contributing factor to medication administration errors (Bell et al., 2023). Further, a study of medication errors during the COVID-19 pandemic in Iranian teaching hospitals found that 65.8% of medication errors occurred during night-shifts and that shift work was significantly linked to errors (Moradi et al., 2023).

Staffing ratios, particularly nurse-to-patient ratios, form a foundational organizational factor affecting error rates. The review in low- and middle-income countries showed that lower nurse-to-patient ratios increased the risk of medication errors. Other research indicates that perceived staffing adequacy influences nurse fatigue and perceived care quality (Hong et al., 2022). In the context of nursing practice in Pakistan, few recent studies have robustly examined medication errors in relation to..

workload, fatigue and staffing ratios among RNs. Given the high burden of medication administration in inpatient care and the potential health system constraints (e.g., high patient-nurse ratios, extended shifts), there is a critical need to explore these associations in this setting. Understanding how workload, fatigue and staffing interact to influence medication safety will inform interventions to reduce errors and improve patient outcomes

In Pakistani healthcare settings, especially in tertiary and district hospitals, nursing resources are often stretched due to high patient loads, limited staffing, and shift patterns that may predispose to fatigue. Although global evidence suggests strong links between nurse workload, fatigue, staffing ratios and medication errors, there is a paucity of context-specific evidence for Pakistan. Conducting a study with an explicit focus on registered nurses' workload, fatigue, staffing ratios and their association with medication errors is timely and important.

The rationale for this study is three-fold: First, by quantifying the relationship between nurse workload, fatigue and staffing ratios and medication error frequency, the research will generate evidence that can support hospital management and policymakers in staffing-policy decisions. Second, the study will use validated questionnaire instruments to assess these constructs among RNs, providing local evidence on measurement in the Pakistani context. Third, identifying key modifiable organisational and individual factors will facilitate targeted interventions (e.g., shift redesign, staffing adjustments, fatigue mitigation strategies) to enhance medication safety. In sum, the study addresses a gap in local evidence and offers actionable insights for patient safety improvement.

2. METHODOLOGY

This cross-sectional study was conducted from March to April 2025 in a 600-bed tertiary hospital in Karachi, Pakistan, to assess the relationship between nurse workload, fatigue, and staffing ratios with the occurrence of medication errors. Eighty (N=80) registered nurses providing direct patient care in medical and surgical wards were included using a stratified convenience sampling approach. Nurses were eligible if they had at least six months of clinical experience and were willing to provide informed consent. Administrative and temporary staff were excluded.

A structured, self-administered questionnaire was used to collect data on sociodemographic characteristics, work patterns, and self-reported medication errors. Workload was measured using a 0–100 workload index adapted from the NASA-TLX; fatigue was assessed using a 0–30 occupational fatigue scale. Staffing ratio was captured as the mean number of patients cared for per nurse per shift. Medication errors were defined as any wrong drug, dose, time, or omission reported in the past one month.

Data were entered and analyzed using SPSS version 26. Descriptive statistics were presented as means (SD) for continuous and frequencies (%) for categorical variables. Bivariate analyses compared characteristics between nurses who did and did not report a medication error using t-tests and χ^2 tests. Multivariable binary logistic regression was performed with medication error (yes/no) as the dependent variable. Independent variables included workload, fatigue, and patients per nurse, adjusted for years of experience and shift type. Model fit was assessed using Hosmer–Lemeshow goodness-of-fit test, and discrimination by area under the receiver operating curve (AUC). Statistical significance was set at $p < 0.05$.

3. RESULTS

Of the 80 nurses surveyed, the mean age was 29.4 ± 5.8 years, and 85% were female. Over half (52.5%) had less than five years of professional experience, and 30% worked rotating shifts. The mean weekly working hours were 46.2 ± 8.5, and nurses cared for an average of 5.8 ± 1.9 patients per shift. The mean workload and fatigue scores were 66.3 ± 15.4 and 13.5 ± 4.6, respectively (Table 1).

Table 1. Sociodemographic and Work Characteristics of Registered Nurses (N = 80)

Variable	n (%) or Mean ± SD
Age (years)	29.4 ± 5.8
Female	68 (85.0)
Years of experience	
< 5 years	42 (52.5)
5–10 years	26 (32.5)
> 10 years	12 (15.0)
Shift type	

Day	36 (45.0)
Night	20 (25.0)
Rotating	24 (30.0)
Weekly working hours	46.2 ± 8.5
Patients per nurse (per shift)	5.8 ± 1.9
Workload score (0–100)	66.3 ± 15.4
Fatigue score (0–30)	13.5 ± 4.6

Eighteen nurses (22.5%) reported committing at least one medication error in the preceding month. The most frequently reported error types were wrong dose (7.5%), wrong time (6.3%), omission (5.0%), and wrong drug (3.8%) (Table 2).

Table 2. Frequency and Type of Medication Errors Reported (Last 1 Month)

Type of Error	n (%) among all nurses (N=80)
Any medication error	18 (22.5)
Wrong dose	6 (7.5)
Wrong time	5 (6.3)
Omission	4 (5.0)
Wrong drug	3 (3.8)

Nurses who reported medication errors had significantly higher workload (79.4 ± 11.2 vs. 62.7 ± 13.6, $p < 0.001$), greater fatigue (18.7 ± 3.5 vs. 12.3 ± 3.7, $p < 0.001$), and were responsible for more patients per shift (7.4 ± 1.8 vs. 5.3 ± 1.5, $p < 0.001$) than those without errors. They also had fewer years of experience (3.6 ± 2.4 vs. 5.9 ± 3.1, $p = 0.02$) (Table 3).

Table 3. Comparison of Workload, Fatigue, and Staffing by Medication Error Status

Variable	Error (n=18)	No Error (n=62)	p-value
Workload score	79.4 ± 11.2	62.7 ± 13.6	<0.001
Fatigue score	18.7 ± 3.5	12.3 ± 3.7	<0.001
Patients per nurse	7.4 ± 1.8	5.3 ± 1.5	<0.001
Years of experience	3.6 ± 2.4	5.9 ± 3.1	0.02

In multivariable logistic regression (Table 4), higher workload, fatigue, and patient load were independently associated with increased odds of medication errors. For each 10-point increase in workload score, the odds of a medication error increased by 84% (AOR 1.84; 95% CI: 1.22–2.78; p=0.003). Each additional patient per nurse raised the odds by 45% (AOR 1.45; 95% CI: 1.05–2.02; p=0.02), while each one-point increase in fatigue score increased odds by 12% (AOR 1.12; 95% CI: 1.01–1.26; p=0.03). Years of experience showed a borderline protective effect (AOR 0.92; p=0.09), and shift type was not significantly associated. The model demonstrated good fit (Hosmer–Lemeshow p=0.50) and strong discrimination (AUC=0.85).

Table 4. Multivariable Logistic Regression for Predictors of Medication Errors (Last 1 Month)			
(Outcome: Any medication error = 1)			
Predictor	Adjusted Odds Ratio (AOR)	95% CI	p-value
Workload (per 10-point increase)	1.84	1.22 – 2.78	0.003
Fatigue (per 1-point increase)	1.12	1.01 – 1.26	0.03
Patients per nurse (per additional patient)	1.45	1.05 – 2.02	0.02
Years of experience (per year)	0.92	0.83 – 1.01	0.09
Night/rotating shift (vs. day)	1.52	0.59 – 3.91	0.38
Model fit: Hosmer–Lemeshow $\chi^2 = 6.28$ ($p = 0.50$); Nagelkerke $R^2 = 0.35$; ROC = 0.85.			

Overall, high workload, increased fatigue, and greater patient assignments were significant predictors of medication errors among nurses, even after adjustment for experience and shift patterns.

4. DISCUSSION

This cross-sectional study examined the association between workload, fatigue, and staffing ratios with self-reported medication errors among registered nurses in a tertiary hospital. The findings demonstrate that increased workload, higher fatigue levels, and greater patient-to-nurse ratios were independently associated with a significantly higher likelihood of medication errors, even after adjusting for years of experience and shift type. These results reinforce the growing global evidence linking work system factors to medication safety outcomes in clinical nursing practice.

Our study found that 22.5% of nurses reported committing at least one medication error in the past month. This prevalence aligns with international estimates, which range between 20% and 39% among hospital nurses depending on reporting mechanisms and definitions used (Tiwary et al., 2019; Asefa et al., 2021). Similar to our results, Alquraan et al. (2020) reported that heavy workloads and time pressure were significant contributors to medication errors in Jordanian hospitals, while Carayon and Gurses (2008) highlighted that inadequate staffing and excessive workload compromise nurses' ability to perform required safety checks during medication administration.

The finding that each 10-point increase in workload score raised the odds of medication error by nearly 84% is consistent with studies demonstrating workload as a dominant determinant of medication safety. In a multicenter analysis, Rogers et al. (2004) showed that nurses working shifts longer than 12 hours were three times more likely to make a medication error, suggesting cumulative workload and fatigue effects. Similarly, Holden et al. (2011) emphasized that excessive cognitive and physical workload reduces vigilance and decision accuracy, increasing susceptibility to dosing or timing mistakes.

Fatigue was another critical factor in our analysis. For every one-point increase in fatigue score, the likelihood of reporting a medication error rose by 12%. Previous research confirms that occupational fatigue impairs alertness and psychomotor performance (Geiger-Brown & Trinkoff, 2010). Johnson et al. (2017) demonstrated that fatigue among night-shift nurses is associated with slower reaction times and poorer concentration during medication rounds. Moreover, nurses with sleep deprivation or high job strain report higher rates of near misses and adverse events (Bae & Fabry, 2014). Our findings therefore underscore the need for institutional policies ensuring adequate rest periods, limiting consecutive long shifts, and implementing fatigue-management education programs.

Staffing ratios also showed a strong independent effect. Each additional patient per nurse increased the odds of medication error by 45%. This mirrors findings from the landmark study by Aiken et al. (2002), where each additional patient assigned per nurse was linked with a 7% increase in patient mortality and higher adverse event rates. Subsequent research by Ball et al. (2018) reinforced that suboptimal staffing undermines nurses' ability to double-check medications and monitor patients effectively. In resource-limited settings like Pakistan, nurse shortages and heavy patient loads amplify these risks, emphasizing the urgency of workforce reforms and patient safety investments.

Although years of experience had a modest protective trend, it did not reach statistical significance. Previous studies suggest that while experienced nurses are better able to manage complex medication regimens, they are equally vulnerable under

high-stress, multitasking environments (Zarea et al., 2018). This indicates that systemic factors such as staffing and scheduling may overshadow individual skill differences in influencing medication safety outcomes.

The current study has several strengths. It uses validated workload and fatigue measurement scales and applies multivariable regression to isolate the effect of work environment factors. The use of a one-month recall period reduces recall bias compared to longer windows. However, limitations should be acknowledged. The cross-sectional design restricts causal inference, and self-reported data may underestimate actual medication error frequency due to under-reporting or fear of reprisal (Elden & Ismail, 2016). Furthermore, data were collected from a single hospital, limiting generalizability to other healthcare settings.

Despite these limitations, the findings have strong policy and managerial implications. Hospitals should adopt evidence-based nurse-to-patient staffing ratios, promote protected medication administration times free of interruptions, and enforce rest and recovery periods to mitigate fatigue. Introducing error-reporting systems focused on learning rather than blame can also improve safety culture (Kim & Bates, 2013). Future research should employ longitudinal or observational designs and integrate objective error reporting data to validate and expand these findings.

In conclusion, this study confirms that excessive workload, nurse fatigue, and inadequate staffing are key contributors to medication errors in nursing practice. Addressing these modifiable factors through organizational, staffing, and scheduling interventions can enhance medication safety, protect patients, and promote nurse well-being.

5. CONCLUSION

This study demonstrates that excessive workload, increased fatigue, and higher patient-to-nurse ratios significantly contribute to the occurrence of medication errors among registered nurses. These findings highlight the importance of addressing organizational and system-level factors that compromise medication safety, rather than focusing solely on individual accountability. Ensuring adequate nurse staffing, optimizing shift schedules, and implementing fatigue management and workload monitoring strategies can substantially reduce the risk of medication errors and enhance patient safety.

Moreover, fostering a non-punitive culture of medication error reporting and continuous education in safe medication practices are essential for sustaining improvements in clinical environments. Hospital administrators and policymakers must prioritize workforce planning and resource allocation to maintain safe staffing ratios and manageable workloads, particularly in resource-limited healthcare systems such as Pakistan.

Future research should employ longitudinal and interventional designs to explore causal pathways and evaluate the effectiveness of staffing and fatigue-reduction interventions on medication safety outcomes. By mitigating preventable workplace stressors and improving nurses' working conditions, healthcare institutions can strengthen both patient safety and the well-being of the nursing workforce.

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