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Original Article

The Impact of Chronic Fatigue and Its Prevalence Among Nurses

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ABSTRACT

Background: Chronic fatigue is common among nurses and may adversely affect their health, occupational performance, and patient care. Shift-related social disruption and increasing use of wearable health technologies may be associated with fatigue, but evidence from Pakistani nursing populations is limited. Objective: To examine chronic fatigue among nurses and determine its relationship with wearable technology use and shift-related social isolation. Methods: A quantitative cross-sectional study was conducted among 302 nurses recruited through convenience sampling from selected public hospitals in Lahore, Pakistan. Data were collected using structured measures of wearable technology use, shift-related social isolation, and chronic fatigue. Descriptive statistics, reliability analysis, Pearson correlation, and linear regression were performed using IBM SPSS Statistics version 26.0. Results: Most participants were female (87.4%), and 94.0% were aged 22–50 years. Wearable technology use was weakly associated with chronic fatigue ($r=0.171$, $p=0.003$), as was shift-related social isolation ($r=0.180$, $p=0.002$). In multiple regression, wearable technology use ($B=0.127$, $\beta=0.159$, $p=0.005$) and shift-related social isolation ($B=0.153$, $\beta=0.168$, $p=0.003$) remained significant. The model explained 5.7% of fatigue variance. Conclusion: Wearable technology use and shift-related social isolation were weak correlates of chronic fatigue. The low explained variance and poor reliability of the social isolation scale indicate that additional occupational, psychological, and sleep-related determinants should be investigated. Keywords: Chronic fatigue; nurses; wearable technology; shift work; social isolation; occupational health.

INTRODUCTION

Chronic fatigue is a persistent state of physical and mental exhaustion that may impair concentration, emotional functioning, occupational performance, and recovery even after adequate rest. Among healthcare professionals, nurses are particularly vulnerable because their work frequently involves prolonged shifts, rotating schedules, high patient-to-nurse ratios, emotionally demanding clinical situations, and limited opportunities for recovery. A recent systematic review and meta-analysis reported moderately high levels of work-related fatigue among clinical nurses and identified workload, shift arrangements, organizational conditions, and individual characteristics as important contributing factors (1). Occupational stress, workplace violence, and inadequate organizational support have also been associated with chronic fatigue symptoms among nurses, indicating that fatigue is influenced by both individual and workplace-level conditions (2).

Fatigue among nurses has implications extending beyond personal discomfort. Persistent exhaustion may reduce attention, memory, judgment, and psychomotor performance, thereby increasing the likelihood of medication errors, delayed clinical decisions, patient falls, and other adverse events.

Prolonged working hours and occupational stress have been associated with impaired work performance and a greater risk of errors among nursing personnel (3). Fatigue may also contribute to absenteeism, presenteeism, job dissatisfaction, burnout, and workforce turnover. A narrative review examining fatigue among female nurses similarly emphasized that occupational fatigue can adversely affect nurses' health, professional functioning, and the safety of patient care (4). Evidence comparing nurses engaged in direct and non-direct patient care further suggests that fatigue is shaped by the nature of nursing responsibilities, workload intensity, and opportunities for physical and psychological recovery (5).

Studies from different healthcare settings have reported substantial levels of fatigue among nurses. Research from the United States has described chronic fatigue as a frequent occupational concern among nursing personnel (6). Studies conducted in China, Italy, Spain, and intensive care settings have similarly identified shift work, workload, insufficient rest, emotional stress, and demanding clinical environments as important correlates of fatigue (7–10). Age, underlying health status, professional experience, and coping resources may also influence susceptibility to persistent fatigue (11). Nurses working in intensive care environments may be particularly vulnerable because of sustained vigilance, complex decision-making, emotional exposure, and high patient acuity (12). Workload and shift scheduling have consequently been identified as important predictors of chronic fatigue in nursing populations (13).

The demanding structure of shift-based nursing work is an important contributor to fatigue. Rotating and night shifts can disturb circadian rhythms, reduce sleep duration, impair sleep quality, and limit the time available for family and social activities. Nurses working irregular schedules may therefore experience both physiological sleep disruption and social isolation. Research comparing rotating night-shift and day-shift nurses has shown that shift work can adversely affect psychological and physical health (14). Fatigue, anxiety, and depressive symptoms have also been documented among nurses working shifts in tertiary healthcare settings, demonstrating the interrelationship between occupational schedules, emotional distress, and exhaustion (15). Systematic evidence further indicates that night-shift work may adversely affect mental health, sleep, and fatigue among nurses (16). Reduced contact with family, friends, and community networks may further limit emotional recovery and increase the psychological burden associated with demanding clinical work.

Social support is an important occupational resource that may protect nurses against stress and exhaustion. Nurses who receive adequate support from colleagues, supervisors, and family members may be better able to manage emotionally demanding events and recover from work-related strain. Conversely, shift-related social isolation may weaken support networks, disrupt work–life balance, and contribute to persistent fatigue. Irregular schedules may prevent nurses from attending family gatherings, leisure activities, and community events, while repeated night work may create feelings of exclusion or loneliness. These effects can coexist with sleep disruption, making it difficult to separate the social and physiological consequences of shift work. Examining shift-related social isolation as a distinct occupational exposure may therefore improve understanding of the psychosocial pathways through which nursing schedules are associated with fatigue.

Wearable healthcare technologies, including smartwatches, fitness trackers, and mobile monitoring devices, are increasingly used to record physical activity, heart rate, sleep patterns, and other indicators of health. These devices may help users recognize inadequate sleep, excessive activity, and patterns associated with fatigue. Wearable monitoring may consequently support self-management by encouraging rest, pacing, and healthier daily routines. Reviews of wearable technology have highlighted its potential role in fatigue monitoring and the assessment of physiological and behavioural indicators associated with exhaustion (17). However, wearable technologies may also increase cognitive demands, privacy concerns, health-related anxiety, and perceived pressure to achieve device-generated targets. Challenges related to data interpretation, security, usability, and continuous monitoring may influence how users experience these devices (18). The relationship between wearable technology use and chronic fatigue may therefore be complex.

Orem's Self-Care Deficit Nursing Theory provides a relevant conceptual perspective for examining these relationships. The theory proposes that individuals maintain health through self-care activities, but a self-care deficit develops when personal capabilities are insufficient to meet therapeutic self-care demands (19). In nursing practice, heavy workloads, irregular shifts, emotional strain, and inadequate recovery may limit nurses' ability to maintain sleep, social relationships, physical activity, and other self-care behaviours. Wearable technology may facilitate self-monitoring, whereas shift-related social isolation may restrict emotional and social resources needed for recovery. Chronic fatigue may therefore reflect an imbalance between occupational demands and the capacity of nurses to meet their own physical and psychological care needs.

Burnout represents a related but distinct occupational phenomenon and has been reported globally among nurses (20). Poor sleep quality, particularly in high-acuity clinical environments, may further intensify fatigue and reduce recovery capacity (21). These overlapping occupational and psychological factors indicate that chronic fatigue should not be attributed to a single exposure. Instead, it is likely to arise from interactions among shift patterns, workload, sleep disruption, emotional strain, individual health, workplace support, and self-care capacity.

Previous research has established that work-related fatigue is common among nurses, but several gaps remain. Much of the available evidence has focused on workload, shift duration, sleep disturbance, occupational stress, and burnout. Comparatively less attention has been given to the relationship of chronic fatigue with wearable technology use and the social isolation created by irregular nursing schedules. Evidence is particularly limited among nurses working in public healthcare institutions in Lahore, Pakistan, where staffing patterns, occupational demands, social structures, and access to digital health technologies may differ from those reported in other healthcare systems. Furthermore, studies frequently discuss the consequences of fatigue without simultaneously evaluating technological and social factors that may be associated with it.

The present study was therefore conducted to examine chronic fatigue among nurses employed in selected public healthcare institutions in Lahore and to determine its relationship with wearable technology use and shift-related social isolation. It was hypothesized that wearable technology use would be significantly associated with chronic fatigue and that shift-related social isolation would be significantly associated with chronic fatigue among participating nurses.

MATERIALS AND METHODS

A quantitative cross-sectional study was conducted to examine chronic fatigue and its relationship with wearable technology use and shift-related social isolation among nurses employed in public healthcare institutions in Lahore, Punjab, Pakistan. The cross-sectional design was selected because it enabled the simultaneous measurement of the study variables within the participating nursing population and allowed assessment of their statistical associations without introducing an intervention or longitudinal follow-up.

Participants were recruited from five public healthcare institutions in Lahore: The Children's Hospital, Mayo Hospital, Lahore General Hospital, Shaikh Zayed Hospital, and Lady Aitchison Hospital. These institutions were selected because they provide a broad range of clinical services and employ nurses working across different hospital units and shift schedules. The unit of analysis was the individual nurse. Nurses employed at the selected institutions who were available during data collection and voluntarily agreed to participate were eligible for recruitment. Participants were enrolled using a non-probability convenience sampling technique because access to the nursing workforce was determined by participant availability and willingness to take part in the study.

The accessible nursing population across the selected institutions was estimated using institutional workforce figures available to the researchers. The required sample size was calculated using Slovin's formula with a 5% margin of error. Based on this calculation and the practical resources available for recruitment and data collection, a final sample of 302 nurses was included in the analysis. Convenience recruitment continued across the selected hospitals until the required sample was obtained.

Data were collected using a structured self-administered questionnaire distributed electronically or in person according to participant accessibility. Before completing the questionnaire, participants received information explaining the study purpose, procedures, voluntary nature of participation, potential discomfort associated with answering questions about stress and fatigue, and measures used to protect confidentiality. Participation was based on informed consent. Respondents were permitted to decline participation, omit questions that caused discomfort, or withdraw without penalty. Responses were anonymized, securely maintained, and used exclusively for academic research purposes.

The questionnaire consisted of demographic questions and three multi-item measures assessing wearable technology use, shift-related social isolation, and chronic fatigue. Demographic information included age and gender. Responses to the study items were recorded on a five-point Likert scale ranging from strongly disagree to strongly agree. Composite scores were generated for each study variable, with higher scores indicating greater endorsement of the relevant construct.

Wearable technology use was assessed using an eight-item questionnaire attributed in the source manuscript to Jiban Khuntia and colleagues. The items evaluated ownership and regular use of wearable healthcare devices, monitoring of health indicators, willingness to share device-generated data with healthcare providers, confidence in using wearable technology, perceived effects on health and wellness, privacy and security concerns, and the influence of healthcare-provider recommendations. The source instrument was reported to have demonstrated good internal consistency, with an overall Cronbach's alpha of 0.87 and subscale coefficients ranging from 0.85 to 0.89. In the present sample, internal consistency was reassessed before inferential analysis.

Shift-related social isolation was measured using eight items attributed in the source manuscript to S. S. Sundararaman and S. S. Sathyanarayanan. The items examined reduced interaction with family and friends, disruption of leisure activities, feelings of social isolation, exclusion from daytime gatherings, strain in personal relationships, difficulty participating in community activities, weakened support systems, and difficulty maintaining work–life balance because of shift schedules. The source instrument was reported to have a Cronbach's alpha of 0.85. Because internal consistency can vary across populations and settings, reliability was evaluated again using data from the present study.

Chronic fatigue was assessed using a 10-item questionnaire attributed in the source manuscript to Xiao-Hua Wang and colleagues. The instrument assessed persistent tiredness despite rest, impaired memory and concentration, unexplained muscle aches, joint pain, headaches, unrefreshing or disturbed sleep, recurrent sore throat, tender lymph nodes, and marked exhaustion following physical or mental activity. The source questionnaire was reported to have internal consistency coefficients exceeding 0.80. Higher composite scores represented greater chronic fatigue symptom burden.

Wearable technology use and shift-related social isolation were treated as the independent variables, while chronic fatigue was treated as the dependent variable. Data quality was evaluated before inferential analysis by checking questionnaire completeness, coding accuracy, score ranges, and the distributions of continuous composite scores. Internal consistency was examined using Cronbach's alpha. The reliability coefficients were interpreted cautiously because a low coefficient indicates limited coherence among scale items and may weaken the precision of subsequent association estimates.

Data were analysed using IBM SPSS Statistics version 26.0. Frequencies and percentages were calculated for categorical demographic characteristics, while means, standard deviations, skewness, and kurtosis were used to summarize composite scale scores. Distributional assumptions were evaluated from skewness and kurtosis statistics rather than assuming normality solely from the sample size. Pearson correlation coefficients were calculated to examine bivariate associations between wearable technology use, shift-related social isolation, and chronic fatigue. Simple linear regression was used to evaluate the unadjusted association between wearable technology use and chronic fatigue. Multiple linear regression was subsequently used to examine the combined associations of wearable technology use and shift-related social isolation with chronic fatigue. Regression coefficients, standard errors, standardized beta coefficients, t statistics, p-values, and model coefficients of determination were used to describe the magnitude and statistical significance of the associations. Statistical significance was established at $p<0.05$. Because the study used a cross-sectional observational design, regression findings were interpreted as associations rather than evidence of causation.

RESULTS

A total of 302 nurses participated in the study. Most participants were female, accounting for 264 respondents (87.4%), while 38 participants (12.6%) were male. Regarding age, 143 participants (47.4%) were aged 22–30 years and 141 (46.7%) were aged 31–50 years. Thus, 284 participants (94.0%) were between 22 and 50 years of age, whereas 18 participants (6.0%) were aged 51 years or older.

Table 1. Demographic Characteristics of the Participants

Characteristic	Category	n	%
Gender	Male	38	12.6
	Female	264	87.4
Age group, years	22–30	143	47.4
	31–50	141	46.7
	≥51	18	6.0

Percentages may not total exactly 100 because of rounding.

The internal consistency and distributional characteristics of the three study scales are presented in Table 2. The wearable technology use scale demonstrated excellent internal consistency, with a Cronbach's alpha of 0.905, while the chronic fatigue scale demonstrated good internal consistency, with an alpha of 0.801. In contrast, the shift-related social isolation scale had a Cronbach's alpha of 0.382, indicating poor internal consistency in the present sample. Consequently, associations involving this scale should be interpreted cautiously because the low reliability may have reduced measurement precision.

The mean score for wearable technology use was 3.66 ± 0.76, while the mean shift-related social isolation score was 3.97 ± 0.67. The mean chronic fatigue score was 3.18 ± 0.61. Wearable technology use showed moderate negative skewness but no substantial excess kurtosis. Chronic fatigue scores were approximately symmetric. Shift-related social isolation, however, showed marked positive skewness and pronounced kurtosis, indicating a substantially non-normal distribution.

Table 2. Reliability and Descriptive Characteristics of the Study Scales

Scale	Items, n	Cronbach's α	Mean	SD	Skewness	Kurtosis
Wearable technology use	8	0.905	3.663	0.761	−1.147	0.766
Shift-related social isolation	8	0.382	3.967	0.672	2.384	16.511
Chronic fatigue	10	0.801	3.178	0.608	0.149	−0.617

SD: standard deviation; α: Cronbach's alpha.

Bivariate correlation analysis showed a weak positive association between wearable technology use and chronic fatigue, with $r=0.171$ and $p=0.003$. Shift-related social isolation was also weakly and positively associated with chronic fatigue, with $r=0.180$ and $p=0.002$. The association between wearable technology use and shift-related social isolation was weak and statistically non-significant, with $r=0.070$ and $p=0.225$.

Although the two hypothesized predictors were statistically associated with chronic fatigue, the small correlation coefficients indicate limited effect magnitude.

Table 3. Correlations Between Wearable Technology Use, Shift-Related Social Isolation, and Chronic Fatigue

Variable	1	2	3
1. Wearable technology use	1.000		
2. Shift-related social isolation	0.070	1.000	
3. Chronic fatigue	0.171	0.180	1.000

For wearable technology use and shift-related social isolation, p=0.225. For wearable technology use and chronic fatigue, p=0.003. For shift-related social isolation and chronic fatigue, p=0.002. Correlations are Pearson correlation coefficients.

Simple linear regression was used to examine the association between wearable technology use and chronic fatigue. Wearable technology use was positively associated with chronic fatigue, with an unstandardized coefficient of B=0.136, standard error=0.045, standardized β=0.171, t=2.998, and p=0.003. The corresponding 95% confidence interval for the unstandardized coefficient was approximately 0.047 to 0.225.

Because a standardized coefficient of 0.171 in a simple linear regression corresponds to an R^2 of approximately 0.029, wearable technology use explained approximately 2.9% of the variance in chronic fatigue scores. The derived model F statistic was approximately 9.04, and the adjusted R^2 was approximately 0.026. The association was statistically significant but small in magnitude.

Table 4. Simple Linear Regression of Wearable Technology Use With Chronic Fatigue

Predictor	B	SE	95% CI for B	Standardized β	t	p
Constant	2.679	0.170	2.344 to 3.014	—	15.767	<0.001
Wearable technology use	0.136	0.045	0.047 to 0.225	0.171	2.998	0.003

Model R^2=0.029; adjusted R^2=0.026; derived F(1,300)=9.04. B: unstandardized regression coefficient; SE: standard error; CI: confidence interval.

Multiple linear regression was subsequently used to examine the simultaneous associations of wearable technology use and shift-related social isolation with chronic fatigue. Wearable technology use remained positively associated with chronic fatigue after inclusion of shift-related social isolation in the model, with B=0.127, standard error=0.045, standardized β=0.159, t=2.821, and p=0.005. The corresponding 95% confidence interval for B was approximately 0.038 to 0.216.

Shift-related social isolation was also positively associated with chronic fatigue, with B=0.153, standard error=0.051, standardized β=0.168, t=2.993, and p=0.003. Its approximate 95% confidence interval ranged from 0.053 to 0.253. The standardized coefficients indicate that shift-related social isolation had a marginally stronger statistical association with chronic fatigue than wearable technology use, although both associations were weak.

Together, wearable technology use and shift-related social isolation explained 5.7% of the variance in chronic fatigue scores. The adjusted R^2 was approximately 0.051, and the derived overall model statistic was F(2,299)=9.04. Therefore, approximately 94.3% of the observed variability in chronic fatigue remained unexplained by these two predictors. These findings support the presence of statistically significant associations but also indicate that chronic fatigue among nurses is likely influenced by numerous occupational, psychological, physiological, and organizational factors not included in the model.

Table 5. Multiple Linear Regression of Wearable Technology Use and Shift-Related Social Isolation With Chronic Fatigue

Predictor	B	SE	95% CI for B	Standardized β	t	p
Constant	2.108	0.254	1.608 to 2.608	—	8.304	<0.001
Wearable technology use	0.127	0.045	0.038 to 0.216	0.159	2.821	0.005

Predictor	B	SE	95% CI for B	Standardized β	t	p
Shift-related social isolation	0.153	0.051	0.053 to 0.253	0.168	2.993	0.003

Model R^2=0.057; adjusted R^2=0.051; derived F(2,299)=9.04. B: unstandardized regression coefficient; SE: standard error; CI: confidence interval.

The first hypothesis, proposing a significant relationship between wearable technology use and chronic fatigue, was supported by the bivariate and regression analyses. The second hypothesis, proposing a significant relationship between shift-related social isolation and chronic fatigue, was also supported. However, these findings represent associations only and should not be interpreted as evidence that either exposure caused chronic fatigue.

DISCUSSION

The present study examined chronic fatigue among nurses and assessed its relationship with wearable technology use and shift-related social isolation. The principal finding was that both predictors showed statistically significant but weak positive associations with chronic fatigue. Wearable technology use was correlated with chronic fatigue at r=0.171, while shift-related social isolation was correlated with chronic fatigue at r=0.180. In the multiple regression model, both variables remained statistically significant, but together they explained only 5.7% of the variability in fatigue scores. These findings indicate that wearable technology use and shift-related social isolation may be relevant correlates of fatigue, although neither variable alone, nor the combination of both, provides a comprehensive explanation of chronic fatigue among nurses.

The high representation of female participants reflects the demographic composition of the nursing workforce in many healthcare systems. However, the predominance of women in the sample limits the ability to determine whether the observed associations differ by gender. Most participants were between 22 and 50 years of age, suggesting that the findings primarily represent early- and middle-career nurses rather than older nursing professionals. Age-related differences in sleep recovery, physical workload tolerance, family responsibilities, digital technology use, and exposure to rotating shifts may influence fatigue, but these possible differences were not examined in the available analysis. Previous research has indicated that age-related characteristics may influence chronic fatigue among nurses (11).

The observed chronic fatigue mean of 3.18 on a five-point response scale indicates that fatigue symptoms were present at a moderate level across the study population. This finding is broadly consistent with evidence indicating that nurses experience substantial work-related fatigue because of prolonged shifts, workload, occupational stress, emotional demands, and inadequate recovery opportunities (1–5). Pi et al. reported moderately high levels of fatigue among clinical nurses and emphasized the influence of organizational culture, management systems, personal characteristics, and occupational demands (1). Li et al. similarly found that occupational stress, workplace violence, and insufficient organizational support were associated with chronic fatigue syndrome among nurses (2). Studies conducted in different countries and clinical settings have also linked nursing fatigue with workload, shift patterns, insufficient rest, and demanding workplace conditions (6–13). The present findings reinforce the broader conclusion that fatigue in nursing is a multifactorial occupational health problem.

Wearable technology use showed a weak positive association with chronic fatigue. This relationship should not be interpreted to mean that wearable devices produce fatigue. One plausible interpretation is that nurses experiencing fatigue may be more likely to adopt wearable devices to monitor sleep, heart rate, physical activity, or general health. This possibility represents reverse causation, which cannot be distinguished from a direct effect in a cross-sectional study. Alternatively, frequent interaction with digital monitoring systems may increase cognitive burden, performance awareness, or concern about health indicators. Device alerts, target-based feedback, privacy concerns, and continuous self-monitoring may also contribute to psychological strain in some users. Reviews of wearable monitoring have recognized both its potential value for fatigue assessment and the practical challenges associated with continuous data collection and interpretation (17,18).

The direction of the association may therefore reflect several competing mechanisms. Wearable devices may support fatigue management by helping nurses identify poor sleep, inadequate recovery, excessive physical activity, or irregular patterns. At the same time, nurses who are already concerned about their health may use wearable devices more frequently, creating an apparent positive relationship between device use and fatigue. The study instrument also measured several distinct aspects of wearable use, including device ownership, confidence, data sharing, perceived benefits, privacy concerns, and provider influence. These dimensions may not have identical relationships with fatigue. A total scale score may consequently obscure differences between beneficial monitoring behaviours and potentially stressful aspects of technology use.

The magnitude of the wearable technology association was small. In the simple regression model, wearable technology use explained approximately 2.9% of the variance in chronic fatigue. After shift-related social isolation was added to the model, wearable technology use retained an independent association with fatigue, but the standardized coefficient remained modest at $\beta=0.159$. This suggests that wearable technology use may be statistically relevant but is unlikely to be a dominant determinant of chronic fatigue among nurses.

Shift-related social isolation also showed a weak positive association with chronic fatigue. Nurses working night, rotating, or irregular shifts may have fewer opportunities to interact with family members, friends, and community networks. They may miss social gatherings, experience difficulty participating in leisure activities, and struggle to maintain work–life balance. Such disruption can reduce access to emotional and practical support and may contribute to loneliness, stress, and reduced psychological recovery. Shift work can simultaneously disturb circadian rhythms and sleep quality, making it difficult to separate the social consequences of irregular schedules from their physiological effects.

The finding is consistent with previous evidence that rotating and night shifts adversely affect nurses' psychological and physical health (14). Ferri et al. observed differences in health outcomes between nurses working rotating night shifts and those working day shifts, supporting the broader relationship between irregular schedules and occupational well-being (14). Kaliyaperumal et al. also reported fatigue, anxiety, and depression among nurses engaged in shift work, demonstrating the close relationship between shift patterns, emotional distress, and exhaustion (15). Systematic evidence concerning night-shift work similarly indicates adverse effects on mental health and fatigue among nurses (16). The present study adds a specific psychosocial dimension by focusing on perceived social isolation associated with shift schedules.

Shift-related social isolation had a slightly stronger standardized association with fatigue than wearable technology use, with $\beta=0.168$ compared with $\beta=0.159$. The difference was small and should not be interpreted as evidence that one predictor is clinically more important than the other. The two predictors together explained only 5.7% of fatigue variability. The remaining unexplained variance may reflect factors such as workload intensity, nurse-to-patient ratios, shift duration, consecutive night duties, sleep quality, burnout, occupational stress, workplace violence, emotional exhaustion, physical health conditions, caregiving responsibilities, organizational support, and access to rest periods. Previous research has demonstrated associations between fatigue and many of these occupational and personal factors (1,2,7–13,20,21).

An important measurement concern was the low internal consistency of the shift-related social isolation scale. Its Cronbach's alpha was 0.382, substantially below conventional standards for acceptable reliability. This finding indicates that the eight items may not have measured a single coherent construct in the present population. Cultural differences, variation in shift arrangements, translation or comprehension problems, heterogeneous item content, and response-pattern effects may have contributed to the poor reliability. Low reliability can attenuate or destabilize associations, meaning that the reported relationship between social isolation and fatigue may not precisely represent the underlying construct.

The distribution of shift-related social isolation scores also showed marked non-normality, with skewness of 2.384 and kurtosis of 16.511. The pronounced kurtosis may indicate clustering of responses, a ceiling or floor effect, influential observations, or limited variability across several scale items. The use of Pearson correlation and linear regression should therefore be interpreted carefully. Future analyses should examine item-level distributions, influential observations, residual plots, heteroscedasticity, and robust or non-parametric alternatives. Spearman correlation or bootstrapped confidence intervals may provide more reliable estimates if the distributional assumptions of conventional parametric methods are not satisfied.

The findings have practical implications, but intervention recommendations should remain proportionate to the small effect sizes and observational design. Healthcare institutions may consider reviewing scheduling practices, ensuring adequate rest between shifts, promoting peer support, and improving opportunities for social connection among nurses working nights or rotating schedules. Team-based scheduling, structured handover support, mentorship, and access to psychological services may help reduce the social and emotional burden associated with irregular work hours. Nevertheless, the present analysis does not establish that these interventions will reduce chronic fatigue, and their effectiveness would need to be evaluated prospectively.

Wearable technologies may be used constructively when their implementation is voluntary, clinically relevant, and accompanied by clear guidance regarding privacy, data interpretation, and the limitations of device-generated indicators. Nurses should not be subjected to excessive monitoring or performance pressure through wearable systems. Institutions considering fatigue-monitoring technologies should distinguish supportive self-management from surveillance and should evaluate whether devices improve sleep awareness, recovery behaviour, and occupational well-being without adding cognitive or psychological burden (17,18).

This study has several strengths. It included 302 nurses from multiple public hospitals in Lahore and examined two relatively underexplored correlates of chronic fatigue. The wearable technology and chronic fatigue measures demonstrated good to excellent internal consistency. The analysis also evaluated both bivariate and multivariable relationships, allowing the independent contribution of each predictor to be estimated.

Several limitations must also be considered. First, the cross-sectional design prevents determination of temporal sequence or causality. It remains unclear whether wearable technology use and social isolation preceded fatigue or whether fatigued nurses reported greater technology use and social disruption. Second, convenience sampling may have introduced selection bias and limits generalizability beyond the participating hospitals. Third, all variables were assessed through self-report, creating potential recall bias, social desirability bias, and common-method variance. Fourth, the low reliability and marked non-normality of the shift-related social isolation scale weaken confidence in estimates involving that variable.

Fifth, the regression model included only two predictors and explained 5.7% of fatigue variability. Important confounders and alternative explanatory factors were not incorporated, including sleep duration, shift type, weekly working hours, consecutive night shifts, patient load, professional experience, marital status, chronic disease, occupational stress, burnout, workplace violence, and organizational support. Sixth, the analysis did not report formal diagnostics for linearity, independence, homoscedasticity, residual normality, influential observations, or multicollinearity. Finally, the study did not establish a clinically validated threshold for chronic fatigue; consequently, it assessed symptom levels and statistical associations rather than epidemiological prevalence based on a diagnostic case definition.

Future studies should use probability-based or stratified sampling across hospitals and clinical departments, employ psychometrically validated instruments adapted for the local population, and record detailed information on shift patterns, sleep, workload, occupational stress, and organizational support. Longitudinal designs would help determine temporal relationships, while qualitative research could explore how nurses perceive social isolation and digital monitoring. Intervention studies could subsequently evaluate whether scheduling reform, peer-support programmes, sleep-health interventions, or carefully designed wearable-assisted fatigue management produce meaningful improvements in nurse well-being and patient safety.

CONCLUSION

Chronic fatigue was present at a moderate level among the participating nurses and was weakly but significantly associated with wearable technology use and shift-related social isolation. Both predictors remained statistically significant in the multiple regression model, although together they explained only 5.7% of the variability in fatigue scores. Shift-related social isolation showed a marginally stronger standardized association with fatigue than wearable technology use, but its poor scale reliability requires cautious interpretation. The findings indicate that chronic fatigue among nurses is multifactorial and cannot be adequately explained by these two variables alone. Prospective studies using reliable measures and broader occupational, psychological, sleep-related, and organizational predictors are required to clarify the determinants of fatigue and inform appropriately targeted workplace strategies.

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