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Research Article

The Role of Ambient Room Lighting Patterns in Reducing Nighttime Falls: A Nurse-Driven Experiment

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Abstract

Nighttime falls in hospital settings remain a costly and dangerous challenge, particularly for aging and medically complex patients. This nurse-driven quasi-experimental study investigated the efficacy of an ambient room lighting intervention tailored to enhance nighttime visibility while minimizing sleep disruption, deployed in two medical-surgical wards in a large tertiary hospital. Over twelve months, fall incidence, patient-reported mobility confidence and sleep quality, and nursing staff perceptions were evaluated using mixed methods. The intervention introduced bespoke low-lux, warm-spectrum lighting with motion activation, co-designed with clinical and engineering teams. Quantitative data revealed a statistically significant 61% reduction in nighttime falls, especially among older adults and sedative medication users, without degradation of sleep quality. Qualitative analyses demonstrated strong nursing engagement, with reports of streamlined nocturnal care and perceived patient safety improvements. This study advances environmental fall-prevention paradigms by validating nurse-led ambient lighting as a low-cost, scalable, and clinically effective approach to nighttime fall reduction. It highlights the need for integration of human factors and circadian science into nursing practice and healthcare design to promote holistic patient safety and quality care. [1]

Keywords: Ambient lighting, nighttime falls, patient safety, nursing intervention, fall prevention, hospital environment, circadian rhythms, patient mobility, healthcare quality, environmental design, human factors, geriatric care, lighting technology.

1. Introduction

Hospital falls represent a persistent and complex problem within healthcare systems worldwide, with significant consequences for patient safety, healthcare costs, and institutional reputation. According to the World Health Organization, falls rank as the second leading cause of accidental injury-related deaths globally, a statistic that underscores the critical importance of effective fall prevention strategies in all care settings (WHO, 2018). Within hospitals, the incidence of falls is notably high, especially among elderly and medically fragile patients, with reported rates ranging from 3 to 20 falls per 1,000 patient days, depending on the patient population and care environment (Bouldin et al., 2013; Oliver et al., 2004). Such falls frequently lead to injuries such as fractures and head trauma, often resulting in prolonged hospital stays, increased need for rehabilitative care, and in some cases, permanent disability or death.

Nighttime falls are particularly problematic because the conditions at night exacerbate many of the intrinsic and extrinsic risks faced by patients. The diminished ambient lighting characteristic of hospital wards during night hours impairs visual acuity and depth perception, key sensory modalities for safe movement. This reduced lighting environment, coupled with the effects of medications, fatigue, and disorientation common in hospitalized patients, increases vulnerability to falls (Tzeng & Yin, 2013). Recent data indicate that a disproportionate number of hospital falls—up to half—occur during nighttime, when staffing ratios may be reduced and continuous supervision less feasible (Fisher et al., 2019). Patients' circadian shifts also play a critical role, as disrupted sleep-wake patterns around the hospital stay may impair attention and balance.

This study seeks to address these intersecting needs by evaluating a nurse-driven ambient lighting intervention designed explicitly to reduce nighttime falls in hospital settings. Conceived through collaborative efforts among nursing staff, clinical leadership, and lighting engineers, the intervention employs low-intensity, warm-spectrum, motion-activated ambient lighting designed to enhance safe patient mobility-

at night without compromising sleep quality or nursing workflow. The objectives are to quantify the impact on fall rates, assess patient experience regarding mobility and sleep, and explore nursing staff perceptions surrounding efficacy and feasibility.

By situating nurse-led environmental modifications within the broader context of patient-centered fall prevention, this research fills a critical gap in the healthcare literature. It further aligns with evolving models of hospital design that emphasize holistic safety, human-centered care, and the integration of biological rhythms. Ultimately, this study contributes new knowledge with potential for scalable, low-cost innovations that empower nursing practice to improve patient outcomes and mitigate one of the most persistent safety challenges in inpatient care. [2–29]

2. Methodology

This study employed a quasi-experimental pre-post design to assess the effects of an ambient lighting intervention on nighttime fall rates in hospital wards. The design balanced the need for scientific rigor with the practical and ethical constraints of a real-world clinical setting. The intervention took place in two adult medical-surgical wards at a large urban academic hospital, each with similar patient populations that included a significant number of elderly individuals at elevated fall risk. Participants included ambulatory patients able to move independently or with minimal assistance during nighttime hours, while those who were bed-bound or had severe cognitive impairments that prevented informed consent were excluded.

The lighting intervention was developed collaboratively by nursing leadership, clinical staff, lighting engineers, and environmental psychologists. The goal was to create a system that provided low-intensity illumination—calibrated between 10 and 20 lux at eye level—adequate to support safe navigation during night hours without disturbing patients' sleep. Warm-spectrum LED lights, ranging from 2700 to 3000 Kelvin, were selected to minimize blue light exposure that can suppress melatonin and disrupt circadian rhythms. The system incorporated motion-activated sensors that triggered lighting upon patient-movement, promoting energy efficiency and safety. Lighting fixtures were strategically placed along corridors, near bathrooms, and in bedside areas to form a continuous, softly illuminated path.Before implementation, nursing staff took part in hands-on training covering the physiological basis of the lighting design, operational guidelines, and basic troubleshooting. This process fostered staff engagement and encouraged a sense of ownership over the intervention. During the 12-month study period, feedback was continually collected to identify operational challenges and enable adjustments to the protocol.

Data collection drew from multiple sources to comprehensively evaluate the intervention's effectiveness. Fall incidents were recorded through the hospital's incident reporting system. Patients completed validated surveys—the Pittsburgh Sleep Quality Index and a Mobility Confidence Scale—both before and after the intervention to assess changes in sleep quality and mobility confidence. Additionally, nursing staff participated in focus groups, which were audio-recorded to gain qualitative insights into usability, workflow impacts, and perceptions of patient safety improvements.

Quantitative data underwent descriptive statistical analysis with chi-square tests applied to fall incidence comparisons and paired t-tests used to evaluate changes in continuous measures such as mobility confidence and sleep quality. Subgroup analyses targeted particularly vulnerable populations, including older adults and patients prescribed sedative medications. Qualitative data from focus groups were transcribed verbatim and subjected to thematic analysis based on Braun and Clarke's six-phase approach. Coding was independently performed by two researchers to ensure reliability, with any discrepancies resolved through consensus discussions.

The ethical framework guiding this research was robust. Prior to commencement, institutional review board approval was secured (IRB #2025-045), ensuring compliance with ethical guidelines protecting human subjects. Patient confidentiality was preserved through anonymze-

of survey data and secure handling of incident reports. Written informed consent was obtained from all patients who participated in survey completion and from nursing staff involved in focus groups. The environmental nature of the intervention posed minimal risk, and the primary intent was to enhance patient safety and comfort by reducing environmental fall hazards during night hours.

The study received approval from the hospital's Institutional Review Board (IRB #2025-045). Patient confidentiality and ethical standards were rigorously maintained throughout, with informed consent obtained from participants engaged in survey and focus group activities. The intervention, focusing on environmental modification, involved minimal risk and was designed with the goal of enhancing patient safety and comfort during nighttime hours.[2, 16, 24, 29]

3. Literature Review

Falls within hospital settings have been extensively studied, revealing their multifactorial nature and profound impacts on patient safety and healthcare systems. Intrinsic factors such as advancing age, cognitive impairment, medication use (particularly sedatives and psychotropics), and physical frailty interact with extrinsic environmental hazards to increase fall risk (Tinetti et al., 1995; Oliver et al., 2004). Hospital-acquired falls result in serious injuries, including fractures and head trauma, resulting in longer hospital stays and significant additional healthcare costs. Research estimates these falls add billions annually to healthcare expenditures worldwide (Hausdorff & Richardson, 2004; Florence et al., 2018). Importantly, patients' experiences suffer as falls often lead to reduced independence and psychological distress, underscoring the imperative for effective preventive strategies.

Conventional fall prevention in hospitals has mainly focused on patient-centered interventions, such as risk screening, use of bed and chair alarms, gait aids, and staff education (Gillespie et al., 2012). However, the success of such strategies is often limited by inconsistent implementation and insufficient attention to environmental contributors. The physical environment, particularly ambient-conditions like lighting, play an essential but frequently neglected role in fall risk mitigation.Adequate lighting is critical for safe ambulation, as it affects visual acuity, depth perception, and hazard detection, especially for older adults who experience declines in contrast sensitivity and dark adaptation (Brabyn et al., 2001; Owsley, 2016). Studies in both hospital and residential care settings identify poor lighting conditions—including low illuminance and glare—as significant extrinsic factors elevating fall risk (Dalke et al., 2006; Lord et al., 2007). Enhancing ambient lighting to improve navigational safety has demonstrated promising results in reducing falls in aged care facilities, yet its translation to acute care hospitals remains sparse and underexplored (Sekhar & Nayak, 2009).

Lighting also interfaces intricately with patients' circadian rhythms. Hospital environments commonly expose patients to irregular light-dark cycles and disruptive nocturnal light exposure, leading to circadian misalignment, sleep disturbances, and delirium (Xie et al., 2019). Exposure to blue wavelengths in particular suppresses melatonin, a hormone essential for regulating sleep-wake patterns, thereby impairing restorative sleep and cognitive function (Gooley et al., 2010). Poor sleep and delirium are well-established risk factors for falls and functional decline among hospitalized patients (Sloane et al., 2012; Inouye et al., 1999). Conversely, lighting that minimizes blue spectrum exposure—using warm-spectrum LEDs—has been shown to support melatonin production and preserve sleep quality (Rahman et al., 2014). Incorporating motion-activated, dimmable lighting systems may further balance safety with minimal circadian disruption, an approach gaining attention in healthcare design (Fonken & Nelson, 2014).

Nurses are frontline agents in fall prevention efforts due to their ongoing patient contact, environmental assessments, and direct care activities. They possess unique insight into patient needs and environmental barriers that affect safety (Cameron et al., 2012). Empirical studies advocate for nurse-led environmental modificate-

as an effective pathway to reduce falls, yet little research specifically addresses lighting interventions driven by nursing teams (Hitcho et al., 2004; Koehler & Wu, 2021). Participatory design processes that actively engage nursing staff in intervention development enhance program feasibility, acceptability, and sustainability (Ulrich et al., 2008; Joseph, 2010). By combining circadian-informed lighting with nursing expertise, hospitals can pioneer holistic fall prevention strategies that reflect both biological and practical realities.

Despite growing awareness of the importance of the hospital environment for patient outcomes, ambient lighting interventions remain underrepresented in scholarly literature, particularly within the scope of nurse-led initiatives. Bridging this gap requires rigorous evaluations that address clinical, patient-centered, and operational dimensions. This literature review highlights the necessity of such integration and forms the foundation for the present study's focus on a nurse-driven, circadian-conscious ambient lighting intervention aimed at reducing nighttime falls. [3–29]

4. Results

The ambient lighting intervention led to a marked and statistically significant reduction in nighttime hospital falls. Analysis of incident reports over the 12 months preceding and following implementation revealed a decrease in falls from 7.5 to 2.9 per 1,000 patient nights, equating to a 61% reduction ($p < 0.001$). This trend was consistent across both medical-surgical wards involved in the study, demonstrating the intervention's robust applicability in different yet comparable clinical units. Falls resulting specifically in injury showed an even larger reduction, dropping by 67%, indicating that not only were fewer falls occurring, but the severity of those falls that did happen was also diminished.

Subgroup examination underscored the intervention's effectiveness among high-risk populations. Patients aged 65 and older experienced a reduction in fall rates from 9.2 to 3.1 per 1,000 patient nights ($p = 0.002$), reflecting a critical impact on the demographic most vulnerable to fall-related morbidity. Similarly, individuals prescribed sedative or psychotropic medications—a group with an established elevated risk—had a 58% fall rate decrease post-intervention ($p = 0.004$), suggesting the lighting system helped mitigate fall risks exacerbated by medication effects.Patient-reported outcomes offered additional insights. Scores on the Mobility Confidence Scale increased by an average of 37% after installation of the ambient lighting ($p = 0.003$), reflecting patients' enhanced trust and comfort in navigating the hospital environment during night hours. Importantly, the Pittsburgh Sleep Quality Index scores remained statistically unchanged ($p = 0.47$), indicating that the lighting intervention succeeded in maintaining restful sleep, a key factor in patient recovery and safety. These results highlight the system's careful calibration to support safe visibility while preserving circadian rhythm integrity.

Qualitative feedback from nursing staff corroborated and expanded upon these quantitative findings. Nurses described the lighting as providing "just enough" illumination to assist patients safely without the harshness or disruption associated with conventional overhead lighting. Several staff members remarked that the motion-activated system reduced their dependence on handheld flashlights or bedside lamps, simplifying nighttime care routines such as assisting with bathroom visits or medication administration. This facilitation contributed to a calmer ward environment and improved the perceived quality of nighttime care.

Despite initial technical challenges—most notably occasional delays in sensor activation and occasional malfunctions in high-traffic areas—ongoing troubleshooting and additional staff training helped mitigate these issues over time. Nursing personnel expressed strong support for continued use and broader adoption of the lighting system, emphasizing that clear communication regarding its purpose and operation was essential for full team engagement.

Together, these results demonstrate the intervention's effectiveness not only in reducing falls and injuries but also in fostering enhanced patient confidence and supporting nursing workflows. The combined quantitative and qualitative data reveal a well-rounded impact-

underscoring the potential for nurse-led, circadian-aware ambient lighting solutions to improve patient safety outcomes in hospital settings sustainably and meaningfully. [1, 4, 21, 23]

5. Discussion

The substantial reduction in nighttime falls observed in this study supports the hypothesis that nurse-driven ambient lighting interventions can play a critical role in enhancing patient safety in hospital settings. The 61% overall decrease, along with a concurrent drop in fall-related injuries, signals a meaningful clinical improvement that goes beyond mere statistical significance. These findings align with prior research emphasizing the importance of environmental factors, particularly lighting, in mitigating fall risk (Dalke et al., 2006; Lord et al., 2007), while also extending this knowledge into the acute care context through a practical nursing-led approach.

The improvement in mobility confidence reported by patients adds a valuable psychological dimension to the intervention's benefits. Feeling secure in navigating an unfamiliar and often disorienting hospital environment is crucial for patient autonomy and reduces anxiety, which can itself contribute to safer movement (Cameron et al., 2012). Importantly, the intervention maintained sleep quality, a common challenge with night-time lighting solutions. The use of warm-spectrum, low-intensity, motion-activated lighting appears to successfully balance illumination needs against circadian preservation, addressing a key limitation in many prior designs that either sacrificed visibility or disrupted sleep (Chang et al., 2015; Rahman et al., 2014).

Nurses' overwhelmingly positive feedback underscores the importance of involving frontline staff in the design and implementation of safety interventions. Their unique insights helped tailor the lighting system to real-world workflows and patient care patterns, facilitating usability and sustainability (Ulrich et al., 2008). The practical benefits cited—such as reduced need for flashlights and smoother nighttime care tasks—highlight how environmental modifications can simultaneously support staff efficiency and patient safety, fostering a safer and-more supportive hospital atmosphere.Some initial technical challenges, including motion sensor delays and malfunctions, indicate areas for further refinement. Future iterations should focus on enhancing sensor responsiveness and reliability, particularly in high-traffic zones, to ensure consistent performance. Continued staff training and engagement remain essential components of successful deployment.

This study's strengths lie in its multidisciplinary approach, real-world clinical setting, and combined quantitative and qualitative evaluation. However, certain limitations should be acknowledged. The quasi-experimental design lacks a randomized control group, which limits causal inference. Additionally, while the intervention's effects were measured over 12 months, longer-term studies would help confirm durability. Patient surveys, although validated, rely on subjective reporting. Future research could integrate objective mobility tracking and explore the intervention's applicability to other clinical areas and patient populations.

Overall, this research advances understanding of how thoughtfully designed environmental interventions, guided by nursing expertise and circadian principles, can reduce falls and improve patient outcomes. At a time when hospitals seek scalable, cost-effective solutions to pervasive safety challenges, nurse-led ambient lighting modifications offer a promising pathway—one that acknowledges the complex interplay of human factors, biology, and care delivery. [1–7, 16, 21, 26]

6. Conclusion

This study provides compelling evidence that a nurse-driven ambient lighting intervention can substantially mitigate nighttime hospital falls while respecting patients' sleep and circadian health. The significant 61% reduction in fall incidence and the concurrent 67% decline in fall-related injuries mark important milestones in the ongoing effort to combat patient harm in acute care settings. These improvements not only demonstrate effectiveness but also reflect deeper progress in understanding the complex, multifactorial causes of falls—highlighting the vital role of environmental modification as a complement to patient-centered-

and technology-based strategies.Crucially, the intervention's human-centered design, grounded in circadian science and nursing practice, reflects a new frontier in patient safety: one that recognizes health and healing occur within an interplay of biological rhythms, environmental cues, and caregiver support. By employing low-intensity, warm-spectrum lighting that activates only upon patient movement, this approach respects the natural physiology of nighttime rest while ensuring sufficient visibility to reduce falls. This delicate balance addresses a longstanding gap where illuminating hospital environments for safety often inadvertently disrupts restorative sleep or exacerbates delirium, thereby creating new risks. The success of this intervention underscores the importance of interdisciplinary collaboration—melding engineering precision with nursing insight and chronobiology—to create tailored, nuanced solutions that address both safety and well-being.

Patients' enhanced confidence moving within the hospital at night reveals another dimension of impact beyond the reduction of adverse events. Confidence and autonomy are essential to patients' dignity, mental health, and physical recovery. When patients trust their environment, they are more likely to mobilize safely, maintain function, and participate actively in their care plan. Supporting mobility fosters not only physical health but also psychological resilience and reduces the deleterious consequences of prolonged immobility such as muscle atrophy and hospital-associated deconditioning.

From the nursing perspective, the study demonstrated how involving frontline caregivers as partners in intervention design promotes uptake, sustainment, and meaningful innovation. Nurses provided invaluable feedback that refined the lighting system to fit seamlessly into complex nighttime workflows. Their positive reception of the intervention—highlighting convenience, improved patient safety, and reduced reliance on intrusive lighting devices—speaks to the power of participatory design and acknowledges nurses' critical role as everyday architects of patient environments. This empowerment of nursing staff-aligns with broader shifts in healthcare delivery that elevate multidisciplinary collaboration and frontline leadership in quality improvement efforts.Nevertheless, the study also illuminated areas ripe for enhancement. Technical issues with sensor sensitivity and placement illustrate the iterative nature of technological adoption in clinical contexts, where dynamic environments and patient variability create challenges not always anticipated in controlled design phases. Addressing these issues through ongoing staff training, responsive maintenance protocols, and future hardware improvements will be essential to maximize benefits and minimize disruption. Going forward, integrating smart lighting systems capable of adaptive spectral tuning and personalized illumination could further advance harmonization between safety, circadian rhythms, and individual patient preferences.

Economic evaluations warrant priority in future studies, as demonstrating cost savings through reduced falls, shortened hospital stays, and decreased litigation risk could accelerate adoption among hospital administrators and policymakers facing tight budgets and regulatory pressures. Given the scalability and relatively low cost of ambient lighting modifications compared to other technologies, the intervention offers an attractive return on investment, particularly if integrated as part of a comprehensive falls prevention program that holistically addresses patient, staff, and environmental factors.

Effective fall prevention in hospitals will require solutions that honor patients' biological rhythms, psychological needs, and environmental realities, while empowering nurses as change agents. Ambient lighting, thoughtfully designed and nurse-led, exemplifies this integrated ethos, offering a scalable, sustainable strategy that could transform nighttime hospital safety worldwide. As healthcare systems evolve amid demographic shifts and mounting complexity, embracing such multidimensional solutions is essential to reduce avoidable harm and foster healing environments where patients can rest safely and recover confidently.[1, 2, 3, 4, 5, 6]

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