Article

Not peer-reviewed version

Environmental Factors Affecting Sleep Quality in Intensive Care Unit Patients in Southern Morocco: An Assessment Study

Abdelmajid Lkoul * , Keltouma Oumbarek , Youssef Bouchriti , Asmaa Jniene , Tarek Dendane

Posted Date: 25 March 2025

doi: 10.20944/preprints202503.1841.v1

Keywords: Intensive care unit; sleep questionnaire; sleep quality; factors affecting sleep

Article

Environmental Factors Affecting Sleep Quality in Intensive Care Unit Patients in Southern Morocco: An Assessment Study

Abdelmajid Lkoul [1,*], Keltouma Oumbarek [1], Youssef Bouchriti [2], Asmaa Jniene [3] and Tarek Dendane [1]

[1] Laboratory of Biostatistics, Clinical Research and Epidemiology, Faculty of Medicine and Pharmacy, Mohammed V University, Rabat, Morocco.

[2] Geosciences, Environment and Geomatic Laboratory, Department of Earth Sciences, Faculty of Sciences, Ibn Zohr University, Agadir, Morocco

[3] Laboratory of Physiology, Exercise Physiology and Autonomic Nervous System Team, Faculty of Medicine and Pharmacy. Pulmonology department, Ibn Sina Hospital, Ibn Sina University Hospital Center Mohammed V University, Rabat, Morocco

* Correspondence: abdelmajid_lkoul@um5.ac.ma; Phone.: +212662153009.

Highlights

What are the main findings?

- Sleep deprivation is one of the most underestimated complications of the intensive care unit.
- Noise and light exposure were identified as the most significant factors who disturb patient's sleep

What is the implication of the main finding?

- Improvements in pain management and minimization of environmental noise and staff disturbance could significantly improve intensive care patient's sleep quality.

Abstract: Introduction: Sleep disturbances are a commonly underestimated complication of intensive care unit (ICU) stays. This study aimed to assess sleep quality among ICU patients and to analyze the environmental and clinical factors influencing sleep quality during their stay in the ICU. **Methods**: We conducted a six-month cross-sectional study involving patients who stayed in the ICU for ≥ 3 nights and were oriented to time and place upon discharge. Sleep quality was assessed using the Arabic version of the Freedman sleep questionnaire, examining both environmental and non-environmental factors, such as illness severity and pain. Differences across three periods were analyzed using the Wilcoxon test and Spearman correlation, while multiple regression analyses identified factors influencing sleep quality. Statistical analyses were performed using JAMOVI software (version 2.3.28). **Results**: 328 patients were recruited. The average age was 49.74 ± 17.89 years. 75.3% of the participants were adults. The primary admission reasons were circulatory distress 45.73%, followed by metabolic disorders 24.09%. Self-reported sleep quality score at home and the ICU strongly indicated a difference in sleep quality between the two environments ($Z = -14.870$, $p < 0.001$), with significantly lower ranks for sleep quality in the ICU. The EVA and APACHE II scores showed a statistically significant effect on sleep quality ($p < 0.001$ and $p= 0.015$), while the Charlson and Quick Sofa scores are not significant ($p = 0.128$ and $p=0.894$). Several environmental factors showed a statistically significant impact on sleep quality such noise ($p = 0.008$), light ($p = 0.009$), and nursing intervention ($p=0.009$) significantly influence sleep quality. **Conclusion**: Patients generally reported a poor perception of nighttime sleep quality. Enhancing the pain management and minimizing both environmental noise and staff-related disturbances could significantly improve their sleep quality.

Keywords: Intensive care unit; sleep questionnaire; sleep quality; factors affecting sleep

 doi:10.20944/preprints202503.1841.v1

1. Introduction

Sleep deprivation is a commonly underrecognized complication of Intensive Care Unit (ICU) admission, affectingover 61% of critically ill patients [1]. This disruption in sleep patterns has been shown to increase the risk of infections, endocrine disturbances, impaired glucose tolerance, and heightened sympathetic nervous system activity [2–5]. Polysomnographic studies consistently report a decrease in total sleep time, increased fragmentation of sleep, and alterations in sleep architecture among ICU patients. Specifically, there is an increase in lighter sleep stages (N1 and N2), with a significant reduction or absence of restorative deep sleep (N3) and rapid eye movement (REM) sleep [6]. While environmental factors, such as elevated noise levels, have been frequently identified as primary contributors to sleep deprivation, it is essential to acknowledge that frequent interruptions for diagnostic procedures and routine care also increase sleep fragmentation [7–10]. Furthermore, non-environmental factors, such as the patient's underlying medical conditions (e.g., obstructive pulmonary disease, myocardial infarction, pain) and the treatments administered (e.g., sedatives, ventilators), are key contributors to these sleep disturbances [11–14].

Given the critical nature of patients' conditions, scientific literature emphasizes the necessity of using objective tools, including polysomnography and actigraphy, to obtain precise and reliable sleep assessments [15,16]. However, these tools are not universally available in all ICU settings, and their interpretation requires specialized training. In the absence of these objective measures, subjective methods, such as questionnaires, are employed. Although these subjective tools may increase the risk of bias, they remain cost-effective and are more feasible for large-scale assessments. The Critical Care Medicine Society has developed the PADIS guidelines, which propose a multi-component approach to mitigate the adverse effects of pain, agitation, delirium, immobility, and sleep disturbances, thereby promoting better sleep quality in critically ill patients [17].

The ICU environment presents numerous challenges to sleep, including both environmental and medical factors. Recognizing the critical role of sleep in patient recovery and implementing strategies to increase sleep quality in the ICU is vital for enhancing patient outcomes and reducing ICU complications.

2. Materials and Methods

This cross-sectional study was conducted among adult patients admitted to the Intensive Care Unit (ICU) in three public hospitals in south of Morocco. Patients were selected through a convenience sampling method. The total number of the patients who were admitted to the ICUs at the selected hospitals during May - December 2024 and met the inclusion criteria was 494. From this number, 328 eligible patients agreed to participate in the study and complete their participation in the study successfully. This study was approved by the Committee for Biomedical Research Ethics (CERB) of the Faculty of Medicine and Pharmacy of Rabat (N/R: File No. 85/24), and authorization for data collection was delivered by the regional department of health and social protection in the Souss-Massa region. . Prior to participation, all patients were provided with a detailed explanation of the study and gave their written informed consent.

Data collection took place at three distinct times: at the beginning, middle, and end of each patient's hospital stay. Sociodemographic data (age, gender, marital status, geographic origin (rural/urban), profession, education level), medical data (body mass index (BMI), immune status, reason for admission), and hospitalization-related data (length of stay, type of intensive care, health insurance coverage, regular physical activity) were collected using structured questionnaires and by consulting the patients' medical records. Sleep quality was assessed using the Arabic version of Freedman questionnaire, which we have already validated in a previous work (Cronbach's alpha value=0.816 and ICC=0.85). Additionally, the following standardized clinical scores were recorded

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 25 March 2025 doi:10.20944/preprints202503.1841.v1

for each patient: the Charlson score, categorized into three levels of mortality risk (0-1: low, 2-3: moderate, ≥4: high) based on the patient's comorbidity; the Quick SOFA score, categorized into three levels of sepsis risk (0: low, 1-2: moderate, 3: high); the EVA-pain score categorized into three levels of pain severity (0-3: low, 4-7: moderate, 8-10: high) and the Apache II score, categorized into four levels of mortality risk (0-4: low, 5-9: moderate, 10-19: high, >19: very high) based on the severity of the illness.

Statistical analysis of the data considered their distribution. The Kolmogorov-Smirnov test was used to check the normality of sleep quality data. Given the non-normality of the data, the Wilcoxon test for paired samples was used to compare sleep quality in the ICU and at home. The evolution of sleep quality during the ICU stay was also analyzed using the Wilcoxon test. Finally, multiple linear regressions were conducted to explore the relationships between sleep quality (dependent variable) and the aforementioned clinical scores, as well as various environmental factors (noise level, light intensity, nursing interventions, medical equipment) within the ICU. Standardized and unstandardized regression coefficients, 95% confidence intervals, p-values, tolerance, and the variance inflation factor (VIF) were calculated to assess the importance and statistical significance of each predictor and to control for multicollinearity.

3. Results

This study examined the sociodemographic, medical characteristics, and hospital stays of a sample of 328 patients admitted to the intensive care unit (ICU). The results presented in this paper focus on the sleep quality of these patients, comparing their sleep in the ICU with their sleep at home, as well as analyzing factors influencing their sleep quality in the ICU. Statistical analyses, including non-parametric tests (Wilcoxon) and multiple linear regressions, were used to explore the associations between sleep quality and various variables, such as the EVA, APACHE II, Charlson, and Quick SOFA scores, as well as service activities and noise levels in the ICU.

1. Sociodemographic Characteristics of Patients Admitted to Intensive Care

Table 1 presents the distribution of sociodemographic, medical characteristics, and hospital stays of a sample of 328 individuals. The average age was 49.74 ± 17.89 years (18 to 93 years), with a median of 50 years. 75.3% of the participants were adults (18-65 years), and 24.7% were aged 65 years and older. The average BMI was 23.06 ± 4.60 kg/m² (15 to 41 kg/m²), with a median of 22 kg/m². The BMI distribution showed 45.73% with normal weight (18.5-24.9 kg/m²), 25% with overweight (25-29.9 kg/m²), 8.54% with obesity (30-34.9 kg/m²), 1.22% with morbid obesity (>35 kg/m²), and 19.51% with underweight (<18.4 kg/m²). The average length of stay was 5.20 ± 2.44 days (2 to 16 days), with a median of 4 days.

Table 1. Sociodemographic Characteristics of Patients Admitted to Intensive Care, n = 328.

Variables / modalities	n (%) [a]	95% LCL – LCU [b]
Age		
18 - 65	247 (75,30)	70,43 – 29,57
≥ 65	81 (24,70)	20,26 – 29,57
BMI		
< 18,4	64 (19,51)	15,50 – 24,06
18,5 - 24,9	150 (45,73)	40,40 – 51,14
25- 29,9	82 (25,00)	20,55 – 29,89
30 - 34,9	28 (8,54)	5,87 – 11,93
≥ 35	4 (1,22)	0,41 – 2,87
Gender		
Male	161 (49,09)	43,70 – 54,48

 doi:10.20944/preprints202503.1841.v1

Female	167 (50,91)	45,52 – 56,30
Marital status		
Single	49 (14,94)	11,40 – 19,10
Divorced	11 (3,35)	1,79 – 5,73
Married	246 (75,00)	70,11 – 79,45
Widowed	22 (6,71)	4,37 – 9,80
Origin		
Rural	172 (52,44)	47,03 – 57,80
Urban	156 (47,56)	42,20 – 52,97
Level of education		
None	134 (40,85)	35,63 – 46,23
Primary	98 (29,88)	25,12 – 34,99
Secondary	78 (23,78)	19,42 – 28,60
University	18 (5,49)	3,40 – 8,35
Physical activity		
No	284 (86,59)	82,58 – 89,95
Yes	44 (13,41)	10,05 – 17,42
Immunization status		
Immunocompetent	177 (53,96)	48,55 – 59,30
Immunocompromised	151 (46,04)	40,70 – 51,45
Reason for admission		
Other	17 (5,18)	3,17 – 7,99
Metabolic disorder	79 (24,09)	19,70 – 28,93
Circulatory distress	150 (45,73)	40,40 – 51,14
Respiratory distress	82 (25,00)	20,55 – 29,89
Type of intensive care		
Surgical	38 (11,59)	8,46 – 15,38
Medical	234 (71,34)	66,28 – 76,03
Postoperative	56 (17,07)	13,30 – 21,43

[a] : a: n: sample size, %: percentage. [b] : LCL: lower confidence limit at 95%, UCL: upper confidence limit at 95%.

Regarding the other variables presented in Table 1, there was almost an equal distribution between men (49.09%) and women (50.91%). The majority of participants were married (75%), followed by singles (14.94%). The origin of the patients was nearly equivalent between rural areas (52.44%) and urban areas (47.56%). 40.85% had no formal education, 29.88% had primary education, 23.78% had secondary education, and 5.49% had university-level education. 86.59% of participants did not engage in regular physical activity. 53.96% were immunocompetent. The primary admission reasons were circulatory distress (45.73%), followed by metabolic disorders (24.09%), respiratory distress (25%), and other reasons (5.18%). Finally, the majority of ICU admissions were medical (71.34%).

The 95% confidence intervals for the mean age, BMI, and length of stay were [47.80; 51.69] years, [22.56; 23.56] kg/m², and [4.94; 5.47] days, respectively.

2. Comparative analysis of sleep quality: Intensive care unit (ICU) and home environment

Table 2 compares sleep quality in the ICU and at home. This comparison revealed a significant difference. Patients reported significantly poorer sleep quality in the ICU (mean score of 4.02 ± 2.04, ranging from 1 to 10) compared to at home (mean score of 6.55 ± 1.80, ranging from 2 to 10). The non-

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 25 March 2025 doi:10.20944/preprints202503.1841.v1

normal distribution of the scores, confirmed by the Kolmogorov-Smirnov tests ($p < 0.001$ for both), led to the use of the Wilcoxon rank-sum test. This test strongly indicated a difference in sleep quality between the two environments ($Z = -14.870$, $p < 0.001$), with significantly lower ranks for sleep quality in the ICU. This conclusion is further supported by individual rankings: 297 patients reported worse sleep in the ICU, only 4 reported better sleep, and 27 noticed no difference.

Table 2. Wilcoxon test on sleep quality between ICU and home in patients admitted to ICU, n = 328.

Variables	M ± SD	Min – Max	p (K-S) [a]	Positive rankings	Negative rankings	Ranks es-aequo	Z [b]	p [c]
Sleep quality ICU	4,02 ± 2,04	1 – 10	< 0,001	-	-	-	-	-
Sleep quality at homme	6.55 ± 1,80	2 – 10	< 0,001	-	-	-	-	-
Sleep quality ICU - Sleep quality at homme	-	-	-	297 [d]	4 [e]	27 [f]	-14,870	< 0,001

[a]: Kolmogorv-Smirnov normality test p-value. [b]: Z test based on positive rankings. [c]: Wilcoxon two-sided asymptotic significance of the statistical rank test. [d]: Sleep quality ICU < Sleep quality at home. [e]: Sleep quality ICU > Sleep quality at home. [f]: Sleep quality ICU = Sleep quality at home.

3. Analysis of sleep quality and daytime sleepiness throughout the ICU stay (Start-Middle-End)

Sleep quality was assessed at different time points and compared to sleep quality in the ICU (Table 3). In the intensive care unit, on a scale of 1 to 10, the average sleep quality was 4.02 ± 2.04. At the beginning of the study, the average was 4.44 ± 2.03, which improved to 4.60 ± 2.04 at the midpoint, and further improved to 4.81 ± 2.16 by the end of the study. The worst average sleep quality was observed in the ICU. Among the three time points (beginning, middle, and end), the worst sleep quality was recorded at the beginning of the study.

Table 3. The analysis of sleep quality and daytime sleepiness throughout the ICU stay (Start-Middle-End).

Variables	M ± SD	Min – Max	p (K-S) [a]	Negative rankings (average rank)	Positive rankings (average rank)	Ranks es-aequo	Z [b]	p [c]
Sleep quality ICU	4,02 ± 2,04	1 – 10	< 0,001	-	-	-	-	-
Sleep Quality First	4,44 ± 2,03	1 – 10	< 0,001	68 (65,40)	106 (101,68)	154	-4,859	< 0,001
Sleep Quality Middle	4,60 ± 2,04	1 – 10	< 0,001	49 (55,00)	115 (94,22)	164	-6,804	< 0,001
Sleep Quality End	4,81 ± 2,16	1 – 10	< 0,001	15 (39,27)	124 (73,72)	189	-9,093	< 0,001
Day Time Sleepiness ICU	6.16 ± 2.06	2 – 10	< 0,001	-				
Day Time Sleepiness First	5.48 ± 2.21	1 – 10	< 0,001	112 (77.15)	32 (56.23)	184	-6.933	<0.001

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 25 March 2025 doi:10.20944/preprints202503.1841.v1

Day Time Sleepiness Middle	5.76 ± 2.02	1 – 10	< 0,001	90 (71.94)	38 (46.88)	200	-5.685	<0.001
Day Time Sleepiness End	6.08 ± 2.09	2 – 10	< 0,001	38 (49.05)	43 (33.88)	247	-0.974	0.330

[a]: Kolmogorov-Smirnov normality test p-value. [b]: Z test based on positive rankings. [c]: Wilcoxon two-sided asymptotic significance of the statistical rank test.

The Wilcoxon test was used to compare sleep quality at these different nights to overall sleep quality in the ICU. The comparison between initial sleep quality and sleep quality in the ICU revealed 68 negative ranks, 106 positive ranks, and a Z value of -4.859 ($p < 0.001$). The comparison between sleep quality at the midnight and overall sleep quality in the ICU showed 49 negative ranks, 115 positive ranks, and a Z value of -6.804 ($p < 0.001$). Finally, the comparison between sleep quality at the end of stay and sleep quality in the ICU indicated 15 negative ranks, 124 positive ranks, and a Z value of -9.093 ($p < 0.001$). These results, based on the negative ranks, indicate a statistically significant improvement in sleep quality from the beginning to the end of the study compared to sleep quality in the ICU.

For the comparison between "First day" daytime sleepiness and overall ICU daytime sleepiness, indicate negative rank (lower sleepiness on the «First day») accounted for 112 observations, while positive ranks (higher sleepiness on the "First day") included 32 observations. Tied ranks were observed in 184 cases. The two-tailed significance value was <0.001, indicating a significantly higher level of daytime sleepiness in the ICU compared to the "First day".

Regarding the comparison between the "Middle day" and overall ICU daytime sleepiness, it was negative rank (90 observations) outnumbered positive ranks (38 observations). The p-value <0.001 further confirmed significantly greater daytime sleepiness in the ICU than on the "Middle" day.

Conversely, for the comparison between the "last day" and overall ICU daytime sleepiness, negative (38 observations) and positive (43 observations) ranks were nearly balanced. The p-value of 0.330 indicated no statistically significant difference between these two days, suggesting a similar level of daytime sleepiness at the end of stay and during the ICU stay.

4. Correlation between sleep quality and clinical scores in ICU patients

Table 4 presents a multiple linear regression to predict sleep quality in the ICU based on the APACHE II, EVA, Charlson, and Quick SOFA scores. The model explains 10.4% of the variance in sleep quality ($R^2 = 0.104$, adjusted $R^2 = 0.093$). The standard error of the estimate is 1.946. The Durbin-Watson statistic (2.051) indicates no autocorrelation of residuals, validating one of the assumptions of linear regression. The EVA and APACHE II scores have a statistically significant effect on sleep quality ($p < 0.001$ and $p = 0.015$, respectively), while the Charlson and Quick Sofa scores are not significant ($p = 0.128$ and $p = 0.894$). The absence of multicollinearity between the predictors strengthens the validity of the model.

Table 4. Multiple linear regression of ICU sleep quality based on EVA, Charlson, Sofa, and Apache II Scores, n = 328.

Model	β [a]	Standard error	p [b]	95% CI (β) [c]	Tolerance [d]	VIF [e]
(Constante)	5,241	0,236	< 0,001	4,777 – 5,704	-	-
Score EVA	-0,145	0,034	< 0,001	-0,212 – -0,078	0,975	1,026
Score Charlson	-0,131	,086	0,128	-0,301 – 0,038	0,880	1,136

 doi:10.20944/preprints202503.1841.v1

Score Quick SOFA	0,021	0,154	0,894	-0,283 – 0,324	0,746	1,340
Score APACHE II	-0,055	0,023	0,015	-0,100 – - 0,011	0,670	1,492

[a]: Unstandardized coefficients. [b]: Statistical significance of the Student's t-test. [c]: 95% confidence interval of the unstandardized coefficients β. [d]: Collinearity test using tolerance measurement. [e]: Collinearity test using variance inflation factor (VIF).

Unstandardized coefficients (B) indicate the effect of each predictor on sleep quality in raw units. A negative coefficient suggests a negative association: an increase in the predictor's score is associated with a decrease in sleep quality. For example, for each increase of one unit in the EVA score, sleep quality decreases by 0.145. Standardized coefficients (Beta) allow for comparison of the relative importance of different predictors. The EVA score has the most significant effect (-0.228), followed by the APACHE II score (-0.157). The 95% confidence intervals for the B coefficients indicate the range of plausible values for each predictor's real effect in the population. Collinearity statistics (tolerance and VIF) suggest no multicollinearity issues between the predictors. All tolerance values are above 0.3 (and even above 0.6), and all VIF values are below 4 (and even below 2). This means the predictors are not strongly correlated with each other, further validating the model.

5. Association between patient's sleep quality and ICU care activities and noises

Table 5 presents a multiple linear regression to understand the factors influencing sleep quality in the ICU. The model tested uses various environment and medical care-related variables as predictors. Overall, the model explains about 19.1% of the variability in sleep quality ($R^2 = 0.191$). This is confirmed by a significant ANOVA test ($p < 0.001$), indicating that the model is generally relevant. The adjusted R^2, at 0.152, is lower, suggesting that some variables may be redundant or less important, such as Vital Signs and Ventilator alarm, which were removed from the model due to their high correlation with Oxygen finger probe ($r = 0.864$, $p < 0.001$) and Ventilator sound ($r = 0.992$, $p < 0.001$), respectively, and their very high multicollinearity, with a VIF of 5.132 and 66.543.

Table 5. Multiple linear regression of ICU sleep quality based on care activities and noises.

Model	β [a]	Standard error	p [b]	95% CI (β) [c]	Tolerance [d]	VIF [e]
(Constante)	5,238	0,534	< ,001	4,187 – 6,290		
Noise	-0,200	0,075	0,008	-0,347 – -0,052	0,762	1,312
Light	0,214	0,082	0,009	0,053 – 0,375	0,333	3,004
Nursing intervention	0,558	0,213	0,009	0,138 – 0,978	0,887	1,127
Diagnostic testing	-0,018	0,078	0,818	-0,171 – 0,135	0,337	2,964
Blood Samples	-0,096	0,065	0,137	-0,223 – 0,031	0,488	2,047
Medication	-0,010	0,063	0,877	-0,134 – 0,114	0,593	1,685
Heart monitor alarm	-0,448	0,116	< 0,001	-0,676 – -0,220	0,303	3,299
Ventilator sound	-0,032	0,071	0,653	-0,171 – 0,107	0,490	2,040
Oxygen finger probe	0,085	0,066	0,200	-0,045 – 0,214	0,478	2,091
Talking	-0,098	0,073	0,178	-0,242 – 0,045	0,347	2,884
IVpump	-0,053	0,060	0,038	-0,171 – 0,066	0,479	2,087
Suctionning	0,144	0,120	0,232	-0,093 – 0,381	0,288	3,473
Nebulayzer	0,138	0,107	0,197	-0,072 – 0,348	0,330	3,034
Television	-0,117	0,088	0,184	-0,290 – 0,056	0,304	3,294

 doi:10.20944/preprints202503.1841.v1

Telephone	-0,107	0,188	0,569	-0,477 – 0,262	0,943	1,060

[a]: Unstandardized coefficients. [b]: Statistical significance of the student's t-test. [c]: 95% confidence interval of the unstandardized coefficients β. [d]: Collinearity test using tolerance measurement. [e]: Collinearity test using variance inflation factor (VIF).

An analysis of the individual coefficients reveals that several factors have a statistically significant impact on sleep quality. Noise (p = 0.008), light (p = 0.009), IV pump (p =0.038), Nursing intervention (p = 0.009) and heart monitor alarm (p<0.001) significantly influence sleep quality. Other variables, although included in the model, do not show a statistically significant effect at a 5% threshold. These include Diagnostic testing (p = 0.818), medication (p = 0.877), blood sampling (p = 0.137), ventilator noise (p = 0.653), oxygen finger probe (p = 0.200), conversations (p = 0.178), suction noise (p = 0.232), and nebulization noise (p = 0.197).For the significant variables, the sign of the coefficient indicates the direction of the relationship: a negative coefficient suggests that an increase in the predictive variable is associated with a decrease in sleep quality.

Examination of the collinearity statistics (tolerance and VIF) indicates an absence of multicollinearity between the predictors.

4. Discussion

This study aimed to identify the sleep disturbance associated with the environment sitting among ICU patients using a self-administered questionnaire. This study, which was conducted in three ICUs public hospitals in south of Morocco. The multifactorial nature of sleep disruption in the ICU, combined with the vulnerability of critically ill patients, complicates the identification of factors that impact sleep quality. It is clear, however, that these patients experience a significant deterioration in sleep quality during their ICU stay compared to sleep at home. Our findings align with those of Freedman and other existing literature. In accordance with prior studies, we observed that ICU patients suffered notably poorer sleep quality than they did at home [4,6,11,18]. While we did not find statistically significant differences in sleep during the ICU stay, as reported by Al Mutair et al.[2], we documented a significant reduction in patient drowsiness by the end of the ICU admission. Furthermore, most patients experienced daytime sleepiness, indicative of inadequate nighttime rest.

In contrast to many previous studies, we expanded our investigation to include a broader range of factors that may influence sleep quality. Beyond the commonly studied environmental factors, such as those described by Freedman et al.[19], our analysis also considered non-environmental factors, including the severity of illness, ICU length of stay, and pain levels. We deemed it essential to examine both clinical and environmental factors to better understand the root causes of sleep disruption in the ICU. Numerous reports highlight the importance of sleep disorders as a significant issue for ICU patients, and our study is the first of its kind in Morocco to address this concern. In our multivariate analysis, both environmental and non-environmental factors were found to impact the quality of sleep during ICU stays.

This study did not identify any significant relationships between patients' demographic characteristics and their perceived quality of sleep. The literature presents mixed findings regarding the influence of demographic factors on sleep quality. For instance, the results of this study align with those of Younis, who conducted research in Jordan and similarly reported no significant correlations between demographic data and sleep quality [13]. Also, Boyko et al.'s study, found no significant correlation between age, gender, or sedation regimen with abnormal sleep patterns as evaluated by polysomnography [20].

Regarding clinical factors, our results did not reveal a significant impact of post-operative status on sleep quality. However, previous research indicates that deep sleep is often reduced or absent immediately following surgery and anesthesia [21,22] . This discrepancy could be attributed to the limited proportion of post-operative cases in our sample, which accounted for only 28%. Also, the study was conducted in multidisciplinary intensive care units, a context that likely hindered the precise identification of this factor's influence. Interestingly, no significant correlations were

 doi:10.20944/preprints202503.1841.v1

observed between sleep quality and variables such as infection severity (SOFA score) and patient's comorbidities (Charlson score). A potential explanation for this outcome could be the influence of antibiotics and anti-inflammatory medications, which are commonly administered as part of daily treatment and may have impacted the results. However, The illness severity (APACHE II score) in our study have a statistically significant effect on sleep quality ($p < 0.015$) in contrast with several studies that showed no significate corelation between APACH II and sleep quality [23,24]. This discrepancy could be attributed to the specific context of the ICUs in which the previous studies were conducted, as their focus was limited to neurology patients in one case and pulmonology patients in the other. In contrast, our study was carried out in a setting where patients exhibited a diverse range of pathologies with varying degrees of severity. This heterogeneity in patient profiles may have influenced the observed outcomes and highlights the importance of considering the variability in clinical presentations when interpreting results.

The pain intensity (EVA score) appeared a statistically significant effect on sleep quality ($p < 0.001$) aligning with founding in previous studies[2,13,14,25,26], This finding can be attributed to the inadequate management and assessment of pain in the ICU. Pain management practices predominantly on the administration of paracetamol and anti-inflammatory medications. While these may provide some relief, they are often insufficient in addressing severe nociceptive pain or neuropathic pain, which require a more comprehensive approach. This insufficient pain control can also negatively impact the quality of sleep, as unrelieved pain often disrupts sleep patterns, leading to poor recovery and overall decreased patient prognostic.

Furthermore, an improvement in sleep quality was noted with increased hospitalization duration. This finding contrast with previous research, including studies by Al Mautair and al,[2] indicated that there were no significant differences in sleep between the first and the last night in the ICU, as per the study conducted by Freedman et al.[27] on 24 ICU patients using polysomnography. These results suggest that while extended hospitalization may partially mitigate sleep disturbances, the environmental disruptions inherent to the ICU remain significant and cannot fully substitute the restorative benefits of sleep in a familiar setting.

Previous authors have estimated that the ICU environment factors contribute to patient arousals and awakenings in this setting. Machines noise-related disruptions to sleep quality in the ICU have been well-documented [4,7–9,11,13,14,23,28]. In our study, the most disruptive noises were heart monitor alarm/sounds and IV pump. One possible solution to mitigate this problem would be to reduce the volume of monitor sounds and alarms emphasizing the need for prompt response to alarms to minimize disturbances.

Our findings confirm that noise in the ICU is a predominant factor affecting sleep quality, aligning with observations in previous studies. Noise has been shown to induce arousal without full awakening, contributing to sleep fragmentation and a subsequent decline in sleep quality. The average acceptable level of noise in a hospital, as recommended by the World Health Organization, should not exceed 40 dB during the night [28]. In addition to environmental noise, nursing activities and medical interventions, particularly the measurement of vital signs, were highlighted by patients as significant disruptors of sleep. Specifically, the use of blood pressure cuffs was frequently identified as a primary source of disturbance. This observation is consistent with other studies that emphasize the impact of routine nursing care on sleep disruption [9,11,13,26,28]. These results underscore the importance of minimizing environmental noise and optimizing care routines to mitigate their negative effects on patient sleep quality in the ICU setting.

Light exposure was identified as the second most significant factor, likely due to the design of many ICU environments that often lack individualized patient areas with adequate shading or control over light exposure. This environmental shortcoming can disrupt circadian rhythms and adversely affect sleep quality. In many ICUs, lights remain on throughout the entire unit, further exacerbating this disruption. These findings align with the research by Pamuk and al., which highlighted the detrimental impact of light exposure on patients' nighttime rest, emphasizing the

 doi:10.20944/preprints202503.1841.v1

need for improved lighting strategies to support circadian alignment and enhance patient recovery [10].

Although numerous studies have been conducted on sleep quality in the ICU, this remains a complex and unresolved issue due to its multifactorial nature. Clinical guidelines for sedo-analgesia management in critically ill adults strongly recommend non-pharmacological measures, such as reducing nighttime noise and adjusting light exposure, to improve sleep quality by reducing sleep fragmentation [5,16,17,24]. It is important to adopt these guidelines, as sleep disturbances extend beyond the ICU.

Further research is essential to better understand and address sleep quality among ICU patients. Several critical aspects remain underexplored, such as the effects of depression, anxiety, invasive ventilation, and ventilatory modes on sleep, as well as the impact of inotropic or cardiovascular-active drugs on sleep deprivation. Moreover, there is a clear need for additional multicenter studies to evaluate targeted interventions and strategies aimed at promoting sleep and minimizing disruptions to sleep-wake patterns in ICU settings. Such studies should consider key variables, including disease severity, patient age, medication regimens, and length of ICU stay, to develop more comprehensive and effective approaches to improving sleep outcomes for critically ill patients

5. Conclusions

The results of this study revealed that several ICU environmental factors have significant correlations with patients' perceived quality of sleep such as noise, light exposure, and nursing activities significantly disrupt the sleep of ICU patients. By addressing these issues through reducing noise, adjusting lighting, and minimizing unnecessary nighttime interventions ICU staff can improve sleep quality. These environmental adjustments not only foster a more restful environment but also play a crucial role in the overall recovery process of patients. Creating a sleep conducive ICU environment is essential for enhancing patient recovery and supporting their healing journey. Therefore, it is crucial for healthcare providers to recognize the impact of these environmental factors and actively work towards mitigating them for the benefit of patients.

Limitations

Our study has several limitations that should be acknowledged. Firstly, sleep quality and its influencing factors were assessed subjectively, which limits our ability to accurately determine the patients' true sleep architecture and the extent of sleep disruption caused by environmental stimuli. This reliance on subjective methods also introduces the possibility of recall bias, a common issue in questionnaire-based studies. However, we believe this limitation had minimal impact on our results, as previous research by Freedman has indicated that recall bias is not a significant concern over the relatively short recall periods typically associated with ICU stays. Another limitation lies in our methodology, as we did not incorporate objective tools like actigraphy, which is a cost-effective and low-labor option for monitoring sleep-wake cycles in ICU settings. Additionally, there may have been recruitment and selection biases, which could restrict the generalizability of our findings to the broader ICU population. Finally, while our study focused on assessing quantitative factors disrupting sleep in the ICU, psychological factors such as stress, depression, fear, and mood—which are known to significantly influence sleep quality—were not evaluated. Addressing these limitations in future studies could provide a more comprehensive understanding of sleep disturbances in ICU patients.

Author Contributions: "Conceptualization, A.L. and T.D.; methodology, Y.B.; software, Y.B.; validation, A.J., T.D. and Y.B.; formal analysis, Y.B.; investigation, A.L.; resources, A.L.; data curation, Y.B.; writing—original draft preparation, A.L.; writing—review and editing, O.K.; visualization, O.K.; supervision, T.D. All authors have read and agreed to the published version of the manuscript

Funding: This research received no external funding.

Institutional Review Board Statement:

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Committee for Biomedical Research Ethics (CERB) of the Faculty of Medicine and Pharmacy of Rabat, Morocco (N/R: File No. 85/24)

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Dataset available on request from the authors

Acknowledgments: We would like to thank the patients who actively participated in this study, as well as the professionals and research members for their important contribution to this research.

Conflicts of Interest: We declare no financial support or relationships that may pose a conflict of interest.

References

1. Silva, R.D., et al., Sleep, anxiety, depression, and stress in critically ill patients: a descriptive study in a Portuguese intensive care unit. Acute Crit Care, 2024. 39(2): p. 312-320.
2. Al Mutair, A., et al., Intensive care unit patients' perception of sleep quality and factors of sleep disruption: cross-sectional study. Dr. Sulaiman Al Habib Medical Journal, 2019. 1(1): p. 30-35.
3. Altman, M.T., M.P. Knauert, and M.A. Pisani, Sleep disturbance after hospitalization and critical illness: a systematic review. Annals of the American Thoracic Society, 2017. 14(9): p. 1457-1468.
4. Bani Younis, M. and F.A. Hayajneh, Quality of Sleep Among Intensive Care Unit Patients: A Literature Review. Crit Care Nurs Q, 2018. 41(2): p. 170-177.
5. Nilius, G., M. Richter, and M. Schroeder, Updated perspectives on the management of sleep disorders in the intensive care unit. Nature and Science of Sleep, 2021: p. 751-762.
6. Pisani, M.A., et al., Sleep in the intensive care unit. American journal of respiratory and critical care medicine, 2015. 191(7): p. 731-738.
7. Czempik, P.F., et al., Impact of sound levels and patient-related factors on sleep of patients in the intensive care unit: a cross-sectional cohort study. Sci Rep, 2020. 10(1): p. 19207.
8. Horsten, S., et al., Systematic review of the effects of intensive-care-unit noise on sleep of healthy subjects and the critically ill. British journal of anaesthesia, 2018. 120(3): p. 443-452.
9. Huang, D., et al., Different nursing interventions on sleep quality among critically ill patients: A systematic review and network meta-analysis. Medicine (Baltimore), 2023. 102(52): p. e36298.
10. Pamuk, K. and N. Turan, The effect of light on sleep quality and physiological parameters in patients in the intensive care unit. Appl Nurs Res, 2022. 66: p. 151607.
11. Stewart, J.A., et al., Factors influencing quality of sleep among non-mechanically ventilated patients in the Intensive Care Unit. Aust Crit Care, 2017. 30(2): p. 85-90.
12. Wang, C.Y., et al., Correlation between APACHE III score and sleep quality in ICU patients. J Int Med Res, 2019. 47(8): p. 3670-3680.
13. Younis, M.B., F. Hayajneh, and Y. Rubbai, Factors influencing sleep quality among Jordanian intensive care patients. Br J Nurs, 2020. 29(5): p. 298-302.
14. Zhang, Y., et al., Study on the Sleep Quality Classification and Influencing Factors of Adult ICU Awake Patients Based on Latent Profile Analysis: A Cross-Sectional Survey. Nat Sci Sleep, 2023. 15: p. 861-871.
15. Aitken, L.M., et al., Sleep assessment by patients and nurses in the intensive care: An exploratory descriptive study. Aust Crit Care, 2017. 30(2): p. 59-66.
16. Alsulami, G., A.M. Rice, and L. Kidd, Prospective repeated assessment of self-reported sleep quality and sleep disruptive factors in the intensive care unit: acceptability of daily assessment of sleep quality. BMJ Open, 2019. 9(6): p. e029957.
17. Hume, N.E., et al., Clinical impact of the implementation strategies used to apply the 2013 pain, Agitation/Sedation, delirium or 2018 pain, Agitation/Sedation, delirium, immobility, sleep disruption guideline recommendations: a systematic review and meta-analysis. Critical care medicine, 2024. 52(4): p. 626-636.
18. Martinez, F.E., et al., ICU Patients' Perception of Sleep and Modifiable versus Non-Modifiable Factors That Affect It: A Prospective Observational Study. J Clin Med, 2022. 11(13).

 doi:10.20944/preprints202503.1841.v1

19. Freedman, N.S., N. Kotzer, and R.J. Schwab, Patient perception of sleep quality and etiology of sleep disruption in the intensive care unit. American journal of respiratory and critical care medicine, 1999. 159(4): p. 1155-1162.
20. Boyko, Y., et al., Sleep in intensive care unit: The role of environment. Journal of critical care, 2017. 37: p. 99-105.
21. Dolan, R., et al., A prospective analysis of sleep deprivation and disturbance in surgical patients. Annals of medicine and surgery, 2016. 6: p. 1-5.
22. Lin, D., et al., Perioperative sleep disorder: a review. Frontiers in Medicine, 2021. 8: p. 640416.
23. Foreman, B., et al., Sleep in the neurological intensive care unit: feasibility of quantifying sleep after melatonin supplementation with environmental light and noise reduction. Journal of Clinical Neurophysiology, 2015. 32(1): p. 66-74.
24. Chen, C.-J., et al., Predictors of sleep quality and successful weaning from mechanical ventilation among patients in respiratory care centers. Journal of Nursing Research, 2015. 23(1): p. 65-74.
25. Beck Edvardsen, J. and F. Hetmann, Promoting sleep in the intensive care unit. SAGE Open Nursing, 2020. 6: p. 2377960820930209.
26. Zhang, Y., et al., Analysis of the factors influencing of sleep quality in intensive care unit awake patients based on a structural equation model: A cross-sectional study. J Clin Nurs, 2025. 34(1): p. 171-184.
27. Freedman, N.S., et al., Abnormal sleep/wake cycles and the effect of environmental noise on sleep disruption in the intensive care unit. American journal of respiratory and critical care medicine, 2001. 163(2): p. 451-457.
28. Stafford, A., A. Haverland, and E. Bridges, Noise in the ICU. AJN The American Journal of Nursing, 2014. 114(5): p. 57-63.