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ORIGINAL RESEARCH / *ÖZGÜN ARAŞTIRMA*

The impact of window on delirium, sedation, and sleep quality of intensive care patients: a prospective study

Pencerenin yoğun bakım hastalarının deliryumu, sedasyonu ve uyku kalitesi üzerindeki etkisi: prospektif bir çalışma

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ABSTRACT

Objective: The aim of this study was to assess the impact of window on delirium, sedation, and sleep quality of intensive care patients.

Materials and Methods: This prospective study was conducted with 140 patients admitted to anesthesia intensive care units from April to September 2023. The data collection tools included the patient information form, the Visual Analog Scale for Pain, the Delirium Screening Scale, the RAMSAY Sedation Scale, and the Richards–Campbell Sleep Questionnaire. Multiple linear regression analysis was used.

Results: In the 72nd hour evaluation of the patients, the most important predictors of nighttime delirium were determined to be agitation (β=0.40), non-compliance with treatment (β=0.26), and antipsychotic use (β=0.14) (p<.05). The predictors of daytime delirium were agitation (β=0.41) and non-compliance with treatment (β=0.26, p<.05). In the 7th day evaluation, the predictors of nighttime delirium were determined to be non-compliance with treatment (β=0.28), age (β=–0.26), gender (β=–0.22), and sedative use (β=0.18) (p<.05). Predictors of daytime delirium were age (β=–0.25) and gender (β=–0.19, p<.05).

Conclusion: Having a window in the room is not a significant predictor of delirium and sedation, but it is important for sleep quality. Sleep quality and sedation are significant predictors of each other. Intensive care healthcare professionals should plan and implement psychosocial interventions to reduce the frequency of delirium, sleep problems, and sedation use in patients.

Keywords: delirium, sleep, anesthesia, intensive care, prospective studies

ÖZ

Amaç: Bu çalışmanın amacı, pencerenin yoğun bakım hastalarının deliryumu, sedasyonu ve uyku kalitesi üzerindeki etkisini değerlendirmektir.

Gereç ve Yöntem: Bu prospektif çalışma, Nisan-Eylül 2023 tarihleri arasında anestezi yoğun bakım ünitelerine yatırılan 140 hasta ile yürütülmüştür. Veri toplama araçları arasında hasta bilgi formu, Ağrı İçin Görsel Analog Skala, Deliryum Tarama Skalası, RAMSAY Sedasyon Skalası ve Richards-Campbell Uyku Anketi yer almıştır. Çoklu doğrusal regresyon analizi kullanılmıştır.

Bulgular: Hastaların 72. saatte yapılan değerlendirmesinde, gece ortaya çıkan deliryumun en önemli yordayıcıları ajitasyon (β=0,40), tedaviye uyumsuzluk (β=0,26) ve antipsikotik kullanımı (β= 0,14) olarak belirlenmiştir (p<,05). Gündüz görülen deliryumun yordayıcıları ise ajitasyon (β=0,41) ve tedaviye uyumsuzluktur (β=0,26, p<,05). Yedinci gün yapılan değerlendirmede, gece deliryumunun yordayıcıları tedaviye uyumsuzluk (β=0,28), yaş (β= –0,26), cinsiyet (β=–0,22) ve sedatif kullanımı (β=0,18) olarak saptanmıştır (p<,05). Gündüz görülen deliryumunun yordayıcıları ise yaş (β=–0,25) ve cinsiyettir (β=–0,19, p<,05).

Sonuç: Odada pencere olması deliryum ve sedasyonun önemli bir yordayıcısı değildir, ancak uyku kalitesi için önemlidir. Uyku kalitesi ve sedasyon birbirlerinin önemli yordayıcılarıdır. Yoğun bakım sağlık profesyonelleri, hastalarda deliryum, uyku sorunları ve sedasyon kullanımının sıklığını azaltmak için psikososyal müdahaleler planlamalı ve uygulamalıdır.

Anahtar kelimeler: deliryum, uyku, anestezi, yoğun bakım, prospektif çalışmalar

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Introduction

Delirium is one of the most common clinical conditions in intensive care units and can impair brain function (1). The pathogenesis of delirium is associated with neuro inflammation, abnormal stress responses, neurotransmitter imbalances, and changes in neural networks. Delirium in the intensive care unit is also linked to cognitive problems, such as memory loss, difficulty in concentration, and reduced awareness (2). The prevalence of delirium in coronary and internal medicine intensive care patients is 15%, but it can rise to 50% in internal medicine intensive care units (3). In one study, the incidence of delirium was 32%, with the frequency of the hypoactive subtype reaching 42% (4). Similarly, in another study, delirium was reported in 31% of patients, with the frequency of the hypoactive subtype reaching 56% (5). Another study reported a delirium incidence of 32%, with disease severity being the most significant predictor (6).

It has also been reported that delirium increases mortality and morbidity rates in intensive care patients and prolongs hospital stays (1,6). Furthermore, it has been noted that the frequency of occurrence varies based on personal characteristics, such as age and gender, but the use of physical restraints is the strongest predictor (7). In another study, variables such as age and gender did not predict delirium, but mechanical ventilation, benzodiazepine use, and certain physiological variables significantly predicted delirium (5). Long stays in the intensive care unit, frequent use of physical restraints, increased use of fentanyl, and poor sleep quality are described as important risk factors (8,9).

Delirium is often accompanied by pain and agitation in intensive care patients. It has been suggested that the drugs used to treat these symptoms, such as steroids, sedatives, anticholinergics, and opioids, are precipitating factors for delirium (10). Sleep disturbances are also among the risk factors. They are associated with delirium, but factors such as pain, discomfort, anxiety/fear, noise, and light are said to contribute to sleep problems (11). Sleep disturbances may be associated with emotional stress and cognitive problems, such as delirium, or with mechanical ventilation (12).

To reduce agitation resulting from delirium and mechanical ventilation in intensive care, minimal sedation is recommended. The goal of minimal sedation is to keep patients easily arousable, comfortable, and experiencing low levels of pain when deep sedation is not necessary (13). However, some studies suggest that the use of sedation increases delirium rates and can even be an accelerating factor (1,14). Medications such as midazolam, propofol, dexmedetomidine, and fentanyl are used for sedation. Benzodiazepines, such as midazolam and fentanyl, are more strongly associated with delirium (15). Therefore, reducing sedative use, organizing the intensive care environment, and implementing psychosocial nursing interventions are essential.

In intensive care environments, environmental conditions affecting vision, hearing, and perception are crucial, and poor environmental conditions that disrupt these functions are known to accelerate delirium (14). Windows that provide daylight and views of the outside have been shown to positively impact individuals' well-being (16). Ensuring that people can see objects and activities is the primary purpose of daylight and also facilitates the performance of daily life activities. Moreover, it contributes to well-being through physiological relaxation, enhances attention, improves mood, and increases satisfaction (17). Sleeping in a room with windows also increases patient satisfaction and shortens hospital stays (18). Cumulative delirium incidence in intensive care patients with windows in their rooms is lower than in those without windows (19).

The potential effect of windows on delirium and sleep quality could also be related to the circadian rhythm. The circadian rhythm is an internal biological clock that regulates various physiological processes, including the secretion of melatonin and cortisol, hormones essential for sleep regulation and stress response. Disturbances in this rhythm, such as altered melatonin

and cortisol secretion patterns, have been associated with the development of delirium, especially in ICU patients (20). Sleep deprivation and circadian disruption can impair immune function, cognition, and increase mortality risk, all of which contribute to delirium onset (21). Exposure to natural light through windows plays a significant role in synchronizing the circadian rhythm by influencing melatonin secretion and promoting a normal sleep-wake cycle. Patients in rooms with windows receive more direct sunlight, which can help regulate their circadian rhythm and potentially reduce delirium risk by improving sleep quality and cognitive function (22).

The aim of this study was to assess the impact of window on delirium, sedation, and sleep quality of intensive care patients.

The main research questions are as follows:

1. Is there a difference in the average scores of the nighttime and daytime delirium screening scales between patients in rooms with windows and those without windows?

2. Is there a difference in the average scores of the RAMSAY sedation scale between patients in rooms with windows and those without windows?

3. Is there a difference in the average scores of the Richards–Campbell sleep questionnaire between patients in rooms with windows and those without windows?

4. What are the predictors of delirium, sedation, and sleep quality?

Materials and Methods

Study design

This research is a prospective study. This study was reported according to The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

Setting and sample

This study was conducted with patients hospitalized in Anesthesia Intensive Care I and II units at Giresun University Training and Research Hospital from April to September 2023. There are 12 beds in the Anesthesia Intensive Care I unit and 12 beds in the Anesthesia Intensive Care II unit. Fifteen of these beds are in rooms with windows and nine are in rooms without windows. A total of 42 certified intensive care nurses and 8 anesthesia and reanimation doctors work in both intensive care units.

The number of samples calculated with anticipated effect size (*f2*): 0.15, desired statistical power level: 0.8, number of predictors: 12, and probability level: 0.05 is 127 patients (https://www.danielsoper.com/statcalc/calculator.aspx?id=1). One hundred forty patients who met the inclusion criteria between the specified dates were included in the sample. In the post hoc analysis conducted with G*Power 3.1.9.7, taking into account the RSS averages, the effect size was determined as 0.9793 with power (1 - β)=81.0% margin of error. In Post-hoc Statistical Power Calculator for Multiple Regression, observed statistical power calculated with number of predictors: 12, Observed R^2: 0.25, probability level: 0.05 and sample size: 140 is 0.9984 (https://www.danielsoper.com/statcalc/calculator.aspx?id=9). Patients were divided into two groups: those who hospitalized in rooms with and without windows.

The inclusion criteria for the study were agreeing to participate in the study, length of stay in intensive care unit ≥24 hours, and being ≥18 years old. Exclusion criteria from the study included patients who were diagnosed with delirium upon admission, were unconscious, had a mental and cognitive problem, and had serious hearing and vision problems.

Ethical consideration

This study was approved by the Institutional Review Board of a state university (Approval Date: 21.03.2023, Approval Number: KAEK-40/7). The principles of the Declaration of Helsinki were taken into consideration

in conducting the research. After the purpose of the research was explained, verbal and written consents were obtained from all the patients.

Instruments

The data collection tools included the patient information form, the Visual Analog Scale for Pain (VAS), the Delirium Screening Scale (DSS), the RAMSAY Sedation Scale (RSS), and the Richards–Campbell Sleep Questionnaire (RCSQ).

The Patient Information Form was prepared by the researchers. It consists of questions such as whether there is a window in the patient's room, the day of admission, age, gender, education level, marital status, pulse, blood pressure, respiration and oxygen saturation, whether there is agitation and pain, the severity of the pain, whether sedative and antipsychotic medication is given.

The VAS is a unidimensional scale used to record patients' pain progression or assess pain severity. It is scored from 0 (no pain) to 10 (very severe pain) (23).

The DSS was developed by Gaudreau et al. (24). The validity and reliability of the scale in Turkish was conducted by Karataş and Baglama (25). The DSS is a five-item instrument consisting of disorientation, inappropriate behavior, inappropriate communication, illusions/hallucinations, and psychomotor retardation. Cronbach's α internal consistency coefficient was calculated as 0.74. In this study, the 72nd Hour was calculated as night DSS .67 and daytime DSS .64, and the 7th Day was calculated as night DSS .75 and daytime DSS .75.

The RSS was developed by Ramsay (26). Turkish reliability and validity were evaluated by Esen et al. made by (27). The scale includes a total of six items, the first three items indicating the level of alertness and the three items indicating the level of sleep. Answers are scored from 1 to 6. An increase in the score obtained from the scale indicates an increase in the level of sedation.

The RCSQ was developed by Richards et al. (28). Turkish reliability and validity were conducted by Özlü and Özer (29). A minimum of 0 and a maximum of 100 points can be obtained from the scale. An increase in the score obtained from the scale indicates that sleep quality increases. The Cronbach's α internal consistency number of the scale is .91. In this study, it was found to be .97 at the 72nd hour and .97 at the 7th day.

Procedure

The data were collected face to face in the intensive care unit by the primary investigator, who is an anesthesia and reanimation physician from April to September 2023. Evaluations were made at the 72nd hour and on the 7th day, which is the time period when delirium is most common according to sources. Patients were evaluated twice, between 08:00-10:00 in the morning and 20:00-22:00 at night. Physiological findings were evaluated between 08:00 and 10:00 in the morning. Additionally, the 28-day mortality status of the patients was evaluated. The forms were filled in approximately 20 minutes by observation. Both daytime and nighttime assessment for delirium was performed.

Data analysis

The data were analyzed using the SPSS (Statistical Package for Social Sciences) for Windows 25.0 program. Number, percentage, mean and standard deviation values are given in the presentation of demographic data, physiological findings and scale score averages. In comparing the demographic data, physiological findings and scale averages of patients who were and were not hospitalized in a windowed room, Chi-square analysis was used for categorical variables and independent sample t-test was used for numerical and continuous variables. According to Skewness and Curtosis values, it was determined that the data showed normal distribution. With Multiple Linear Regression analysis, early and late term predictors of day and night delirium, sedation and sleep levels were tried to be determined in patients

sleeping and not sleeping in a windowed room. The evaluation for the early period was made at the 72nd hour, and the evaluation for the late period was made on the 7th day. In each model, Adjusted R^2 values were examined to determine how much of the variance the independent variables explained. The 28-day mortality status of all patients included in the study was examined. Independent samples t test was used to compare physiological findings and scale score averages according to 28-day mortality status. Statistical significance level was accepted as $p<.05$.

Results

The demographic characteristics of intensive care patients who stayed in rooms with windows and of those who stayed in rooms without windows are compared and presented in Table 1. There were no significant differences in demographic features—age, gender, marital status, smoking, alcohol use, hypertension, diabetes mellitus, chronic obstructive pulmonary disease (COPD), and heart disease—between the two groups ($p>.05$).

Table 1. Comparison of patients' demographics

Variable	Patients treated in a room with window (n=87)	Patients treated in a room without window (n=52)	Test value	p value
Age (M±SD)	64±18.03	65.40±17.73	0.44	.656
	n (%)	**n (%)**		
Sex				
Female	27 (31.0)	21 (40.4)	1.25	.262
Male	60 (69.0)	31 (59.6)		
Marital status				
Single	17 (19.5)	9 (17.3)	0.10	.744
Married	70 (80.5)	43 (82.7)		
Smoking				
Yes	35 (40.2)	23 (44.2)	0.21	.643
No	52 (59.8)	29 (55.8)		
Alcohol				
Yes	14 (16.1)	9 (17.3)	0.03	.852
No	73 (83.9)	43 (82.7)		
Hypertension				
Yes	32 (36.8)	24 (46.2)	1.18	.276
No	55 (63.2)	28 (53.8)		
Diabetes mellitus				
Yes	12 (13.8)	8 (15.4)	0.06	.796
No	75 (86.2)	44 (84.6)		
COPD				
Yes	17 (19.5)	16 (30.8)	2.26	.132
No	70 (80.5)	36 (69.2)		
Cardiac disease				
Yes	18 (20.7)	11 (21.2)	0.00	.948
No	69 (79.3)	41 (78.8)		

Table 2. Comparison of patients' clinical findings (72nd hour)

Clinical Properties	Patient treated in a room with window (n=87)	Patient treated in a room without window (n=52)	Test value	p value
	M±SD	M±SD		
Pulse	89.32±18.58	84.88±15.88	1.43	.153
Systolic blood pressure	130.69±19.34	126.40±19.48	1.26	.210
Diastolic blood pressure	72.13±11.36	70.44±11.70	0.83	.405
Respiratory rate	22.39±6.04	21.94±5.06	0.44	.654
Oxygen saturation (Sp02)	95.61±2.41	95.38±2.91	0.49	.625
Visual Analoq Scale	21.57±23.31	14.02±20.53	1.93	.056
Ramsay Sedation Scale	1.86±0.57	1.81±0.44	0.58	.559
Delirium Screening Scale (nighttime)	7.26±1.11	7.63±0.74	2.12	.035
Delirium Screening Scale (daytime)	7.31±1.05	7.63±0.74	1.93	.055
Richards–Campbell Sleep Questionnaire	235.22±107.59	221.34±108.46	0.73	.464
	n (%)	n (%)		
Ventilatory support				
No	7 (8.0)	5 (9.6)	5.05	.282
Mask	51 (58.6)	38 (73.1)		
NIMV	27 (31.0)	8 (15.4)		
HFNC	1 (1.1)	1 (1.9)		
Tracheostomized patient with easy-breathe	1 (1.1)	0 (0.0)		
Agitation				
Yes	23 (26.4)	11 (21.2)	0.49	.483
No	64 (73.6)	41 (78.8)		
Non-compliance with treatment				
Yes	23 (26.4)	9 (17.3)	1.53	.216
No	64 (73.6)	43 (82.7)		
Pain				
Yes	45 (52.3)	19 (36.5)	3.24	.072
No	41 (47.7)	33 (63.5)		
Sedative				
Yes	13 (14.9)	4 (7.7)	1.84	.398
No	74 (85.1)	48 (92.3)		
Antipsychotic				
Yes	12 (13.8)	2 (3.8)	3.55	.081
No	75 (86.2)	50 (96.2)		

The initial assessment of intensive care patients who stayed in rooms with windows versus those who stayed in rooms without windows was conducted at 72h (Table 2). There were no significant differences in the average values of pulse rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory rate, oxygen saturation (SPO_2), and VAS, RSS, and RCSQ scores between the two groups ($p>.05$). While there were no statistically significant differences in the average scores of the daytime delirium observation scale (DSS) ($p>.05$), a significant difference was observed in the average scores of nighttime DSS ($p=.035$). There were no statistically significant differences between patients staying in rooms with

Table 3. Comparison of clinical findings in patients based on 28-day mortality rates

Values	72nd Hour (n=140)			7th Day (n=104)		
	Excitus	Survived	p	Excitus	Survived	p
	M±SD	M±SD		M±SD	M±SD	
Pulse	92.19±22.45	86.95±16.65	.211	90.58±24.61	83.58±14.42	.154
Systolic Blood Pressure	120.86±21.53	130.56±18.68	.034	118.59±25.52	130.26±18.03	.043
Diastolic Blood Pressure	66.62±11.33	72.44±11.31	.032	65.23±14.39	72.49±9.57	.019
Respiratory rate	24.81±6.45	21.82±5.45	.026	24.08±6.76	21.38±4.37	.057
Oxygen saturation	94.67±3.56	95.65±2.39	.113	94.00±2.48	95.42±3.90	.207
Visual Analog Scale	17.24±26.04	18.92±21.90	.753	9.62±18.08	14.35±17.48	.365
Ramsay Sedation Scale	2.10±0.76	1.80±0.46	.017	2.00±0.71	1.81±0.47	.213
Delirium Screening Scale (nighttime)	7.23±0.99	7.43±1.00	.404	6.30±1.37	7.39±1.09	.002
Delirium Screening Scale (daytime)	7.28±0.90	7.46±0.97	.440	6.38±1.32	7.41±1.08	.002
Richards–Campbell Sleep Questionnaire	249.76±119.26	225.75±105.60	.348	231.15±108.30	227.33±110.12	.907

windows and those without windows in terms of respiratory support, agitation, non-compliance with treatment, pain status, and the use of sedatives and antipsychotics ($p>.05$).

When patients' findings were compared according to their 28-day mortality status (Table 3), at the 72-h assessment, patients who subsequently expired had lower measurements of SBP (120.86±21.53) and DBP (66.62±11.33) compared to the surviving patients (130.56±18.68 and 72.44±11.31) ($p<.05$). The respiratory rate (24.81±6.45) and RSS score averages (2.10±0.76) of patients who later expired were higher than those of surviving patients (21.82±5.45 and 1.80±0.46) ($p<.05$). At the day-7 assessment (Table 3), surviving patients had higher values of SBP (130.26±18.03) and DBP (72.49±9.57) compared to those who expired (118.59±25.52 and 65.23±14.39) ($p<.05$). The nighttime delirium observation scale (DSS) (7.39±1.09) and daytime DSS (7.41±1.08) averages of surviving patients were higher than those of patients who ultimately expired (6.30±1.37 and 6.38±1.32) ($p<.05$).

Early predictors were evaluated at 72 h (Table 4), and the most significant variables were included in the model. The most important predictors of nighttime delirium were agitation (β=0.40), non-compliance with treatment (β=0.26), and antipsychotic use (β=0.14, $p<.05$). This model explained 50.1% of the variance in nighttime delirium ($p<.001$). The most important predictors of daytime delirium were agitation (β=0.41) and non-compliance with treatment (β=0.26, $p<.05$). This model explained 45.5% of the variance in daytime delirium ($p<.001$). The most important predictors of sleep quality were daytime DSS (β=0.76), the presence of pain (β=0.38), and agitation (β=0.35, $p<.05$). For RCSQ, the model explained 22.7% of the variance ($p<.001$). The most important predictors of sedation level were agitation (β=0.56), non-compliance with treatment (β=0.19), age (β=0.14), and antipsychotic use (β=–0.16, $p<.05$). This model explained 55.9% of the variance for RSS ($p<.001$).

The evaluation of late predictors was performed on day 7 (Table 5). The most important predictors of nighttime delirium on day 7 were non-compliance with treatment (β=0.28), age (B=–0.26), gender (β=–0.22), and sedative use (β=0.18, $p<.05$). This model explained 35.0% of the variance in nighttime delirium on day 7 ($p<.001$). The most important predictors of daytime delirium were age (β=–0.25) and gender (β=–0.19, $p<.05$). This model explained 28.3% of the variance in daytime delirium on day 7 ($p<.001$). The most important predictors of sleep quality on day 7 were RSS (β=0.38), pain (β=0.30), and staying in a

Table 4. Early predictors of delirium, sleep, and sedation levels (n=140)

Variable	B	S.E.	β	t	p
Nighttime Delirium Screening Scale (R^2=0.545, Adjusted R^2=0.501, F=12.46, p<.001)					
Window	0.233	0.131	0.112	1.78	.077
Sex	-0.037	0.137	-0.018	-0.27	.786
Age	-0.003	0.004	-0.053	-0.74	.460
Agitation	0.961	0.265	0.408	3.62	<.001
Non-compliance with treatment	0.620	0.219	0.260	2.83	.005
Pain	0.102	0.220	0.050	0.46	.645
Visual Analog Scale	0.005	0.005	0.121	1.16	.245
Sedative	0.047	0.204	0.017	0.22	.820
Antipsychotic	0.488	0.225	0.147	2.17	.032
Ramsay Sedation Scale	0.051	0.182	0.027	0.28	.780
Richards–Campbell Sleep Questionnaire	0.000	0.001	0.021	0.29	.766
Daytime Delirium Screening Scale (R^2=0.502, Adjusted R^2=0.455, F=10.51, p<.001)					
Window	0.214	0.131	0.108	1.63	.105
Sex	-0.019	0.138	-0.009	-0.13	.890
Age	-0.002	0.004	-0.042	-0.55	.577
Agitation	0.934	0.266	0.414	3.51	.001
Non-compliance with treatment	0.601	0.219	0.263	2.74	.007
Pain	0.021	0.221	0.011	0.09	.925
Visual Analog Scale	0.005	0.005	0.111	1.02	.308
Sedative	-0.020	0.204	-0.007	-0.09	.922
Antipsychotic	0.402	0.225	0.126	1.78	.077
Ramsay Sedation Scale	-0.024	0.182	-0.013	-0.13	.896
Richards–Campbell Sleep Questionnaire	0.001	0.001	0.063	0.85	.396
Richards–Campbell Sleep Questionnaire (R^2=0.300, Adjusted R^2=0.227, F=4.09, p<.001)					
Window	-22.327	17.572	-0.100	-1.27	.206
Sex	-17.377	18.269	-0.077	-0.95	.343
Age	-0.688	0.532	-0.114	-1.29	.198
Agitation	89.185	36.338	0.353	2.45	.016
Non-compliance with treatment	-17.328	30.065	-0.068	-0.57	.565
Pain	83.817	28.617	0.388	2.92	.004
Visual Analog Scale	0.640	0.630	0.131	1.01	.311
Sedative	-24.377	27.258	-0.081	-0.89	.373
Antipsychotic	26.336	30.612	0.074	0.86	.391
Ramsay Sedation Scale	30.438	24.309	0.148	1.25	.213
Nighttime Delirium Screening Scale	-78.967	42.381	-0.737	-1.86	.065
Daytime Delirium Screening Scale	85.667	42.196	0.766	2.03	.044
Ramsay Sedation Scale (R^2=0.601, Adjusted R^2=0.559, F=14.35, p<.001)					
Window	-0.073	0.065	-0.067	-1.12	.262
Sex	0.007	0.067	0.006	0.10	.920
Age	0.004	0.002	0.140	2.12	.036
Agitation	0.689	0.122	0.562	5.66	<.001
Non-compliance with treatment	0.246	0.108	0.198	2.27	.025
Pain	0.009	0.109	0.009	0.08	.932
Visual Analog Scale	0.003	0.002	0.140	1.43	.153
Sedative	-0.028	0.100	-0.019	-0.27	.781
Antipsychotic	-0.285	0.110	-0.165	-2.59	.010
Nighttime Delirium Screening Scale	0.228	0.156	0.437	1.45	.148
Daytime Delirium Screening Scale	-0.224	0.156	-0.412	-1.43	.154
Richards–Campbell Sleep Questionnaire	0.000	0.000	0.084	1.25	.213

Table 5. Late predictors of delirium, sleep, and sedation levels (n=104)

Variable	B	S.E.	B	t	p
Nighttime Delirium Screening Scale (R^2=0.426, Adjusted R^2=0.350, F=5.57, p<.001)					
Window	0.176	0.218	0.071	0.80	.421
Sex	-0.547	0.225	-0.224	-2.43	.017
Age	-0.017	0.006	-0.266	-2.65	.009
Agitation	0.324	0.376	0.122	0.86	.391
Non-compliance with treatment	0.892	0.410	0.280	2.17	.032
Pain	0.373	0.338	0.157	1.10	.272
Visual Analog Scale	0.007	0.009	0.100	0.71	.478
Sedative	0.619	0.294	0.187	2.10	.038
Antipsychotic	0.304	0.255	0.118	1.19	.237
Ramsay Sedation Scale	-0.125	0.288	-0.053	-0.43	.665
Richards–Campbell Sleep Questionnaire	0.000	0.001	-0.022	-0.22	.822
Daytime Delirium Screening Scale (R^2=0.367, Adjusted R^2=0.283, F=4.35, p<.001)					
Window	0.139	0.225	0.057	0.61	.538
Sex	-0.478	0.233	-0.199	-2.05	.043
Age	-0.016	0.007	-0.257	-2.44	.017
Agitation	0.273	0.389	0.105	0.70	.485
Non-compliance with treatment	0.749	0.423	0.240	1.77	.080
Pain	0.367	0.349	0.156	1.05	.296
Visual Analog Scale	0.007	0.010	0.109	0.74	.461
Sedative	0.443	0.303	0.136	1.46	.148
Antipsychotic	0.366	0.263	0.145	1.38	.168
Ramsay Sedation Scale	-0.043	0.297	-0.019	-0.14	.885
Richards–Campbell Sleep Questionnaire	0.000	0.001	-0.041	-0.39	.695
Richards–Campbell Sleep Questionnaire (R^2=0.349, Adjusted R^2=0.254, F=3.66, p<.001)					
Window	-46.410	20.920	-0.205	-2.21	.029
Sex	-11.274	22.995	-0.050	-0.49	.625
Age	0.279	0.651	0.048	0.42	.669
Agitation	19.077	37.022	0.079	0.51	.608
Non-compliance with treatment	-17.751	41.731	-0.061	-0.42	.672
Pain	67.170	32.559	0.308	2.06	.042
Visual Analog Scale	1.287	0.919	0.209	1.40	.165
Sedative	-55.418	30.147	-0.183	-1.83	.069
Antipsychotic	31.480	25.104	0.134	1.25	.213
Ramsay Sedation Scale	82.436	27.097	0.385	3.04	.003
Nighttime Delirium Screening Scale	37.094	49.162	0.406	0.75	.453
Daytime Delirium Screening Scale	-38.997	47.555	-0.420	-0.82	.414
Ramsay Sedation Scale (R^2=0.587, Adjusted R^2=0.527, F=9.73, p<.001)					
Window	0.086	0.079	0.081	1.07	.284
Sex	-0.037	0.086	-0.035	-0.43	.668
Age	-0.001	0.002	-0.052	-0.58	.561
Agitation	0.514	0.127	0.453	4.05	<.001
Non-compliance with treatment	0.357	0.151	0.263	2.36	.020
Pain	-0.061	0.124	-0.060	-0.49	.622
Visual Analog Scale	0.005	0.003	0.164	1.38	.170
Sedative	0.024	0.114	0.017	0.21	.831
Antipsychotic	0.078	0.094	0.071	0.82	.410
Nighttime Delirium Screening Scale	-0.252	0.182	-0.589	-1.38	.169
Daytime Delirium Screening Scale	0.233	0.176	0.536	1.32	.189
Richards–Campbell Sleep Questionnaire	0.001	0.000	0.244	3.04	.003

room with a window (β=–0.20, p<.05). This model explained 25.4% of the variance in RCSQ ($p<.001$). The most important predictors of patients' sedation levels on day 7 were agitation (β=0.45), non-compliance with treatment (β=0.26), and RCSQ (β=0.24, $p<.05$). This model explained 52.7% of the variance in RSS on day 7 ($p<.001$).

Discussion

This comparison of patients in intensive care units with and without windows revealed interesting findings. While no statistically significant differences were observed in physiological parameters, pain assessments, sedation, sleep quality, agitation, treatment compliance, or the use of sedatives and antipsychotics at the 72-h assessment, a significant discrepancy was identified in delirium levels, particularly in the average night delirium rating scale (DSS) scores. Patients in windowless rooms had higher average night DSS scores compared to those in windowed rooms. This result aligns with prior research indicating that patients benefit from natural daylight in intensive care units, experiencing a lower incidence of delirium (19). A prospective study highlighted that patients exposed to daylight through windows experienced less agitation and hallucinations compared to those in dark rooms, who were thus likelier to use antipsychotics (30). Additionally, some studies have suggested that nighttime light levels may be a more powerful predictor of delirium than daytime light levels (31,32). In another study, no difference was found in terms of delirium development between in patients with and without a window (21). It should be noted that conflicting findings exist in the literature, necessitating further research in future studies, including measuring the intensity of daylight through the windows.

Regarding 28-day mortality, the study found that surviving patients had higher systolic and diastolic blood pressure (SBP and DBP) values compared to those of patients who ultimately expired. At the 72-h assessment, patients who eventually died had higher respiratory rates and sedation score averages than survivors. On day 7, survivors also had higher night and day DSS score averages than patients who ultimately expired. Nevertheless, no direct relationship was observed between 28-day mortality rates and the presence of windows in the intensive care unit. Similarly, no significant difference in 28-day mortality rates was noted between patients in windowed versus windowless intensive care unit rooms (19). However, some physiological parameters were linked to mortality. Specifically, in one study, there was a significant association between high mortality rates and low SBP and DBP values in intensive care unit patients (33). Another study found that deceased patients in the intensive care unit had previously had higher respiratory rates compared to surviving patients. Additionally, this study had reported higher pulse rates and lower SpO_2 levels previously among patients who died (34). These findings suggest that 28-day mortality rates are not directly influenced by the presence of windows, and further research is warranted to better understand the intricate relationship between patient outcomes and windowed environments.

In this study, the assessment conducted at 72 h revealed that the most significant predictors of nighttime delirium were agitation, non-compliance with treatment, and the use of antipsychotic medication. On day 7, the important predictors were non-compliance with treatment, age, gender, and sedative use. For daytime delirium, the crucial predictors were agitation at 72 h and non-compliance with treatment on day 7, along with age and gender. These findings align with recent advances in delirium prediction emphasizing multifactorial risk models that incorporate clinical, demographic, and treatment-related variables (35,36). Machine learning models have further demonstrated the value of integrating physiological and clinical data for early delirium detection, supporting the importance of continuous monitoring of agitation and medication effects (35). The identification of non-compliance as a consistent predictor suggests that interventions to improve patient engagement and adherence could be

pivotal in delirium prevention strategies. Overall, this study reinforces the need for dynamic, time-sensitive assessment protocols in the ICU that address modifiable factors such as agitation and medication use while considering patient-specific characteristics to reduce delirium incidence and improve outcomes.

Regarding the use of antipsychotic medication, this study showed that as the average delirium score increased at 72 h, antipsychotic use also increased. This increase paralleled the rise in agitation and non-compliance with treatment. In one study, approximately half of the patients who developed delirium were administered antipsychotic drugs, which were found to be effective in managing delirium (37). However, one study suggested that psychoactive drugs, such as antipsychotics and anticonvulsants, pose a moderate risk factor for delirium (38). In contrast, a review of randomized controlled trials found no significant difference in delirium frequency, duration, length of hospital stay, or mortality rates between haloperidol use and a placebo. Additionally, there was insufficient evidence to support the efficacy of haloperidol regarding delirium severity, cognitive function, and sedation (39). In one study, approximately 45% of delirious patients were administered antipsychotics, and it was found that haloperidol and olanzapine increased the likelihood of delirium persistence and mortality; only quetiapine reduced mortality rates (40). While antipsychotics play a significant role in delirium treatment, further studies are needed to evaluate their long-term effects, including mortality rates.

In this study, the day-7 evaluation indicated that delirium was less common in older individuals, but females had a higher incidence compared to males. These findings differ from those of other studies, which have reported different risk factors. One study reported that advanced age is a risk factor for delirium without gender differences (38). Another study found that older individuals were more prone to persistent delirium, alongside factors such as the use of physical restraint, severe illness, prolonged mechanical ventilation, hospitalization, and repeated admissions (7). Some studies found that while the incidence of delirium in intensive care unit patients did not differ by age and gender, it was associated with prolonged mechanical ventilation, hypoxia, extended intensive care unit stays, severe pain, increased agitation, and sedation (9,41). Different results were obtained in the studies. In this study, the risk of delirium decreased with increasing age. In one study, patients younger than 55 years of age in intensive care were more affected by biological and environmental factors (42). These varying results emphasize the need for further research, particularly to clarify the relationships between age and gender in different group comparisons.

In this study, the assessment conducted at 72 h indicated that the most critical predictors of sleep quality were daytime intensive care unit (ICU) stay, the presence of pain, and agitation. On day 7, the most important predictors of sleep quality were the Richmond Agitation-Sedation Scale (RSS), the presence of pain, and staying in a room with windows. The relationship between sleep deprivation and delirium has been observed, especially in older patients (43). In one study evaluating risk factors for delirium in elderly patients, poor sleep quality was found in delirious patients (9). In older patients who underwent surgical procedures for femur fractures, experiencing sleep disturbances was identified as a predictive factor for delirium (44). Changes in sleep quality and quantity have been recognized as one of the factors accelerating delirium in ICU patients (45). Hence, it is crucial to continually assess sleep and delirium in patients, implement psychosocial interventions for those experiencing sleep problems or delirium symptoms, and make environmental adjustments.

In this study, in addition to delirium, pain and agitation were also significant predictors of sleep quality. In ICU patients, agitation can result from factors such as pain and delirium (46). Factors like pain have been reported to disturb a patient's sleep in the ICU and increase anxiety, leading to agitation (10). In a systematic review, the severity of the disease, age, pain, delirium,

comorbidities, gender, and pre-hospitalization sleep problems were identified as individual factors affecting sleep disorders (47). ICU patients have reported that factors such as pain, discomfort, anxiety/fear, noise, light, and ICU care-related activities contribute to sleep disturbances (11). Identifying and supporting pain and agitation early with psychosocial nursing interventions can help effectively manage symptoms and address the problems they cause, such as sleep disorders.

This study found that patients who stayed in rooms with windows had better sleep quality. Some sources have reported that factors such as light and noise are significant factors that reduce sleep quality, particularly continuous exposure to strong light (11,12,48,49). In a cohort study, environmental factors, such as noise and artificial lighting, were found to have a more substantial impact on sleep quality in ICU patients compared to biological factors (42). In ICU patients, circadian rhythm is considered crucial, with the circadian rhythm most affected by light. Environmental factors, such as strong lighting, have been reported to disrupt circadian rhythm, leading to problems with sleep duration and quality (50). Most studies seem to focus on the relationship between light intensity and sleep quality. Therefore, conducting studies comparing patients who stayed in rooms with windows to those who did not is recommended to further explore this issue.

In this study, the predictors of sedation level at 72 h included agitation, non-compliance with treatment, age, and antipsychotic medication use. On day 7, the most important predictors of patients' sedation levels were agitation, non-compliance with treatment, and sleep quality. In ICU patients, agitation can arise from various factors, including pain, delirium, and medication. Agitation can lead to unintended removal of tubes and catheters, prolonged ICU stays, and various secondary complications (46). To calm patients, facilitate procedures such as mechanical ventilation and tracheal intubation, and promote their adaptation to daily care and nursing practices, sedation is often administered (51). While it is recommended to use sedatives at very low doses, interventions such as improving the patient's environment, reducing nighttime noise and light, and enhancing sleep quality are also advised (10). It is possible to prevent or minimize factors predicting sedation through nursing interventions. Before resorting to medication, proper interventions should be planned and implemented, and making the necessary assessments and adjustments in the ICU.

Strengths and limitations

One of the strengths of this study is that it is a prospective study. Prospective studies allow researchers to collect future data which helps to better assess cause-and-effect relationships. Additionally, conducting two separate assessments on the same patients contributed to a better understanding of predictors for both early and late dependent variables, enhancing the internal validity of the research. Another strength is the validation and reliability of the assessments, which used standardized tools. This ensures that the data collected are accurate and reliable.

Nevertheless, a significant limitation of the study is that it was conducted in a single center. Therefore, the results obtained may only be applicable to the sampled population in that specific center, and different results may be obtained in other hospitals. Multicenter studies are recommended to increase the likelihood of obtaining generalizable results.

Conclusion

This study examined predictors associated with delirium, sedation, and sleep quality in anesthesia intensive care unit patients. In general, the most important predictors for delirium, sedation, and sleep quality include factors such as pain, agitation, non-compliance with treatment, and sleep quality. Notably, sleeping in a room with a window did not emerge as a significant predictor for delirium or sedation, but was found to be a significant predictor for sleep quality. In light of these findings, further research on the subject is recommended. The findings of the study

provide guidance for managing important factors related to delirium, sedation, and sleep quality in the ICU. In daily practice, pain and agitation should be regularly assessed and effectively controlled, while individualized sedation plans should be implemented to prevent over-sedation. To improve treatment compliance, patient and family education should be provided, treatment regimens simplified where possible, and adherence supported through multidisciplinary teamwork. To enhance sleep quality, rooms with windows should be preferred when feasible, noise and light disturbances minimized during nighttime, and non-pharmacological sleep-promoting methods utilized. Additionally, routine screening for delirium should be conducted for early detection, modifiable risk factors actively managed, and the environment maintained calm, well-lit, and orienting. Finally, raising healthcare staff awareness on these issues and encouraging interprofessional collaboration play a critical role in improving patient outcomes.

Ethical approval

This study was approved by the Institutional Review Board of Giresun University Training and Research Hospital (Approval Date: 21.03.2023, Approval Number: KAEK-40/7). The principles of the Declaration of Helsinki were taken into consideration in conducting the research. After the purpose of the research was explained, verbal and written consents were obtained from all the patients.

Author contribution

Study conception and design: AB, EBY; data collection: AB, EBY; analysis and interpretation of results: AB, EBY; draft manuscript preparation: AB, EBY. The author(s) reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

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