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Post-COVID-19 Sleep Quality and Its Determinants in Geriatric Patients: A Cross-Sectional Analysis

Ömer Faruk Tulun[1], Muharrem Bayrak[1]*, Adil Furkan Kılıç[1], Mehmet Mutlu Akıncı[2], Kenan Çadırcı[1], Dogan Nasır Binici[1]

[1]Department of Internal Medicine, Erzurum Faculty of Medicine, Health Sciences University, Erzurum, Türkiye
[2]Department of Econometrics, Faculty of Economics and Administrative Sciences, Erzurum Technical University, Erzurum, Türkiye

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****Corresponding Author***
Muharrem Bayrak
Department of Internal Medicine
Erzurum Faculty of Medicine
Health Sciences University
Erzurum, Turkey
Phone: +90 5385555933
E-mail: muharrem.bayrak@sbu.edu.tr

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Authors' ORCIDs
Ömer Faruk Tulun
https://orcid.org/0009-0009-1001-7723
Muharrem Bayrak
https://orcid.org/0000-0003-2760-4181
Adil Furkan Kılıç
https://orcid.org/0000-0003-2209-5437
Mehmet Mutlu Akıncı
https://orcid.org/0000-0003-0175-9134
Kenan Çadırcı
https://orcid.org/0000-0002-2765-4288
Doğan Nasır Binici
https://orcid.org/0000-0003-0790-1744

Abstract: This study explores sleep quality in older adults who previously tested positive for COVID-19, examining key factors that may affect it. As the pandemic has posed unique health challenges, understanding these sleep disturbances is particularly relevant for elderly individuals. A total of 121 participants aged 65 and above with a history of COVID-19 were included. Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI), along with an analysis of demographic, clinical, and biochemical data. The average age of participants was 72.2 years, with poor sleep quality observed more frequently in women (72.1%, p = 0.004). A lower level of education was linked to worse sleep quality (p = 0.029). Anxiety disorder (OR = 6.380, p = 0.006) and restless legs syndrome (OR = 4.605, p = 0.002) were among the main factors impacting sleep. Additionally, low haemoglobin levels and the use of sleep medications were associated with poor sleep quality (p = 0.011).Findings suggest that anxiety, restless legs syndrome, low haemoglobin, and hypnotic drug use contribute to poor sleep quality in older adults. Addressing these factors could support better sleep and overall well-being in this population.©2025 NTMS.

Keywords: COVID-19; Geriatric Patients; Sleep Quality.

1. Introduction

COVID-19 has been the world's first virus detection in Wuhan, China. The virus has spread rapidly worldwide and has become a global problem. The World Health Organization (WHO) has named this disease COVID-19 on the 30th of January 2020. The COVID-19 infection is highly contagious and can cause severe respiratory infections. The COVID-19 virus belongs to the family of beta coronaviruses, such as the Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS) viruses[1]. According to data released by the WHO in January 2024, more than 774 million COVID-19 cases and more than 7 million deaths have been reported[2]. The COVID-19 pandemic has caused severe mortality and morbidity worldwide. While many patients experience the infection with mild to moderate symptoms, some may develop a condition called 'Long COVID', in which the symptoms are more prolonged[3]. These patients have fatigue, weakness,

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shortness of breath, cardiovascular pathology and sleep disturbances[4]. The importance of 'Long COVID' in treatment approaches has increased as researchers better understand its physiological mechanisms post-COVID-19 pandemic[5].

COVID-19 infection can cause immune system cells to move, interact with nerve endings and affect the brain differently. In this case, the peripheral immune system may be affected by the uncontrolled release of cytokines from the immune system. REM and NREM sleep phases may be affected, and various sleep problems may ocur[6]. The function of the immune system is directly related to sleep and mental health. An excellent immune system must do its job against viral infections for good quality sleep. The relationship between immune cells and central nervous system (CNS) neurons is complex. Tumour necrosis factor-alpha (TNF-alpha) and interleukin-6 (IL-6) are essential in the sleep immune system. IL-6 increases energy expenditure in catabolic events and has a pro-inflammatory function in the immune system. TNF-α is involved in immune response and cell death[7,8]. With increased inflammation in the human body, the immune system may deteriorate, leading to further deterioration in sleep quality, especially in the elderly[9].

Social isolation during the COVID-19 pandemic has negatively affected the elderly. The impact of social isolation on sleep quality and mental health in the elderly following the pandemic was assessed using the International COVID-19 Sleep Study (ICOSS), revealing significant findings[5]. In the ICOSS study, a negative situation was observed in the sleep quality of people with the evening-type chronotype, which showed that it negatively affected the quality of life and mental health of elderly people[5,10].

Studies have found a severe deterioration in quality of life and sleep quality in elderly individuals after the pandemic compared to their previous lives[11,12]. After the pandemic, sleep quality in the young population is negatively affected, especially in individuals who adhere to social distancing rules[13]. Studies on sleep quality after the pandemic in elderly individuals remain limited. The relationship between chronic disease and sleep in elderly patients is of concern, given the severe relationship between sleep quality and general health and psychosocial status. During the COVID-19 pandemic, social isolation policies significantly decreased sleep quality in elderly people[14,15].

This study aims to clarify the detrimental alterations in sleep quality within this demographic by evaluating the influence of clinical and biochemical markers on sleep quality in the elderly post-COVID-19 pandemic. This study aims to contribute to the formulation of sustainable health strategies for at-risk older populations during future pandemics. The fact that most participants had experienced COVID-19 more than 18 months earlier lends a distinctive clinical relevance to our findings, reflecting the persistent burden of long COVID. Given the limited evidence focusing on this extended period in older populations, our study provides a novel contribution by highlighting the enduring impact of long COVID on sleep quality in the elderly.

2. Material and Methods

2.1. Study Design

Our study was conducted between September 2022 and March 2023 on patients aged 65 and older who applied to the Internal Medicine Outpatient Clinic of Erzurum Medical Faculty Hospital.

2.2. Study Population

Patients aged 65 years and older who had COVID-19 infection during the COVID-19 pandemic and presented to the outpatient clinic with a positive PCR test were included in the study. Exclusion criteria for our study:

Patients were excluded if they had primary sleep disorders (insomnia, hypersomnia, parasomnia), were undergoing hemodialysis, had severe auditory or visual impairments, suffered from acute infections, or had advanced neuropsychiatricmotor disorders.

2.3. Socio-demographic Profiles and Clinical Characteristics

Data were obtained both from the hospital database and directly from the patients. The socio-demographic data recorded included age, gender and marital status. Educational status was categorised into three categories: illiterate, primary, and high school. Type of COVID-19 treatment (outpatient, inpatient or intensive care), time since COVID-19 infection, presence of systemic diseases, psychiatric conditions (such as anxiety disorder, depression, psychotic disorder), day time sleepiness and intrinsic sleep disturbance factors (such as pain, caffeine consumption, restless leg syndrome) were evaluated. The use of sleep medications and polypharmacy (use of five or more medications) were also taken into account. In addition, patients underwent a comprehensive chest and general physical examination for symptoms such as cough and shortness of breath. Urinary and fecal incontinence was assessed, and weight loss of more than 10% in the previous six months was recorded. Body mass index (BMI) was calculated according to the standard formula.

2.4. Biochemical and Other Analyses

Venous blood samples were collected from each patient in the morning after a fasting period of at least eight hours. Serum analyses included glycated haemoglobin A1c (HbA1c, 4-5.6%), creatinine (0.5-1.1 mg/dL for women, 0.6-1.3 mg/dL for men), low-density lipoprotein (LDL, <100 mg/dL), triglycerides (<150 mg/dL), total cholesterol (<200 mg/dL), alanine aminotransferase (ALT, 7-35 U/L for women, 10-40 U/L for men), aspartate aminotransferase (AST, 8-30 U/L for women, 10-40 U/L for men), albumin (3.5-5.0 g/dL), ferritin (15-150 ng/mL for women), 30-400 ng/mL for men), thyroid stimulating hormone (TSH, 0.4-4.0 mU/L), vitamin B12 (200-900 pg/mL), C-reactive protein (CRP, <1 mg/dL), D-dimer (<0.5 μg/mL), lymphocytes (1. 000-4,800 cells/μL), neutrophils (2,500-8,000 cells/μL), white blood cells (WBC, 4,000-11,000 cells/μL), haemoglobin (Hb, 12.0-15.5 g/dL for women, 13.5-17.5 g/dL for men) and platelets (PLT, 150,000-450,000 cells/μL). The glomerular filtration rate (GFR) was calculated using the Cockcroft-Gault formula, with a coefficient of 0.85 for female patients. The normal range was subsequently determined to be >90 ml/min/1.73m². Oxygen saturation (SaO_2) was measured with a pulse oximeter attached to the patient's index finger. Three validated assessment tools were employed in the study: the Pittsburgh Sleep Quality Index (PSQI), the Geriatric Depression Scale (GDS) and the Beck Anxiety Inventory (BAI).

2.5. Pittsburgh Sleep Quality Index (PSQI)

The objective of this 19-item questionnaire is to assess sleep quality and seven primary sleep-related components. The Pittsburgh Sleep Quality Index (PSQI) comprises seven components: subjective sleep quality, time to sleep onset (sleep latency), total sleep time, habitual sleep efficiency, sleep disturbances, use of sleep medications and daytime dysfunction. Each component is assigned a score between 0 and 3, with a total score ranging from 0 to 21. A higher score indicates a lower quality of sleep. A total score above 5 indicates a significant impairment in sleep quality [16]. A total score above 5 indicates a significant impairment in sleep quality, a threshold validated in older populations [14].

2.6. Geriatric Depression Scale (GDS)

The instrument comprises 30 items, each answered in the affirmative or the negative. A score of '1' is assigned to responses indicating the presence of symptoms consistent with a depressive disorder. In contrast, a score of '0' is assigned to responses indicating the absence of such symptoms. The full range of possible scores is from 0 to 30. A total score between 0 and 9 is indicative of a normal state of mental health, while a score between 10 and 19 suggests the presence of mild depression. A score between 20 and 30 is indicative of severe depression[17].

2.7. Beck Anxiety Inventory (BAI)

The scale comprises 21 items, each rated from 0 to 3 according to symptom frequency. Total scores range from 0 to 63, with higher scores denoting greater anxiety severity. Anxiety is classified into four levels: minimal (0–7), mild (8–15), moderate (16–25), and severe (26–63) [18].

2.8. Statistical Analysis

Statistical analyses were conducted using Jamovi (version 2.6, R 4.4 based) following Navarro and Foxcroft (2024)(https://www.jamovi.org).
A significance threshold (p-value) of 0.05 was applied. For continuous variables, descriptive statistics were reported as either mean and standard deviation or median with interquartile range (25th to 75th percentiles) based on the data distribution. For categorical variables, descriptive statistics were expressed as numbers and percentages.

The Shapiro-Wilk test assessed normality; the Student's t-test was used for normally distributed data comparisons, and the Mann-Whitney U test for non-normally distributed data. Fisher's Exact test evaluated categorical variables, and the likelihood ratio test was used when assumptions were not met. Binary logistic regression was performed on significant variables identified through univariate analysis, followed by multivariate binary logistic regression.

Sub-factor significance levels of the PSQI were examined using random forest analysis, and marginal effects on sleep quality were analysed by assessing feature contributions.

A priori sample size considerations were based on the assumption of detecting medium effect sizes in the relationship between sleep quality and clinical/psychiatric variables. Using proportions observed in the literature and confirmed in our cohort (e.g., anxiety disorder prevalence of approximately 18% in poor sleepers vs. 3% in good sleepers), a total sample of 120 participants was estimated to provide >80% power at a two-sided significance level of 0.05. Our final sample of 121 participants therefore exceeded the minimum requirement, ensuring sufficient statistical power to detect clinically meaningful differences.

3. Results

This study analysed 121 participants based on their sleep quality using the PSQI. A total of 61 participants were identified as having poor sleep quality (PSQI > 5) and were thus classified as belonging to the PS group. In contrast, 60 participants were classified as having good sleep quality (PSQI ≤ 5) and were thus included in the GS group.

The mean age of the participants was 72.2 ± 6.2 years, with no significant age difference between the groups (p = 0.131). However, there was a significant gender disparity, with women comprising a larger proportion of the PS group (72.1%), p = 0.004.

The GS group had a more balanced gender distribution with a slight male predominance (53.3%). Educational levels also differed significantly between the groups (p = 0.029), with 60.7% of the PS group being illiterate compared to 38.3% in the GS group. Higher education, especially high school graduation, was associated with better sleep quality. Although 86.8% of the sample was married, marital status did not significantly impact sleep quality. The analysis revealed no statistically significant differences in marriage or divorce rates between the PS and GS groups (p = 0.330) (Table 1).

Body mass index (BMI) levels were similar across the groups (median BMI: 29.0 kg/m² in PS vs. 28.0 kg/m² in GS, p = 0.408). Most participants were either overweight or obese, with no significant differences in BMI distribution between the two groups. A high prevalence of comorbidities was observed, with 96.7% of the sample exhibiting at least one additional medical condition. The most prevalent conditions were hypertension (67.8%) and type 2 diabetes mellitus (57.9%), with no significant between-group differences observed for either condition (p = 0.518 and p = 0.794, respectively).

The prevalence of chronic obstructive pulmonary disease (COPD) was higher in the PS group (26.2% vs. 15.0%, p = 0.125) compared to the GS group. Conversely, the prevalence of coronary artery disease was higher in the GS group (35.0% vs. 23.0%, p = 0.143). However, neither of these differences reached statistical significance.

The prevalence of psychiatric disorders was significantly higher in the PS group (41.0%) compared to the GS group (13.3%, p < 0.001), particularly anxiety disorders (18.0% in PS vs. 3.3% in GS, p = 0.006). Furthermore, the prevalence of depression was higher in the PS group (23.0% vs. 10.0% in GS), although this difference did not reach statistical significance (p = 0.052). Restless Leg Syndrome was significantly more prevalent in the PS group (29.5% vs. 8.3%, p = 0.002). Additionally, internal sleep disruptors such as pain were more frequently reported in the PS group (60.7% vs. 46.7%, p = 0.122), though this difference was not statistically significant.

The utilisation of hypnotic medications was markedly higher in the PS group (23.0%) in comparison to the GS group (1.7%, p < 0.001). Additionally, sedative use was more prevalent in the PS group (18.0%, p < 0.001), whereas the administration of anxiolytics and antidepressants was more common, although these discrepancies were not statistically significant.

Table 1: Comparison of the socio-demographic between the "poor sleepers" (PS) and "good sleepers" (GS) as assessed by the Pittsburgh Sleep Quality Index.

	Overall (n=121)	Group PS (n = 61) (PSQI>5)	Group GS (n = 60) (PSQI≤5)	p
Age (year) (mean ± SD)	72.2 ± 6.2	73.0 ± 7.1	71.3 ± 5.1	0.131
Sex (n(%))				**0.004**
Female	72 (59.5)	44 (72.1)	28 (46.7)	
Male	49 (40.5)	17 (27.9)	32 (53.3)	
Educational status (n(%))				0.029
Illiterate	60 (49.6)	37 (60.7)	23 (38.3)	
Primary	41 (33.9)	19 (31.1)	22 (36.7)	
High school	14 (11.6)	3 (4.9)	11 (18.3)	
University	6 (5.0)	2 (3.3)	4 (6.7)	
Marital status (n(%))				0.330
Single	1 (0.8)	0 (0.0)	1 (1.7)	
Married	105 (86.8)	55 (90.2)	50 (83.3)	
Divorced	15 (12.4)	6 (9.8)	9 (15.0)	

PSQI: Pittsburgh Sleep Quality Index, SD: standard deviation.

Day time sleepiness was not significantly different between the PS and GS groups (p = 0.516) and affected 44.6% of participants.

However, the PS group exhibited a significantly higher risk of falls (57.4% vs. 36.7% in GS, p = 0.022). Cough (45.9% in PS vs. 28.3% in GS, p = 0.045) and urinary incontinence (50.8% in PS vs. 26.7% in GS, p = 0.006) were also significantly more prevalent in the PS group. Although the incidence of dyspnea (44.3% vs. 28.3%, p = 0.068) and weight loss (19.7% vs. 11.7%, p = 0.224) was higher in the PS group compared to the other group, these differences were not statistically significant (Table 2).

The PS group had significantly lower haemoglobin levels (13.4 ± 1.8% vs. 14.2 ± 2.2% in GS, p = 0.011). ROC analysis suggested that haemoglobin levels below 14.1% were predictive of poor sleep quality. Other biomarkers, such as CRP, WBC counts, thyroid function, and ferritin levels, showed no significant differences between the groups. Although D-dimer levels were observed to be higher in the PS group, this difference did not reach the level of statistical significance (p = 0.332). Blood oxygen levels (SpO2) were similar between the groups (93.0% in PS vs. 91.7% in GS, p = 0.321) (Table 3).

Table 2: Comparison of the clinical characteristics between the "poor sleepers" (PS) and "good sleepers" (GS) as assessed by the Pittsburgh Sleep Quality Index.

	Overall (n=121)	Group PS (n = 61) (PSQI>5)	Group GS (n = 60) (PSQI≤5)	p
PSQI (median [IQR])	6.0 [3.0-9.0]	9.0 [7.0-12.0]	3.0 [2.0-4.0]	<.001
BMI (kg/m^2) (median [IQR])	28.5 [26.0-31.0]	29.0 [26.0-31.0]	28.0 [26.0-30.0]	0.408
BMI groups (n(%))				0.391
Underweight (<18.5 kg/m^2)	NA	NA	NA	
Normal (18.5–24.9 kg/m^2)	14 (11.6)	8 (13.1)	6 (10.0)	
Overweight (25–29.9 kg/m^2)	63 (52.1)	28 (45.9)	35 (58.3)	
Obese (≥30 kg/m^2)	44 (36.4)	25 (41.0)	19 (31.7)	
Types ofCOVID-19 treatment (n (%))				0.749
Outpatient	66 (54.6)	31 (50.8)	35 (58.3)	
Inpatient service	47 (38.8)	25 (41.0)	22 (22.37)	
Intensive care	7 (5.8)	4 (6.6)	3 (5.0)	
Duration of COVID-19 treatment (n (%))				0.124
0-6 months	0 (0.0)	0 (0.0)	0 (0.0)	
6-12 months	0 (0.0)	0 (0.0)	0 (0.0)	
12-18 months	4 (3.3)	0 (0.0)	4 (6.7)	
18+ months	117 (96.7)	61 (100.0)	56 (93.3)	
Coexisting diseases (n (%))				0.306
Present	117 (96.7)	58 (95.1)	59 (98.3)	
Absent	4 (3.3)	3 (4.9)	1 (1.7)	
Types of coexisting diseases (n (%))				
Hypertension	82 (67.8)	43 (70.5)	39 (65.0)	0.518
Type 2 diabetes mellitus	70 (57.9)	36 (59.0)	34 (56.7)	0.794
Chronic obstructive pulmonary disease	25 (20.7)	16 (26.2)	9 (15.0)	0.125
Coronary artery disease	35 (28.9)	14 (23.0)	21 (35.0)	0.143
Chronic renal failure	14 (11.6)	5 (8.2)	9 (15.0)	0.239
Cerebrovascular diseases	4 (3.3)	3 (4.9)	1 (1.7)	0.306
Malignancy	5 (4.1)	2 (3.3)	3 (5.0)	0.633
Other	17 (14.0)	10 (16.4)	7 (11.7)	0.453
Psychiatric disorders (n (%))				**<.001**
Present	33 (27.3)	25 (41.0)	8 (13.3)	
Absent	88 (72.7)	36 (59.0)	52 (86.7)	
Types of psychiatric disorders (n (%))				
Depression	20 (16.5)	14 (23.0)	6 (10.0)	0.052
Anxiety disorder	13 (10.7)	11 (18.0)	2 (3.3)	0.006
Psychotic disorder	2 (1.7)	2 (3.3)	0 (0.0)	0.096
Internal sleep disruptors (n (%))				0.120
Present	71 (58.7)	40 (65.6)	31 (51.7)	
Absent	50 (41.3)	21 (34.4)	29 (48.3)	
Types of Internal sleep disruptors (n (%))				
Pain	65 (53.7)	37 (60.7)	28 (46.7)	0.122
Restless leg syndrome	23 (19.0)	18 (29.5)	5 (8.3)	0.002
Caffeine	1 (0.8)	0 (0.0)	1 (1.7)	0.235
Sleeping pill use (n (%))				**<.001**
Yes	14 (11.6)	14 (23.0)	1 (1.7)	
No	107 (88.4)	47 (77.0)	59 (98.3)	
Types of sleeping pill use (n (%))				
Anxiolytic	2 (1.7)	2 (3.3)	0 (0.0)	0.096
Antidepressant	1 (0.8)	1 (1.6)	0 (0.0)	0.240
Sedative	11 (9.0)	11 (18.0)	1 (1.7)	**<.001**
Daytime sleepiness (n (%))	54 (44.6)	29 (47.6)	25 (41.7)	0.516
Hendrich fall risk (n (%))	57 (47.1)	35 (57.4)	22 (36.7)	**0.022**
Polypharmacy (n (%))	72 (59.5)	38 (62.3)	34 (56.7)	0.528
Charlson comorbidity index (median [IQR])	5.0[3.0-6.0]	5.0 [4.0-6.0]	4.5 [3.0-6.0]	0.201
Cough (n (%))	45 (37.2)	28 (45.9)	17 (28.3)	**0.045**
Dyspnoea (n (%))	44 (36.4)	27 (44.3)	17 (28.3)	**0.068**
Urinary incontinence (n (%))	47 (38.8)	31 (50.8)	16 (26.7)	**0.006**
Faecal incontinence (n (%))	6 (5.0)	5 (8.2)	1 (1.7)	0.084
Weight loss (n (%))	19 (15.7)	12 (19.7)	7 (11.7)	0.224

PSQI: Pittsburgh Sleep Quality Index, SD: standard deviation, BMI: body mass index, NA: not applicable.

Table 3: Comparison of the laboratory findings between the "poor sleepers" (PS) and "good sleepers" (GS) as assessed by the Pittsburgh Sleep Quality Index.

	Overall (n=121)	Group PS (n = 61) (PSQI>5)	Group GS (n = 60) (PSQI≤5)	p
Albumin (g/dL) (mean ± SD)	3.99 ± 0.5	3.97 ± 0.46	4.01 ± 0.54	0.253
CRP (mg/dL) (mean ± SD)	16.3 ± 40.3	18.1 ± 47.4	14.5 ± 31.9	0.479
WBC (cells/µL)(mean ± SD)	7750.6 ± 3146.1	7834.6 ± 3521.3	7665.2 ± 2739.8	0.909
Platelet (IU/mL)(mean ± SD)	262.1 ± 95.1	266.4 ± 82.1	257.7 ± 107.1	0.077
TSH (mU/L) (mean ± SD)	2.5 ± 7.5	3.2 ± 10.3	1.8 ± 2.4	0.286
Ferritin (ng/mL) (mean ± SD)	102.1 ± 130.4	104.1 ± 145.4	100.1 ± 114.3	0.343
D-dimer (mcg/mL) (mean ± SD)	1033.5 ± 1465.6	1099.1 ± 1651.5	966.8 ± 1259.5	0.332
Lymphocyte count (cells/µL) (mean ± SD)	2348.4 ± 2159.3	2586.1 ± 2935.4	2106.8 ± 776.6	0.364
Neutrophil count(cells/µL) (mean ± SD)	4514.7 ± 2209.9	4384.1 ± 2070.6	4647.5 ± 2353.2	0.611
Haemoglobin (%)(mean ± SD)	13.8 ± 2.0	13.4 ± 1.8	14.2 ± 2.2	**0.011**
Vitamin B12 (pg/mL) (mean ± SD)	398.3 ± 246.3	407.2 ± 218.5	389.3 ± 273.2	0.556
GFR (mL/min) (mean ± SD)	74.8 ± 23.6	74.7 ± 25.0	75.0 ± 22.3	0.959
HbA1c (%)(mean ± SD)	7.1 ± 1.8	7.1 ± 2.0	7.0 ± 1.7	0.878
Total cholesterol (mg/dL) (mean ± SD)	167.7 ± 44.0	167.0 ± 43.0	168.5 ± 45.3	0.851
LDL (mg/dL) (mean ± SD)	121.0 ± 40.4	121.2 ± 39.5	120.8 ± 41.5	0.791
Triglycerides (mg/dL) (mean ± SD)	156.9 ± 95.3	145.0 ± 84.6	169.1 ± 104.5	0.279
ALT (U/L) (mean ± SD)	22.5 ± 11.3	23.5 ± 13.7	21.5 ± 8.3	0.961
AST (U/L) (mean ± SD)	18.4 ± 8.7	18.6 ± 8.3	18.3 ± 9.1	0.759
SpO_2(%)(mean ± SD)	92.4 ± 8.5	93.0 ± 4.2	91.7 ± 11.4	0.321

PSQI: Pittsburgh Sleep Quality Index, SD: standard deviation, CRP: C-reactive protein, WBC: white blood cells, TSH: thyroid-stimulating hormone, GFR: glomerular filtration rate, HbA1c: glycated haemoglobin, LDL: low-density lipoprotein, ALT: alanine aminotransferase, AST: aspartate amino-transferase, SpO_2: Oxygen saturation.

3.1. Sleep Quality Predictors and Multivariate Analysis

The binary logistic regression analysis results indicated that gender, education, and psychiatric disorders were significant predictors of sleep quality. The odds of women experiencing poor sleep were nearly three times those of men (OR = 2.958, p = 0.004). Education had a protective effect, with high school graduates exhibiting significantly lower odds of poor sleep (OR = 0.170, p = 0.012). Anxiety disorders increased the risk of poor sleep (OR = 6.380, p = 0.006), and multivariate analysis confirmed this association (OR = 4.251, p = 0.033). The use of hypnotic medications showed a complex relationship: it was protective in univariate analysis (OR = 0.057, p < 0.001) but associated with an increased risk in multivariate analysis (OR = 8.177, p = 0.011). Restless Leg Syndrome (OR = 4.605, p = 0.002) and urinary incontinence (OR = 3.051, p = 0.006) also significantly impacted sleep quality (Table 4).

The PSQI consists of seven key sub-factors that collectively comprehensively assess sleep quality. The sub-factors included in this study are subjective sleep quality (PSQI_f1), sleep latency (PSQI_f2), sleep duration (PSQI_f3), habitual sleep efficiency (PSQI_f4), sleep disturbances (PSQI_f5), use of sleeping medication (PSQI_f6), and daytime dysfunction (PSQI_f7). These sub-factors were analysed using the Random Forest algorithm to assess their relative importance in predicting sleep quality. The binary logistic regression analysis results indicated that gender, education, and psychiatric disorders were significant predictors of sleep quality (Figures 1 and 2). The R^2 values presented in Figure 2 correspond to Nagelkerke R^2 from the multivariate logistic regression models used to predict poor sleep quality.

Table 4: Univariate and multivariate binary logistic regression analyses of variables significantly affecting the "poor sleepers" (PS) and "good sleepers" (GS) groups as per the Pittsburgh Sleep Quality Index (poor sleepers vs. ref: good sleepers).

	Univariate		Multivariate (method: stepwise) (p <.001)	
	Odds ratio [95% confidence interval]	P OLRT/(coef.)	Odds ratio [95% confidence interval]	P OLRT/(coef.)
Sex (Female vs. ref: Male)	2.958[1.390-6.295]	0.004 (0.005)	2.005 [0.781-5.149]	**0.047** (**0.048**)
Educational status		0.029	NA	NA
(Primary vs. ref: Illiterate)	0.537 [0.240-1.200]	(0.130)		
(H-sch. vs. ref: Illiterate)	0.170 [0.043-0.673]	(0.012)		
(Uni. vs. ref: Illiterate)	0.311 [0.053-1.835]	(0.197)		
Psychiatric disorders (Present vs. ref: Absent)	4.514 [1.831-11.130]	<.001 (0.001)	NA	NA
Depression (Present vs. ref: Absent)	2.681 [0.954-7.530]	0.052 (0.061)	NA	NA
Anxiety disorder (Present vs. ref: Absent)	6.380 [1.350-30.160]	0.006 (0.019)	4.251 [0.798-22.649]	**0.033** (**0.046**)
Restless leg syndrome (Present vs. ref: Absent)	4.605 [1.582-13.400]	0.002 (0.005)	3.396 [0.988-11.667]	**0.027** (**0.032**)
Sleeping pill use (Yes vs. ref: No)	0.057 [0.007-0.449]	<.001 (0.007)	8.177 [0.934-71.568]	**0.011** (**0.038**)
Sedative pill use (Yes vs. ref: No)	0.078 [0.010-0.617]	0.001 (0.016)	NA	NA
Hendrich fall risk (Present vs. ref: Absent)	2.325 [1.120-4.830]	0.022 (0.024)	NA	NA
Cough (Present vs. ref: Absent)	2.146 [1.010-4.560]	0.045 (0.047)	NA	NA
Urinary incontinence (Present vs. ref: Absent)	2.842 [1.327-6.080]	0.006 (0.007)	3.051 [1.254-7.423]	**0.006** (**0.008**)
Haemoglobin (<14.1 vs. ref: ≥14.1)	2.702 [1.285-5.680]	0.008 (0.009)	2.103 [0.841-5.259]	**0.042** (**0.036**)

OLRT: Omnibus Likelihood Ratio Tests, Coef: Coefficient, H-sch: High school, Uni: University, NA: not applicable.

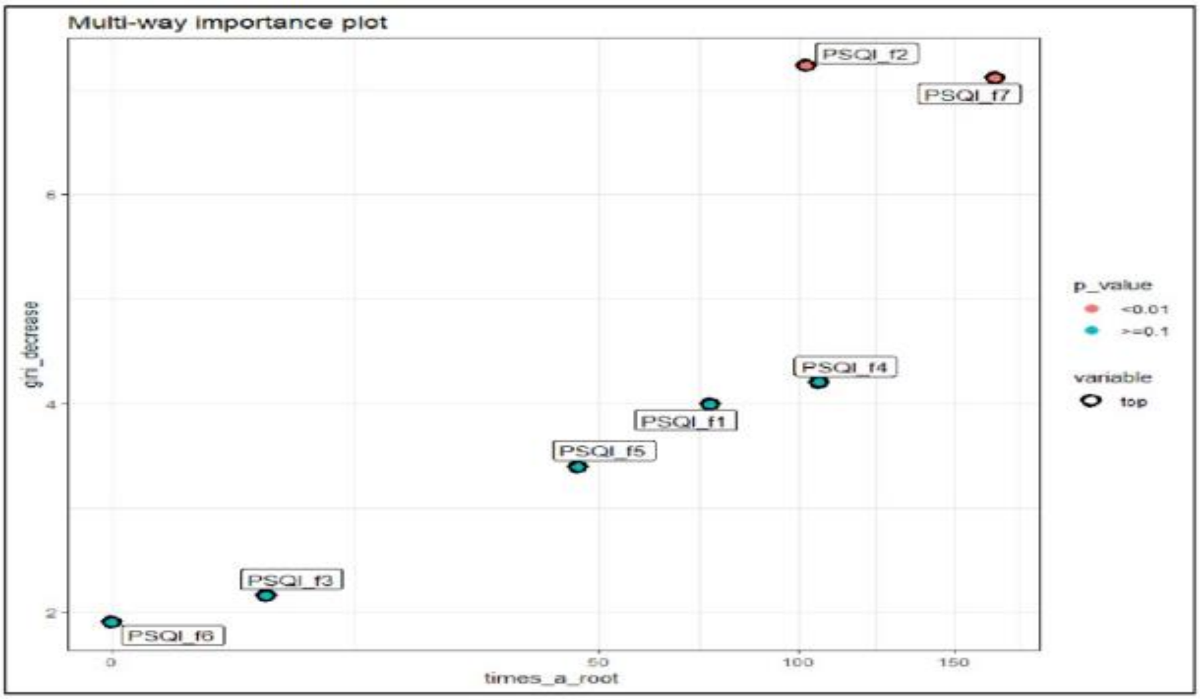

Figure 1: Multi-way importance plot of PSQI sub-factors. The multi-way importance plot derived from the Random Forest analysis highlights the relative contributions of the Pittsburgh Sleep Quality Index (PSQI) sub-factors to overall sleep quality. Sleep latency (PSQI_f2) and daytime dysfunction (PSQI_f7) demonstrated the highest Gini decreases, indicating their dominant influence. Subjective sleep quality (PSQI_f1), habitual sleep efficiency (PSQI_f4), and sleep disturbances (PSQI_f5) showed moderate importance, while sleep duration (PSQI_f3) and use of sleeping medication (PSQI_f6) were the least influential.

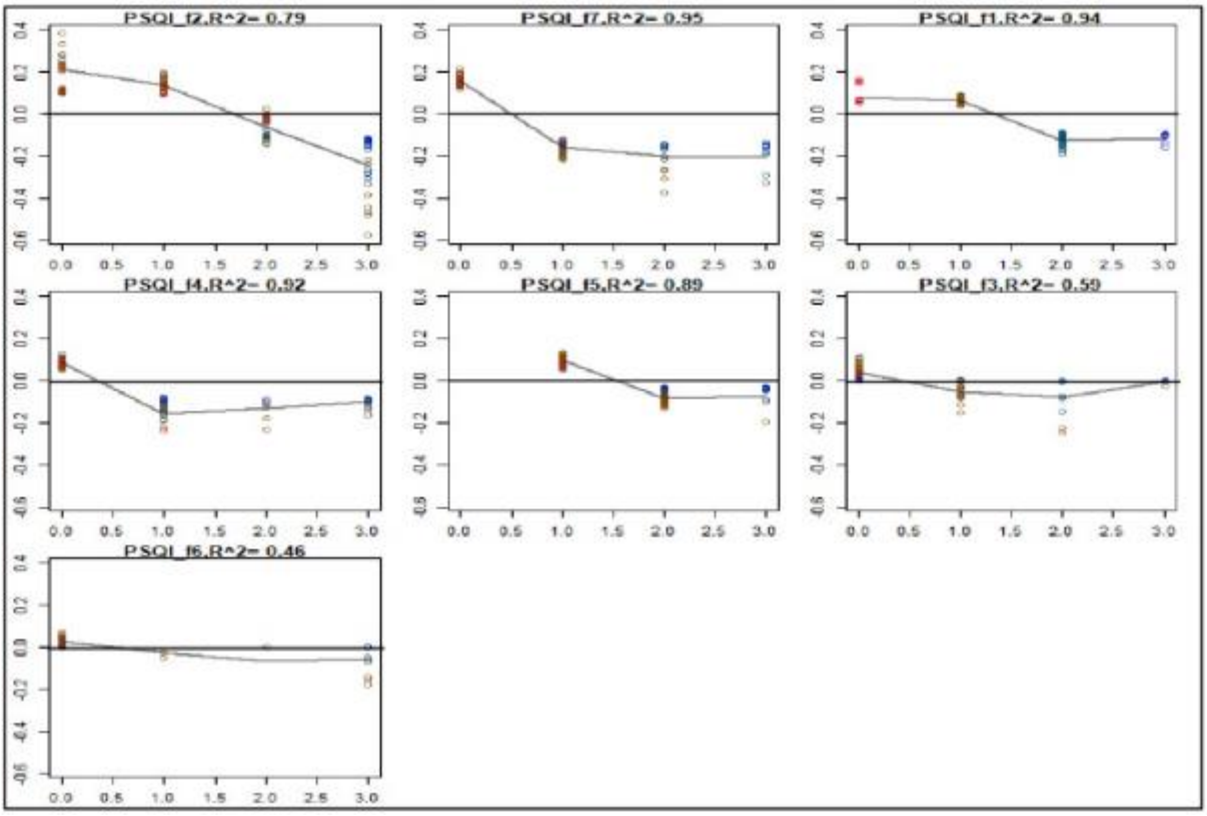

Figure 2: Feature contributions of PSQI sub-factors. The feature contribution plots illustrate the direction and magnitude of each PSQI sub-factor's effect on sleep quality. Levels 0 and 1 of sleep latency (PSQI_f2) and subjective sleep quality (PSQI_f1) were associated with good sleep, whereas higher levels (2–3) contributed to poor sleep. Daytime dysfunction (PSQI_f7) emerged as another critical determinant, with increasing severity linked to deteriorating sleep. Habitual sleep efficiency (PSQI_f4) and use of sleeping medication (PSQI_f6) showed smaller but relevant influences. These findings emphasise the multifactorial nature of post-COVID-19 sleep disturbances in elderly patients.

4. Discussion

Given that studies on smoking addiction should be Our study evaluates factors affecting sleep quality in elderly patients with COVID-19 infection and many systemic diseases. The global pandemic of COVID-19 has precipitated a surge in the incidence of both physical and mental health problems amongst the elderly population. Along with health problems, the COVID-19 infection in the elderly population has negatively affected quality of life and sleep quality. The studies on the quality of sleep conducted after the pandemic have mainly been carried out on young and middle-aged people, and studies on the elderly have been inadequate. Seeing the deficiency in the literature, we have tried to discuss many factors that affect the quality of sleep in elderly patients.

In our study, the fact that sleep disorders were more common in post-menopausal women was consistent with the literatüre [19]. We think that low levels of estrogen and progesterone in post-menopausal women, as well as increased stress and anxiety disorders after the pandemic, reduce sleep quality. In addition, the fact that anxiety disorders and some psychiatric disorders are more likely to occur in women than in men, as in our study, also negatively affects sleep quality.

We believe that the social isolation of female patients after the pandemic and the fear of contracting the virus are additional sources of stres [20-22]. Special stress management services for older female patients and approaches such as cognitive behavioural therapy (CBT) to improve sleep quality may be essential in the future [23,24].

The effect of educational level on sleep quality has been investigated. Elderly patients with a high school education were found to have better sleep quality. This result was found to be consistent with the literature. After the COVID-19 pandemic, people with higher levels of education increased their knowledge about sleep health. Also, they had a higher success rate in fighting diseases that affect sleep quality than individuals with comparatively less education. They also have higher compliance rates with warnings and information about sleep quality and other systemic diseases [25].

Post-COVID-19 pandemic, older adults with limited educational attainment require comprehensive treatment that addresses systemic diseases, sleep hygiene, effective management of comorbidities, and psychological support to improve sleep quality. These therapies are expected to enhance sleep quality and overall health outcomes in the elderly population [26,27]. Anxiety disorder has been found to be compatible with poor sleep quality. The present findings are similar to studies showing the negative effect of anxiety and depression on sleep quality. Anxiety disorder causes hyperawareness and negatively affects sleep quality. We believe that sleep quality will improve due to addressing mental health with cognitive behavioural therapies (CBT) and drug treatment [28,29].

The effect of many systemic diseases, such as type 2 diabetes mellitus, chronic obstructive pulmonary disease (COPD), hypertension, coronary artery disease and malignancy, on sleep quality has been studied, and the results have not shown a significant association, contrary to the literatüre [30,31]. This phenomenon is attributed to the limited number of observed cases, coupled with a significant improvement in patients' clinical symptoms following the COVID-19 pandemic and patients emerging from social isolation, increasing their activity levels, and experiencing a reduction in chronic stress.

A previously known significant relationship between Restless Leg Syndrome (RLS) and urinary incontinence and sleep quality was found to be consistent with our results. Restless legs syndrome (RLS) is characterised by frequent involuntary movements of the legs during the night, resulting in frequent awakenings and a significant deterioration in sleep quality. Urinary incontinence, particularly in elderly patients, is another condition that can adversely affect sleep quality. This effect is attributed to the increased frequency of nocturnal urination, which disrupts the normal sleep cycle [32,33]. The relationship between biochemical and inflammatory markers and sleep quality has been studied, and a significant relationship has been observed with low hemoglobin levels.

The etiology and clinical management of patients with anemia in the elderly following the pandemic are considered inadequate. Anaemia leads to increased fatigue and decreased physical function in older adults, significantly decreasing sleep quality [34]. The observed association between reduced haemoglobin levels and poor sleep quality highlights the clinical relevance of routine anaemia screening in older adults recovering from COVID-19. From a therapeutic perspective, it is essential to differentiate iron deficiency anaemia from anaemia of chronic disease, as their management approaches vary considerably. Timely recognition and appropriate treatment may therefore enhance both general health status and sleep quality in this vulnerable population. Anaemia in elderly patients with COVID-19 infection warrants serious consideration, and prompt diagnosis and treatments are imperative.

The study found that hypnotic sleeping pills adversely affect sleep quality in older people. In a multivariate analysis, long-term use was associated with an increase in many adverse outcomes, such as dependence, daytime sleepiness, cognitive changes and risk of falls. The association between sleep medication use and poor sleep quality should be interpreted with caution, as it may primarily represent indication bias, whereby individuals with more severe disturbances are more likely to receive such prescriptions. In our cohort, the majority of agents prescribed were sedatives, with smaller proportions of anxiolytics and antidepressants, most commonly administered at low to moderate dosages for short- to intermediate durations. Today, there should be healthier guidelines for the use of hypnotics and other sleep medications for severe sleep problems in elderly patients. A literature review reveals a correlation between poor sleep quality and an increased risk of falls. The risk of falls has been found to be high in cases with poor sleep quality [35]. The connection between fall risk and sleep quality is evidenced by several factors observed in the population, including a higher prevalence of hypnotic medication use, extended daytime napping, and increased cognitive alterations [30].

Daytime dysfunction and sleep latency emerged as determinants of sleep quality in the random forest analysis. Sleep duration is also significant in terms of timing and efficiency. As the time it takes to fall asleep increases, the quality of sleep in older people is adversely affected, with consequences for their mental health [36,37]. The concurrence of restless legs syndrome, urinary incontinence, and fall risk in older adults calls for practical management. Iron evaluation**,** pelvic floor exercises**,** evening fluid restriction, and simple environmental adjustments may together reduce symptoms and improve safety in this vulnerable group.

5. Conclusion

As a result, our study evaluates the quality of sleep in elderly people with infection after the COVID-19 pandemic using a number of parameters. Sleep quality was assessed together with physical and mental health and socio-demographic factors. Several factors have been identified as being associated with poor sleep quality, including the experience of the pandemic, low educational level, advanced age, the presence of RLS, low haemoglobin level, urinary incontinence and an increased risk of falls. The COVID-19 pandemic has affected the elderly segment of society. Therefore, comprehensive non-pharmacological methods to improve sleep quality in the long term are needed for this group. Cognitive behavioural therapy (CBT) and training to improve sleep quality should be considered. Future research should concentrate on creating evidence-based medical therapies to improve general health and sleep quality in elderly individuals post-pandemic.

Limitations of the Study

This study had a number of limitations. Firstly, a small number of cases of COVID-19 infection was included in the study. Secondly, sleep quality was assessed at a specific time interval, resulting in an instantaneous assessment. We believe that changes in sleep patterns may make it challenging to identify and establish a causal relationship with patients recovering from

COVID-19 infection. Thirdly, studies using self-report questionnaires such as the PDQI may be at high risk of response bias. Fourth, the lack of longitudinal follow-up information makes it challenging to determine precisely how sleep quality affects clinical and biochemical parameters long after COVID-19 infection. Fifth, haemodialysis patients, terminally ill patients, patients with advanced visual loss and patients with hearing loss, which we did not include in the fifth study, are not assessed for sleep quality, which reduces the validity of the questionnaire for elderly patients.

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Conflict of Interests

The authors declare that they have no conflict of interest to disclose.

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None.

Author Contributions

OFT conceived the idea. MB, DNB, KÇ, AFK developed the theory and performed the computations. MMA, MB verified the analytical methods. All authors discussed the results and contributed to the final manuscript.

Ethical Approval

It was evaluated and approved by the Ethics Committee of Health Sciences University Erzurum Medical Faculty (approval number: 2023/04-37, date: 16.08.2023).

Data sharing statement

The data presented in this study are available on request from the corresponding author.

Consent to participate

Consent was obtained from the patients participating in the study.

Informed Statement

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

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