Association between sleep disturbance and physiological parameters of critically ill patients

Asmaa Atiaa Tolba[1], Mogedda Mohamed Mehany[2], Mona Aly Mohammed[3]

(1) Lecturer of Critical Care and Emergency Nursing - Faculty of Nursing-Assiut University , Egypt

(2,3) Assistant professor of Critical Care and Emergency Nursing, Faculty of Nursing, Assiut University, Egypt

Email: Mogedda@aun.edu.eg

Abstract

Background Adequate sleep quality is required for maintaining the mental and physical health for patients in critical care units (CCUs). **Aim:** This study aimed to evaluate the association between sleep disturbance and physiological parameters in critically ill patients. **Study design and Methods:** A descriptive exploratory study was conducted on purposive sample of 100 critically ill patients in a mixed critical care unit at Assiut University Main Hospital, Egypt. The sleep quality and quantity of each previous night were assessed by using ST Mary's Hospital Sleep questionnaires which was completed every day in the morning between 7 AM and 9 AM for four consecutive days (the 1st day of admission to CCU concerning the first night of sleep in the CCU and 3 consecutive days). Pulse, respiration, and mean arterial blood pressure were evaluated every two hours daily for four days. **Results:** The majority of the study sample (98%) complaining from moderated sleep disturbance, which is positively correlated with physiological parameters (heart rate, mean arterial blood pressure and respiration). **Conclusion:** Poor sleep quality causes significant changes in heart rate, mean arterial blood pressure and respiration among patients in CCUs. **Recommendations:** These findings suggest the need to educate nurses in critical care units on how to assess sleep and to take measures to maintain adequate sleep and then added these to routine care of patients in CCUs.

Keywords: Association, sleep disturbance, physiological parameters, critically ill patients

Introduction

Critically ill patient especially patients are usually complaining from sleep disturbances in the form of sleep fragmentation and shallow sleep in rapid eye movement stage **(Kamdar et al, 2012; Pisani et al, 2015; Devlin et al, 2018; Khalil et al, 2019).** Several factors associated with sleep disturbances for these patients, such as non-circadian light, noise from health care team, monitoring machines and discomfort result from invasive assessment techniques **(Nicola´s et al., 2008; Matthews, 2011; Aitken et al., 2017; Telias and Wilcox, 2019; Honarmand et al, 2020; Miranda-Ackerman et al, 2020)**. In additional to, cardiovascular, respiratory, endocrine, renal, and neurological diseases have been associated with a variety of symptoms that interfere with onset and maintenance of sleep quality **(Gay, 2010; Pisani et al., 2015; Drouot and Quentin, 2016; Rittayamai et al., 2016; Kimia et al, 2020).**

Sleep disturbance may have several adverse effects on the physiological and psychological function such as cardiovascular, respiratory and immune problems, post-traumatic stress disorder, anxiety, and decreased quality of life, which can lead to increased mortality. The multitude of systems that react to sleep disturbance suggest effects beyond the central nervous system and include the total body functioning **(Bourne et al, 2007; Beltrami et al, 2015; Finan et al., 2015; Medrzycka-Dabrowska et al, 2018; Chaudhary et al, 2020).**

Sleep disturbance have negative effects on the cardiovascular functions due to the activation of the sympathetic nervous system and the release of adrenaline and noradrenaline. The release of adrenaline and noradrenaline increases blood pressure, pulse, myocardial demand to oxygen, and cardiac dysrhythmia. These factors can exacerbate myocardial ischemia and result in recurrent heart attacks. Sleep deprivation, for several nights, stimulates the release of inflammatory cytokines that

associated with atherosclerosis, hypertension, and acute coronary artery syndrome. **(Behrozifar et al, 2007& Mullington et al, 2009; Honarmand et al, 2020)**. Sleep disturbance affect on respiratory system function such as, increases oxygen consumption and carbon dioxide production, hypoventilation, reduces forced vital capacity and maximal inspiratory pressure **(Hoey et al., 2014; Kim et al, 2015; Medic et al, 2017)**.

Several methods used to assess sleep in the CCU, nurse observation and polysomnography. Polysomnography is intrusive and technically difficult, and interpretation is uncertain using conventional scoring **(Drouot et al., 2012; Watson et al., 2013; Menear et al., 2017)**. Therefore, subjective nursing assessment of sleep is recognized as a practical alternative for the assessment of sleep quality. Structured interviews, questionnaires, or rating scales may be used to assess patient-reported sleep quality or quantity for patients who are capable of self-reporting **(Storti et al., 2015; Ritmala-Castren et al., 2016)**.

The ST Mary's Hospital Sleep Questionnaire (SMHSQ) is a reliable systematic sleep questionnaire has been devised for assessing the previous night's sleep of a patient and has been designed for repeated use **(Ellis et al., 1981& Leigh et al., 1988)**. Critical care nurses play an important role in promotion of sleep for critically ill patients include an understanding of sleep cycles, different causes of sleep disturbance and objective or subjective methods of sleep assessment **(Aitken et al., 2017; Herscher et al, 2021)**.

Significance of the study

Sleep disturbance is known to have an adverse effect on all physiological systems; leading to abnormal emotional processing, reduced immune function, delayed wound healing and an increased risk of hypertension, heart attack, hypoxia , hypercapnia and stroke **(Wu and Sun, 2017; Astin et al, 2020)**. Critical care nurses in CCUs concentrate their care on cardiac monitoring and maintaining adequate oxygenation rather than maintaining sleep quality and quantity. Sleep quality is typically underreported by members of the health care team despite being an important factor contributing to optimal health and wellness. On the other hand, there is limited evidence on the relationship between the sleep disturbance and physiological parameters among patients in CCUs in our country. Therefore, this study aimed to evaluate the association between sleep disturbance and physiological parameters in critically ill patients.

Operational definition:

Sleep disturbance: Is defined as insufficient duration or quality of sleep which measured in this study by the ST Mary's Hospital Sleep Questionnaire (SMHSQ).

Physiological parameters: Physiological parameters, such as heart rate, blood pressure, and respiratory rate.

Aim of the study

To evaluate association between sleep disturbance and physiological parameters in critically ill patients.

Research question

Does sleep disturbance affect on physiological parameters of patients in CCU?

Research design and setting: A descriptive exploratory study was conducted from August 2019 to January 2020 in a mixed critical care unit at Assiut University Main Hospital, with 4 rooms for 16 patients. Critical care unit receive patients with different diseases; cardiovascular, respiratory, renal and endocrine. Curtains are used between the patients.

Sampling: A purposive sample of 100 critically ill patients was selected for the present study. The sample size was calculated using the Epidemiology Information 2000 statistical software. The calculation was done using the expected frequencies of critical care units from previous studies using 95% confidence interval, 80% power of the study, 95% prevalence of the critically ill patient, and worst acceptable result 5%. The sample size calculated according to the above criteria was 100 critically ill patients. However, 115 critically ill patients from both genders within age 18-60 years were attempted in this research

work to avoid the non-response rate. Fifteen patients were not enrolled in the final statistical analysis of data; five of them died in second day of admission and ten discharged before completion of sleep quality assessment. Unconscious patients, patients with known or suspected pre-existing sleep disorder and mentally ill patients were excluded from this study.

Tools: Two tools were used in this study.

Tool one: Physiological parameters' assessment tool: this tool developed by the researchers after reviewing of the related literatures **(Mullington et al, 2009; Schiza et al, 2012; Aitken et al, 2017; Medic et al, 2017)** to collect data related to patients' characteristics and to assess physiological parameters of the studied patients. This tool consisted of two parts. **Part one:** Patients' medical characteristic: This part included patient's age, sex, patient's diagnosis, past medical history and history of previous admission to CCUs. **Part two:** This part used to assess physiological parameters included pulse, mean arterial blood pressure, and respiration.

Tool two: ST Mary's Hospital Sleep Questionnaire (SMHSQ): This questionnaire adapted by the researchers in this study. ST Mary's Hospital Sleep Questionnaire involved fourteen questions (both Likert type and open-ended type questions) for evaluating the sleep quantity and sleep quality of an individual's previous night's sleep **(Ellis et al., 1981; Leigh et al., 1988)**.

In this study, the researchers modified the first four open-ended questions to closed-ended questions. Four chooses of answer for the 1st and 2nd questions while three chooses of answer for 3rd and 4th questions.

There is not standardized scoring system for this questionnaire. In this study, the SMHSQ questionnaire was scored depended on experts᾽ opinion. This questionnaire divided to two sections; section one illustrated in questions (1,2,3,4,7,8 and 14) and presented sleep quantity while section two illustrated in questions (5,6,9,10,11,12, and 13) and presented sleep quality. Scores are between 6 and 38 which reflected section two of this

questionnaire. A score from 6 to 16 was defined as a severe sleep disturbance; a score from 17 to 27 was defined as a moderate sleep disturbance; and a score from 28 to 38 was defined as a slight sleep disturbance.

Data collection:

• Firstly, the researchers reviewed the national and international related literature related to the topic of the study. This was using textbooks, scientific journals and internet search. This assisted in the preparation of the first assessment tool and in the write-up of the literature review. While the second tool was adapted from **(Ellis et al., 1981& Leigh et al., 1988)**. The SMHSQ questionnaire was translated from English into Arabic following the forward and backward translation technique.

• **Content validity:** the two assessment tools were presented to five panels of experts in critical care medicine and nursing science to assess face and content validation. This included two professors from critical care medicine department and three professors from different scientific departments from Faculty of Nursing- Assiut University. They reviewed the two assessment tools for relevance, comprehensiveness, clarity, and applicability, and some modifications were done according to their opinions. The content validity index was 88% for tool 1, and 87% for tool II.

• **Tool reliability:** Reliability of the two assessment tools were evaluated through assessing their internal consistency and stability measured by Cronbach's alpha coefficient (r = 0.834 & 0.831 respectively).

• **Ethical considerations**: The study was approved by Faculty Research Ethics Committee and by the responsible hospital authorities. After explanation the purpose of the study, each patient given written consent before their participation in the study, confidentiality and anonymity assured. Patients were assured that he can withdraw from the study at any time without any rational.

• **Pilot study:** A pilot study was conducted; it was done on ten percentage of the study

sample (10 patients) before beginning data collection to evaluate the feasibility and applicability of the tools. The necessary modification depended on pilot study was done so patients who participated in the pilot study were excluded from the study sample.

- Once ethical permissions were obtained, and the assessment tools were finalized. The researchers assessed each patient from the first day of admission and record patient demographic and clinical data before any data collection by taking this information from his/her tools.

- **Physiological parameters:** The physiological parameters (pulse, respiration, and mean arterial blood pressure) were recorded from bedside cardiac monitors for each patient every two hours daily for four consecutive days.

- **The sleep quality and quantity**: The researcher was present to CCU every day in the morning between 7 AM and 9 AM to assess patient sleep of each previous night by using ST Mary's Hospital Sleep questionnaires. Data was completed for 4 days (the 1st day of admission to CCU concerning the first night of sleep in the CCU and 3 consecutive days). The filling of the questionnaires took about 15-20 minutes.

Statistical analysis:

- SPSS Statistics (Version 22) were used for statistical analyses. Descriptive statistics were used, including means and standard deviations for continuous data and frequencies for categorical data. Qualitative variables were compared using chi-square test to determine significance.

- The critical value of the test's "P" was considered statistically significant when P less than 0.05.

- Pearson correlation was used to compare between sleep quality score and pulse, respiration and mean arterial blood pressure.

Results

Table [1] represents that one hundred critically ill patients participated in this study.

They were, on average (51.8 ± 6.62) years old, (64%) were diagnosed with cardiovascular diseases and (25 %) of them had history of hypertension and diabetes. This is the first time of admission to CCU for 80 % of study sample.

Figure [1]: illustrates that more than half of study sample (63 %) were male.

Table [2] illustrates that there is gradual improvement in the mean duration of study sample night sleep from the 1st to 4th night after admission $(1.12 \pm 1.03 \& 4.33 \pm 1.43)$ respectively.

Figure [2]: reveals that more than two thirds of the studied patients (73%) complaining from moderate sleep disturbance in the first night of hospitalization in comparison with (95%) in the fourth night of hospitalization. On the other hand, (27 %) of them complaining from sever sleep disturbance in the first night of hospitalization and this percentage decline to (5%) in the fourth night of hospitalization.

Table [3]: shows that the majority of the study sample (98%) complaining from moderated sleep disturbance, which is positively correlated with physiological parameters (heart rate, mean arterial blood pressure and respiration)

Table [4]: shows that more than two thirds (79.6%) from studied patients complaining from moderate sleep disturbance did not have history of admission to CCU with no statistically significant relationship.

Table [1]: Frequency distribution of the studied patient's characteristics (n=100)

Patient's characteristics	No	%
Age		
▪ Less than 40	5	5.0
▪ 40: ≤ 50 years	22	22.0
▪ 50: 60 years	73	**73.0**
Mean± SD	**51.8±6.62**	
Medical diagnosis		
▪ Cardiovascular diseases	64	**64.0**
▪ Respiratory diseases	25	25.0
▪ Other	11	11.0
Chronic diseases		
▪ No	38	38.0
▪ Hypertension	32	32.0
▪ Diabetes mellitus	5	5.0
▪ Hypertension + Diabetes mellitus	25	**25.0**
History of previous admission to critical care unit		
▪ No	80	**80.0**
▪ Yes	20	20.0
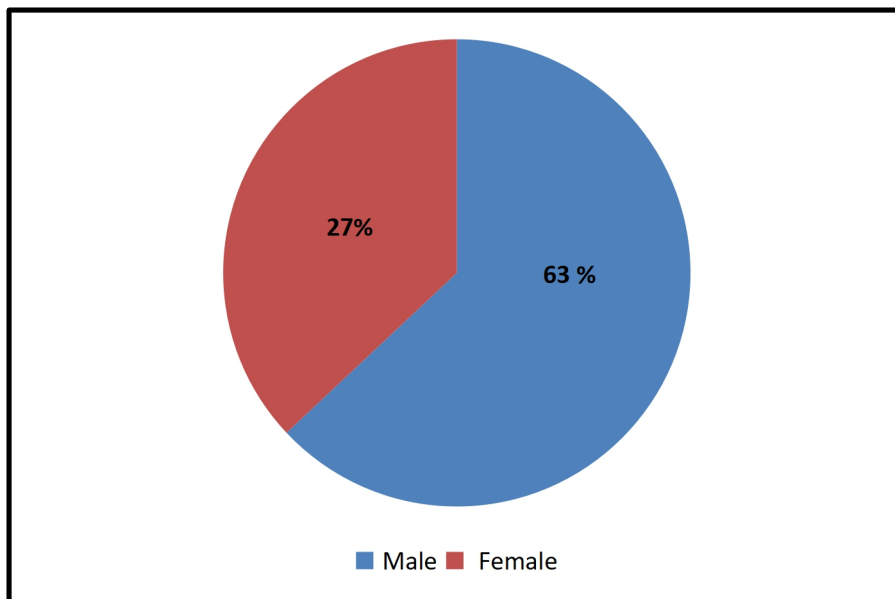
Figure [1]: Percentage distribution of studied patients in relation to gender

Table [2]: Duration of sleep among the studied patients

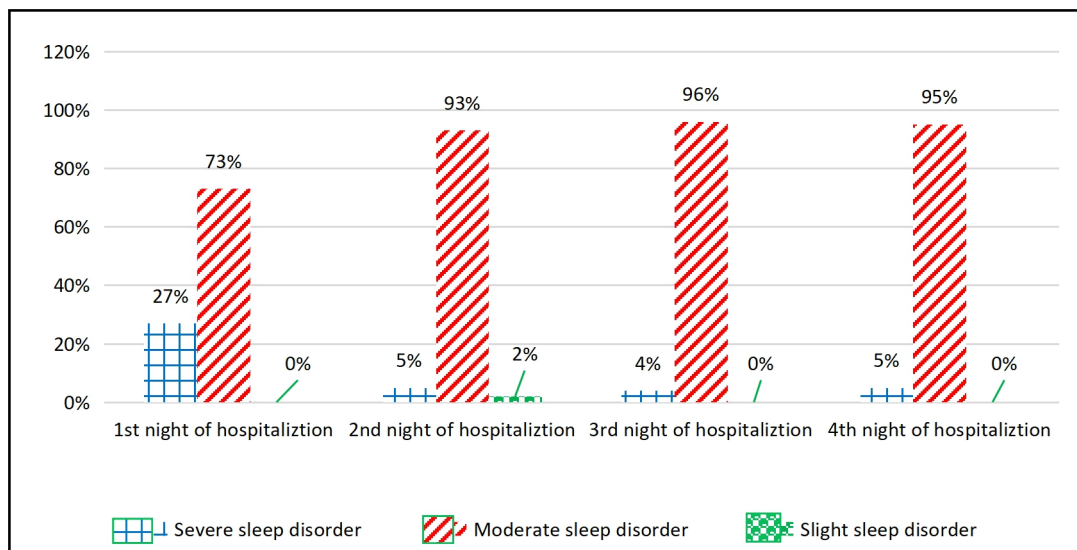| Item	1st night	2nd night	3rd night	4th night
Duration of night sleep	**1.12±1.03**	3.27±1.71	3.97±1.38	**4.33±1.43**

Figure [2]: Sleep quality score among the studied patients

Table [3]: Correlation between sleep quality score and physiological parameters

Variable	Sleep quality				R	P-value
	Severe sleep disturbance		Moderate sleep disturbance			
	No	%	No	%		
Heart rat						
▪ 90: <100	0	0.0	64	65.3		
▪ 100: < 110	2	100.0	18	18.4	0.173	0.017**
▪ 110 or more	0	0.0	16	16.3		
Mean arterial blood pressure						
▪ 70: < 100	0	0.0	78	79.6	0.254	0.007**
▪ 100 or more	2	100.0	20	20.4		
Respiration						
▪ 16:< 20	2	100.0	60	61.2	0.349	0.001**
▪ 20 or more	0	0.0	38	38.8		

Table [4]: Relation between sleep quality scale and history of previous admission to critical care unit

Variable	Sleep quality				P-value
	Severe sleep disorder		Moderate sleep disorder		
	No	%	No	%	
History of previous admission to critical care unit					
▪ No	2	100.0	78	79.6	.475
▪ Yes	0	0.0	20	20.4	

Discussion

The noisy environment, disease severity and medications are the main causes of sleep disturbance among critically ill patients. Sleep disturbance has several adverse effects on physical and psychological functions **(Li et al., 2011; Salandin et al., 2011; Aitken et al., 2017).** More than two thirds of the study sample, their age ranged between 50 to 60

years old and more half of them were males. This can be related to that the aging and elderly population is particularly susceptible to cardiovascular and respiratory diseases. This agrees with **Ritmala-Castren et al., (2014)** who documented that the study sample age ranged between 59± 14 years old and 63 % of them were males. Also, the study conducted by **Shinde and Anjum, (2014)** reported that age,

gender, socio-economic status, and education level affect sleep quality. These findings are supported by **Abd El Khalik et al., (2020)** who reported that the majority of the study groups were male.

The highest percentage of the participants in the study was diagnosed with cardiovascular diseases. This can be attributed that cardiovascular can negatively affect on sleep quality. This might be due to beta blockers used in management of several cardiovascular diseases are correlated with sleep disturbance. Beta blockers reduce the production of melatonin which assists in maintaining sleep quality. Serious consequences of sleep disturbance are as the release of inflammatory substances, increasing blood pressure and exacerbation of myocardial ischemia. In this respect **Menear et al., (2017)** reported that less than quadrant of studied patient, were complaining from cardiovascular diseases.

According to this study, it is the first time of admission to CCU for more than two thirds of the study sample who experienced moderate sleep disorders. It can be attributed to physiological and psychological stress associated with admission to CCU reduces sleep quality. In the study of **Daneshmandi et al., (2012**) which was conducted on 60 patients, it was documented that is the first time of admission for more than half of the study sample and stress resulted from admission to CCU might be the reason for the lack in the sleep quality. Another study conducted by **Magdy et al., (2019)** documented that more than two thirds of the studied patients had first time admission to the respiratory intensive care unit.

Subjective assessment of the study sample sleep revealed that the majority of the studied patients complaining from moderate sleep disturbance, which positively correlated with their heart rate and mean arterial blood pressure. This can be attributed to frequent sleep disruption caused a greater effect on the cardiovascular activity. These findings are supported by **Sauvet et al., (2010)** who reported that sleep disturbance stimulate sympathetic tone, resulting in increasing blood pressure, heart rate and increased risk of acute myocardial infarction.

The study findings also revealed a positive significant correlation between sleep quality score and respiratory rate. This result is in accordance with a study conducted by **Kamdar et al., (2012)** who reported that sleep deprivation have shown significantly increased respiratory muscle fatigue and respiratory rate.

Limitation of the study

The sample recruitment was depended on a convenience non-random sampling and the sample was small which could affect the study findings.

Conclusion

Subjective assessment of sleep for patients in critical care unit documented that their sleep was poor quality. Poor sleep quality causes significant changes in heart rate, mean arterial blood pressure and respiration.

Recommendations

- These findings suggest the need to educate nurses in CCU on how to assess sleep and measures to maintain adequate sleep and then added these to routine care of patients in CCUs.

- The study can be replicated on a large sample there by results can be generalized.

- Further researches are recommended to develop standardized nursing intervention for critically ill patients to improve their sleep quality and quantity.

Financial support

Acknowledgment

Conflict of interest

The authors declare no conflict of interest in this study.

References

Abd El Khalik E , Abd Elbaky M, Ahmed N , Taha S. (2020): The Effectiveness of Using Breathing Exercise on Sleep Quality Among Hospitalized Patients. American Journal of Nursing Science; 9(4): 272-280.

Aitken LM, Elliott R, Mitchell M, Davis C, Macfarlane B, Ullman A, Wetzig K, Datt A & McKinley S. (2017): Sleep assessment by patients and nurses in the intensive care: an exploratory descriptive study. Australian Critical Care; 30: 59–66.

Astin F, Stephenson J , Wakefield J , Evans B , Rob P , Joanna G and Harris E. (2020): Night-time Noise Levels and Patients' Sleep Experiences in a Medical Assessment Unit in Northern England. The Open Nursing Journal; 14:80-91

Behrozifar S, Zonouzi SH, Nezafati M, Esmaeili H. (2007): Relationship between sleep patterns and quality of life in patients undergoing coronary artery by-pass graft surgery. Journal of Sabzevar University of Medical Sciences; 14(1): 53-61.

Beltrami FG, Nguyen XL, Pichereau C, Maury E, Fleury B, Fagondes S. (2015): Sleep in the intensive care unit. J Bras Pneumol; 41(6):539-546.

Bourne RS, Minelli C, Mills GH, Kandler R. (2007): Clinical review: sleep measurement in critical care patients: research and clinical implications. Critical Care journal; 11(4):226.

Chaudhary A, Kumari V, and Neetu N. (2020): Sleep Promotion among Critically Ill Patients: Earplugs/Eye Mask versus Ocean Sound—A Randomized Controlled Trial Stud. Critical Care Research and Practice.

Daneshmandi M, Neiseh F, SadeghiShermeh M, and Ebadi A. (2012): Effect of Eye Mask on Sleep Quality in Patients with Acute Coronary Syndrome. Journal of Caring Sciences; 1(3): 135–143.

Devlin JW, Skrobik Y, Gélinas C. (2018): Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. Crit Care Med.; 46(9): 825-873.

Drouot X & Quentin S. (2016): Sleep neurobiology and critical care illness. Sleep Medicine Clinics; 11: 105–113.

Drouot X, Roche-Campo F, Thille AW, Cabello B, Galia F, Margarit L, d'Ortho MP & Brochard L. (2012): A new classification for sleep analysis in critically ill patients. Sleep Medicine; 13: 7–14.

Ellis B, Johns M, Lancaster R, Raptopoulos P,Angelopoulos N, Priest R. (1981): The St. Mary's Hospital Sleep Questionnaire: a study of reliability. Sleep; 4:93-97.

Finan PH, Quartana PJ, Smith MT. (2015): The effects of sleep continuity disruption on positive mood and sleep architecture in healthy adults. Sleep; 38(11):1735–1742.

Gay P. 2(010): Sleep and sleep-disordered breathing in the hospitalized patient. Respiratory Care journal; 55(9):1240–1254.

Herscher M, Mikhaylov D, Barazani Sh, Sastow D, Yeo I, A, Cho S. (2021): A Sleep Hygiene Intervention to Improve Sleep Quality for Hospitalized Patients. The Joint Commission Journal on Quality and Patient Safety; 47 (6): 343-346

Hoey LM, Fulbrook P & Douglas J. (2014): Sleep assessment of hospitalized patients: a literature review. International Journal of Nursing Studies; 51: 1281–1288

Honarmand K, Rafay H, Le J, Mohan S, Rochwerg B, Devlin J, Skrobik Y, Weinhouse G, Watson P, McKinley Sh, Bosma K. (2020): A Systematic Review of Risk Factors for Sleep Disruption in Critically Ill Adults. The Society of Critical Care Medicine and Wolters Kluwer Health, Inc.; 48(7).

Kamdar BB, Needham DM, Collop NA. (2012): Sleep deprivation in critical

illness: its role in physical and psychological recovery. J Intensive Care Med.; 27(2):97-111.

Khalil N, Moustafa M, El-Bouraei Z. (2019): EFFECTS OF NON-THERAPEUTIC MEASURES ON SLEEP QUALITY AMONG CRITICALLY ILL PATIENTS, EGYPT. International Academic Journal of Health, Medicine and Nursing; 1 (2):175-188.

Kim TW, Jeong JH, Hong SC. (2015): The impact of sleep and circadian disturbance on hormones and metabolism. Int J Endocrinol; 591729.

Kimia H, Hammad R, Jamie L, Sindu M, Bram R, John D, Yoanna S, Gerald W, Xavier D, Paula W, Sharon M; Karen B. (2020): A Systematic Review of Risk Factors for Sleep Disruption in Critically Ill Adults. Critical Care Medicine; 48 (7): 1066-1074

Leigh T, Bird H, Hindmarch I, Constable P, Wright V. (1988): Factor analysis of the St. Mary′s Hospital Sleep Questionnaire. Sleep;11:448-453

Li SY, Wang TJ, Vivienne Wu SF, Liang SY & Tung HH. (2011): Efficacy of controlling night-time noise and activities to improve patients' sleep quality in a surgical intensive care unit. Journal of Clinical Nursing; 20: 396–407.

Magdy D, Metwally A, Makhlouf H. (2019): Study of sleep quality among patients admitted to the respiratory intensive care unit. Egyptian Journal of Bronchology; 13:114–119

Matthews E. (2011): Sleep Disturbances and Fatigue in Critically Ill Patients. AACN Adv. Crit Care; 22(3): 204–224.

Medic G,Wille M, and Hemels M. (2017): Short- and long-term health consequences of sleep disruption. Nat Sci Sleep; 9: 151–161.

Medrzycka-Dabrowska W, Lewandowska K, Kwiecie_n-Jagu_s K, Czyż- Szypenbajl K. (2018): Sleep deprivation in intensive care unit – systematic review. Open Med.; 13:384-393.

Menear A, Elliott R, Aitken L, Lal S and McKinley SH. (2017): Repeated sleep-quality assessment and use of sleep-promoting interventions in ICU. British Association of Critical Care Nurses; 22 (6)

Miranda-Ackerman R, Lira-Trujillo M, Gollaz-Cervantez A, Cortés-Flores A, Zuloaga-Fernández C, García-González L, Morgan-Villela G, Barbosa-Camacho F, Pintor-Belmontes K, Guzmán-Ramírez B, Bernal-Hernández A, Fuentes-Orozco C& González-Ojeda A. (2020): Associations between stressors and difficulty sleeping in critically ill patients admitted to the intensive care unit: a cohort study. BMC Health Services Research; 20 (631).

Mullington J, Haack M, Toth M, Serrador J, and Meier-Ewert H. (2009): Cardiovascular, Inflammatory and Metabolic Consequences of Sleep Deprivation. Prog Cardiovasc Dis.; 51(4): 294–302.

Nicola′ s A, Aizpitarte E, Iruarrizaga A, Va′zquez M, Margall A and Asiain C. (2008): Perception of night-time sleep by surgical patients in an intensive care unit, British Association of Critical Care Nurses, Nursing in Critical Care; 13 (1).

Pisani MA, Friese RS, Gehlbach BK, Schwab RJ, Weinhouse GL & Jones SF. (2015): Sleep in the intensive care unit. American Journal of Respiratory and Critical Care Medicine; 191: 731–738.

Ritmala-Castren M, Axelin A, Kiljunen K, Sainio C and Leino-Kilpi H. (2014): Sleep in the intensive care unit – nurses' documentation and patients' perspectives. British Association of Critical Care Nurses; 22 (4).

Ritmala-Castren M, Virtanen I, Vahlberg T, Leivo S, Kaukonen KM & Leino-Kilpi H. (2016): Evaluation of patients' sleep by nurses in an ICU. Journal of Clinical Nursing; 25: 1606–1613

Rittayamai N, Wilcox E, Drouot X, Mehta S, Goffi A & Brochard L. (2016): Positive and negative effects of mechanical

ventilation on sleep in the ICU: a review with clinical recommendations. Intensive Care Medicine; 42: 531–541.

Salandin A, Arnold J& Kornadt O. (2011): Noise in an intensive care unit. The Journal of the Acoustical Society of America; 130: 3754–3760.

Sauvet F, Leftheriotis G, Gomez-Merino D, Langrume C, Drogou C, Van Beers P, Bourrilhon C, Florence G, Chennaoui M. (2010): Effect of acute sleep deprivation on vascular function in healthy subjects. Appl Physiol; 108(1):68-75.

Schiza S, Simantirakis E, Bouloukaki I, Mermigkis Kallergis E, Chrysostomakis S ,Arfanakis D, Tzanakis, N, Vardas Pand Siafakas N.(2012): Sleep Disordered Breathing in Patients with Acute Coronary Syndromes J Clin Sleep Med. ; 8(1): 21–26.

Shinde MB, Anjum S. (2014): Effectiveness of slow back massage on quality of sleep among ICU patients. International Journal of Science and Research (IJSR); 3: 292–298.

Storti LJ, Servantes DM, Borges M, Bittencourt L, Maroja FU, Poyares D, Burke PR, Santos VB, Moreira RS, Mancuso FJ, de Paola AA, Tufik S, Carvalho AC & Cintra FD. (2015): Validation of a novel sleep-quality questionnaire to assess sleep in the coronary care unit: a polysomnography study. Sleep Medicine; 16: 971–975.

Telias I & Wilcox M. (2019): Sleep and Circadian Rhythm in Critical Illness. Critical Care; 23 (82)

Watson PL, Pandharipande P, Gehlbach BK, Thompson JL, Shintani AK, Dittus BS, Bernard GR, Malow BA & Ely EW. (2013): Atypical sleep in ventilated patients: empirical electroencephalography findings and the path toward revised ICU sleep scoring criteria. Critical Care Medicine; 41: 1958–1967.

Wu L, and Sun D. (2017): Sleep duration and falls: A systemic review and meta-analysis of observational studies. J Sleep Res; 26(3): 293-301.