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RESEARCH ARTICLE

Assessment of Nursing Workload and Adverse Events Reporting among Critical Care Nurses in the United Arab Emirates

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Abstract:

Background:

Nursing is a demanding job, and excessive workloads have been demonstrated to negatively impact patient care. This study aimed to determine the associations between nursing workload on the days of intensive care unit (ICU) admission and discharge and adverse events among patients (*i.e.* ICU readmission and medication errors).

Methods:

This study used a retrospective cohort design. We reviewed medical records for 270 patients admitted to the ICU from three hospitals in the United Arab Emirates between February and April 2023. Collected data included patients' demographics, diagnosis, acuity score on ICU admission/discharge days, Nursing Activities Score (NAS) on ICU admission/discharge days and adverse events reported (*i.e.* occurrence of medication errors and re-admission to ICU after discharge).

Results:

The nursing workload on ICU admission and discharge days was high (NAS=72.61 and NAS=52.61, respectively). There were significant associations between ICU readmission and nursing workload at ICU admission and discharge. Moreover, there was a significant relationship between the occurrence of medication errors and nursing workload on the day of ICU admission, with more medication errors occurring in patients with higher NAS scores.

Conclusion:

The complexity of nursing activities and the severity of patients' conditions directly impact the nursing workload and patient outcomes. A practical strategy to reduce the nursing workload may be calculating the NAS to clarify the actual time spent by nurses to provide the required care based on the patient's condition. Adoption of new technologies to enhance medication safety and minimise errors may be another strategy to reduce the impact of the high nursing workload in ICU settings.

Keywords: ICU nurses, Workload, Adverse events, ICU readmission, Medication errors.

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1. INTRODUCTION

The global nursing and midwifery workforce comprises approximately 27 million individuals [1], accounting for around 60% of the total health professional workforce [2]. Nurses play crucial roles in structuring and implementing health actions, both on the frontline and at the management level [3]. The United Arab Emirates (UAE) Statistics and Research Centre Ministry of Health and Community (2020) noted there were approximately 59,000 nurses across various specialties and work environments in the UAE, including intensive care units (ICUs), general inpatient wards, emergency rooms and operating theatres. It has been projected that the world will require an additional 9 million nurses and midwives by 2030 [1]. With the increasing demand for healthcare services and the anticipated shortage of competent physicians

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and skilled nurses, healthcare systems need to adopt forward-thinking strategies, especially for critical care services [4]. The nursing workforce shortage has significant negative impacts on nurses and other healthcare professionals by increasing their workload and patient outcomes by potentially causing care deficiencies and adverse events [5, 6].

The nursing workload is defined as the amount of time consumed by nurses' physical and cognitive efforts to provide patient care in addition to service management tasks and professional development activities [7, 8]. A high workload may reduce nurses' motivation and ability to provide proper patient care [9]. The ICU is one of the most vital and critical areas in the hospital setting, and the intensity of nursing care and nurses' workload in ICUs has increased because of significant evolution. However, with the persisting task force shortage and increased workload over recent decades, care for critically ill patients may be compromised [10].

Several factors contribute to increased nursing workloads, which can be categorised as nurse-related (*e.g*., age, gender, experience), patient-related (*e.g*., age, gender, disease severity, ICU stay duration) and situational factors such as shift (day or night) and department transfers [11]. Patient acuity, based on the complexity of nursing activities, directly influences workload and may vary during hospitalisation [12]. However, it is important to focus on nurses' workload rather than the patient-nurse ratio, as workload is affected by a patient's condition severity, admission, and discharge time [13]. In the UAE, there are additional factors that may contribute to a heavy workload for nurses, including the longer working hours per week compared with international standards (*e.g*. nurses in the UAE currently work around 45 hours per week). All of these factors contribute to an increased perception of nurses' workload, which in turn may contribute to a higher occurrence of adverse events.

Currently, the most commonly used validated measure for assessing nursing workload is the Nursing Activities Score (NAS). This tool was developed by Miranda *et al*. (2003) [14] and provides a score per patient depending on the nursing tasks that have been performed. This score assesses the nursing workload by measuring the amount of nursing time spent on each patient. The score is reported as a percentage, and ranges from 0% to 177% for each patient. This score reflects the percentage of nursing time required to care for the patient (100% = one nurse) [15]. A high workload has been linked to ICU nurses' well-being [16, 17] and compromised patient safety [6]. Therefore, the nursing workload significantly influences adverse events during ICU stays, including increased ICU readmission rates [15, 18] and medication errors [19].

Patients admitted to ICUs are generally eligible for discharge when they are physiologically stable and advanced monitoring is no longer required. The decision to discharge a patient from the ICU should be made after constructing a complete picture of their clinical condition and considering the various components of medical and nursing care while keeping in mind that the patient will be transferred to a ward that cannot provide the same level of treatment and surveillance as the ICU [20]. Following the transfer, the intensity of medical and nursing care available decreases dramatically, putting staff at risk for failing to recognise, understand and treat key changes in clinical conditions and thereby increasing the chance of ICU readmission [20]. Although early ICU discharge may reduce costs, it increases the risk of adverse outcomes and readmission. A previous study [21] found that nearly one-third of ICU readmissions were due to premature discharge, with readmitted patients facing higher mortality risk and longer stays. Re-evaluating high-risk patients before discharge could prevent ICU readmissions [21]. Identifying patients likely to be readmitted will aid discharge planning, and allow postponement until stability or modified care outside the ICU is achieved [22].

Furthermore, the high nursing workload on ICU discharge days is associated with readmission rate, which may be influenced by patients' age, bedridden status, those who had a tracheostomy during ICU stay and those with chronic diseases and comorbidities [20, 21]. Moreover, the high workload on the day of ICU discharge may be explained by the number of nursing tasks and responsibilities that must be performed before ICU discharge, including laboratory tests and diagnostic procedures, preparing medication, completing patient charts/documentation and patient endorsement to the shifted department [6, 16, 17]. These tasks are time-consuming; the lack of time and additional responsibilities for nurses in the ICU attributable to the increased workload offers an explanation for the workload on the ICU discharge day [23].

Patient safety is paramount, and medication errors are crucial indicators of patient safety [23]. These errors are one of the most significant and preventable types of medical errors, and often stem from improper medication use, which leads to patient harm [24]. In the US, medication errors cause around 7,000 deaths annually and occur in 2%–14% of patients, with 1%–2% resulting in patient loss, primarily due to incorrect prescriptions [25]. Medication errors can be categorised in a variety of ways, but the most commonly used classification approach in hospital settings is based on the stage of medication use once an error occurs, such as prescription, transcribing, dispensing, administration and monitoring. Another category is psychological classifications including 'knowledge-based error', 'rule-based error', 'action-based error' and 'memory-based error' [26, 27]. Moreover, nurse-related factors such as a high workload contribute to medication errors, making them a leading cause of adverse events worldwide [28].

Research indicates there is a relationship between excessive nurse workloads and medication errors [29]. This is because the increased workload could impair the information process which in turn increases the chance of an incorrect judgement that may contribute to medication errors [25]. Nurses administer the majority of medications and in hospitals, spend around 40% of their time doing so [30]. When nurses are exhausted, work demands may mean they postpone medication administration, forget to administer medication, or prepare the incorrect medication for patients [6, 23].

Previous studies reported there was an association between the ICU nursing workload and patients' adverse events, such as nosocomial infection, pressure ulcer and accidental extubation

[31 - 33]. However, limited research has been published on the effects of high nursing workload on ICU readmission and medication error occurrences as adverse events. Understanding of such effects will enhance patient safety, ensure the quality of patient care and foster a positive work atmosphere for ICU nurses. This study aimed to explore the nursing workload on ICU admission/discharge days, the prevalence of medication errors and the ICU readmission rate, and evaluate the associations between nursing workload using the NAS and patients' adverse events.

2. METHODS

2.1. Design, Sample and Settings

This study used a retrospective cohort design to determine associations between the nursing workload and adverse events among critically ill patients, with a focus on ICU readmissions and the occurrence of medication errors, for 3 consecutive months (February to April 2023). The sample was conveniently recruited from three different governmental hospitals in the UAE. These hospitals cover various specialties and sub-specialties in clinical services, including emergency, intensive care medicine and intensive cardiac care.

This study only included general ICUs from the participating hospitals; cardiac ICUs and cardiac care units were excluded because they have different workloads and capacities, and mainly cover cardiac cases. We reviewed the medical records for patients aged ≥18 years who were admitted to the ICU from February 2023 to April 2023 and who had experienced ICU readmission within the same hospitalisation period. The Shapiro-Wilk test was used to test normality in this study ($p<.05$). Based on this result, nonparametric tests, independent-samples Mann-Whitney U tests and correlation coefficients were used for the analyses. The sample size calculation using G* power software revealed that 270 participants would be sufficient to achieve 80% power with an alpha of 0.05.

2.2. Instruments

2.2.1. Demographics and Clinical Data

Information collected from patients' medical records included demographic data (age and gender) and clinical characteristics (diagnosis, type of ICU admission, isolation precaution on admission/discharge days, duration of mechanical ventilation, tracheostomy during ICU stay and discharge shift).

2.2.2. Nursing Workload

The nursing workload was evaluated using the NAS. This tool was developed to categorise activities that compromised the nursing workload at the bedside while the nurse was providing patient care. The NAS was used to calculate the nursing workload at the individual patient level on the days of ICU admission and discharge [14]. The NAS covers 23 categories: 1) monitoring and titration; 2) laboratory, biochemical and microbiological investigations; 3) medication (vasoactive drugs excluded); 4) hygiene procedure; 5) care of drain; 6) mobilisation and positioning; 7) support and care of relatives and patient; 8) administrative and managerial tasks; 9) respiratory support; 10) care of artificial airway; 11) treatment for improving lung function; 12) vasoactive medication; 13) intravenous replacement of large fluid loss; 14) left atrium monitoring; 15) cardiopulmonary resuscitation after arrest; 16) hemofiltration technique; 17) quantitative urine output measurement; 18) measurement of intracranial pressure; 19) treatment of complicated metabolic acidosis/alkalosis; 20) intravenous hyperalimentation; 21) enteral feeding; 22) specific interventions in the ICU (*e.g.* endotracheal intubation, pacemaker insertion, cardioversion); and 23) specific procedures outside the ICU (*e.g.* surgery, diagnostic procedures). These 23 categories are divided into subcategories.

The NAS scoring system allocates a score for each patient based on the nursing activity that was performed. The total NAS for each patient is the sum of the NAS points for all activities and ranges from 0 to 177. A total NAS score of 100 indicates the amount of care that can be provided by one full-time equivalent nurse, and a score >100 indicates the required care can only be given by more than one nurse [14, 18]. In this study, scores for each category and subcategory were calculated based on the patient's condition on the days of ICU admission and discharge. A previous study reported the NAS had acceptable internal consistency, with a Cronbach's alpha of 0.79 for the total scale [34].

2.3. Medication Error Occurrences

The occurrence of medication errors was measured using the Categorizing Medication Errors Index, which is used to identify the harm based on the taxonomy for medication errors and index for categorising medication errors. This tool was developed by the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) in 2001. An algorithm was created to facilitate the error-index categorisation. We used this tool for the present study because it provided guidance (*via* a series of questions) for assigning the proper error type to an event. The tool contains nine medication error classifications based on severity and patient safety measures: circumstances/events that have the capacity to cause error (category A); an error occurred but did not reach the patient (an 'error of omission' does reach the patient) (category B); an error occurred that reached the patient but did not cause patient harm (category C); an error occurred that reached the patient and required monitoring to confirm that it resulted in no harm to the patient or required intervention to preclude harm (category D); an error occurred that may have contributed to/resulted in temporary harm to the patient and required intervention (category E); an error occurred that may have contributed to/resulted in temporary harm to the patient and required initial or prolonged hospitalisation (category F); an error occurred that may have contributed to or resulted in permanent patient harm (category G); an error occurred that required intervention necessary to sustain life (category H); and an error occurred that may have contributed to/resulted in the patient's death (category I). These nine categories are divided into four classes: class I = near misses (category A); class II = error without harm (categories B, C and D); class III = error with harm (categories E, F, G and H); and class IV = error, death (category I) [35]. A previous study reported substantial agreement for this tool, with a Kappa score of 0.61 [35].

2.4. Readmission Rate

ICU departmental records were reviewed to identify patients who were readmitted to the ICU within the same hospitalisation period.

2.5. Data Collection Procedure

The primary researcher met the ICU heads of department and unit managers in the selected hospitals and explained the purpose of this study and was granted permission to access department records and patients' medical records. ICU admission and discharge records were reviewed to identify patients who were admitted to the ICU from February to April 2023 and determine which patients were readmitted to the ICU within the same hospitalisation period. Patients' electronic medical records were reviewed to obtain their demographic data and calculate their NAS based on the acuity level, comprehensive assessment, ongoing assessment tools, and healthcare providers' notes (nurses and physicians). The NAS was calculated for the days of ICU admission and discharge for each patient to identify the nursing workload on these two days and allow us to determine the correlation between the nursing workload and adverse events. Moreover, medication error occurrences were obtained from ICU nurses who were auditing for medication compliance in the department, with the error type and category recorded based on the NCC MERP. All data were entered into a Microsoft Excel document without including patients' identification details or medical record numbers.

2.6. Ethical Considerations

This study was approved by the research ethics committees at Sharjah University (REC-22-12-18-S) and the Ministry of Health and Prevention (MOHAP/DXB-REC/F.M.A/No. 46/2023). Administrative permission was obtained from the Emirates Health Services and ICU heads of departments in the selected hospitals before accessing patients' records. This study was completely anonymous. All collected data were coded and entered into a password-protected computer that only the research team could access.

2.7. Data Analysis

Data were analysed using SPSS version 26. Descriptive statistics (frequency and percentage or mean and standard deviation [SD]) were used to describe patients' sociodemographic characteristics. Descriptive statistics (mean and SD) were used to evaluate the nursing workload on ICU admission/discharge days and the prevalence of adverse events (ICU readmission and medication error occurrences). Independent-samples Mann-Whitney U tests and correlation coefficients were used to determine associations between nursing workload, clinical characteristics and adverse events.

3. RESULTS

3.1. Demographic Data and Clinical Characteristics

In total, 270 electronic medical records from February to April 2023 were reviewed for this study. The majority of patients were male (71.5%) and 28.5% were female. Patients' mean age was 54.13±16.60 years. Patients' clinical characteristics are shown in Table **1**. The most common reason for admission to the ICU was cardiovascular diseases (25.2%), including ST-segment elevation (8.1%), ischaemic heart disease (7%), post-cardiac arrest (6.7%) and non-ST-segment elevation (3.7%). The second most common reason for ICU admission was respiratory disorders (21.9%), including acute respiratory distress syndrome (12.6%), pulmonary oedema (5.2%) and chronic obstructive pulmonary disease (3.7%). Moreover, 15.6% of patients had neurological disorders, including stroke (7.4%), traumatic brain injury (6.3%) and seizure (2.2%). Other diagnoses such as gastrointestinal bleeding, meningioma and trauma cases accounted for 14.4% of patients. Around 12.2% of patients had medical disorders classified as sepsis (10%) and diabetic ketoacidosis (2.2%). Finally, 10.7% had nephrology disorders (end-stage renal disease: 9.3%, acute kidney injury: 1.5%).

Table 1. Patients' clinical characteristics (N=270).

Items	**n (%), Mean ± SD**
Diagnosis	**-**
Cardiovascular	**68 (25.2)**
Non-ST-segment elevation	10 (3.7)
ST-segment elevation	22 (8.1)
Post-cardiac arrest	18 (6.7)
Ischaemic heart disease	19 (7)
Neurology	**42 (15.6)**
Stroke	20 (7.4)
Traumatic brain injury	17 (6.3)
Seizure	6 (2.2)
Respiratory	**59 (21.9)**
Pulmonary oedema	14 (5.2)
ARDS	34 (12.6)
Chronic obstructive pulmonary disease	10 (3.7)

(Table 1) contd.....

Items	n (%), Mean ± SD
Nephrology disorders	**29 (10.7)**
Acute kidney injury	4 (1.5)
End-stage renal disease	25 (9.3)
Medical disorders	**33 (12.2)**
Sepsis	27 (10.0)
Diabetic ketoacidosis	6 (2.2)
Others	**39 (14.4)**
Type of ICU admission	
Inpatient ward	79 (29.3)
Emergency room	148 (54.8)
Operation room	33 (12.2)
Other institution	10 (3.7)
Isolation precautions (admission)	
Standard	242 (89.6)
Contact	12 (4.4)
Airborne	14 (5.2)
Reverse	2 (0.7)
Isolation precautions (discharge)	
Standard	225 (83.3)
Contact	41 (15.2)
Airborne	2 (0.7)
Reverse	2 (0.7)
Length of ICU stay, days	**14.66±11.47**
Mechanical ventilation	
Invasive	170 (63)
Non-invasive	46 (17)
Duration of mechanical ventilation (days)	**8.87±10.07**
Tracheostomy during ICU stay	
Discharge shift	**44 (16.3)**
Morning	171 (63.3)
Night	99 (36.7)

Abbreviation: ICU: intensive care unit.

Table 2. Prevalence of ICU readmission and medication error occurrences.

Items	n	%
ICU readmission within the same hospitalisation	**64**	**23.7**
Medication Error Occurrence	43	15.9
Type of Error		
Wrong order	23	8.5
Wrong time	14	5.2
Wrong documentation	6	2.2
Category of error		
A	13	4.8
B	26	9.6
C	4	1.5

Note: ICU: intensive care unit.

Error categories: A = circumstances/events that have the capacity to cause an error; B = an error occurred but the error did not reach the patient ("error of omission" does reach the patient); and C = an error occurred that reached the patient but did not cause the patient harm.

The largest group of patients (54.8%, n=148) were admitted to the ICU from the emergency room, followed by inpatient wards (29.3%, n=79), the operating room (12.2%, n=33) and transfer from other institutions (3.7%, n=10). The mean length of ICU stay was 14.66 ± 11.47 days. The majority (63%, n=170) of patients required intubation and were under invasive mechanical ventilation; however, 17% (n=46) were treated with non-invasive mechanical ventilators. The mean mechanical ventilator duration was 8.87 ± 10.07 days. Furthermore, 16.3% (n=44) of patients were tracheotomised during their ICU stay. Most patients were discharged from the ICU during the morning shift (63.3%, n=171), and 36.7% (n=99) were discharged during the night shift.

3.2. Nursing Workload on ICU Admission/Discharge Days

For each patient, the NAS was calculated based on the patient's condition on the days of ICU admission and discharge. The mean NAS was 72.61±14.80 on admission day and 52.61±15.38 on discharge day.

3.3. Prevalence of Adverse Events

Table **2** presents the prevalence of adverse events (*i.e*. ICU readmission and occurrence of medication errors). We found that 23.7% (n=64) of patients were readmitted to the ICU within the same hospitalisation period, and 15.9% (n=43) had experienced medication errors. The most frequent medication error was wrong order (8.5%), followed by wrong time (5.2%) and wrong documentation (2.2%). The most common error category was category B (9.6%, n=26), followed by categories A (4.8%) and C (1.5%).

3.4. Associations between the Nursing Workload (NAS) and Patients' Adverse Events and Clinical Characteristics

Independent-sample Mann-Whitney U tests were used to examine the relationships between adverse events and the nursing workload. There were significant associations (p=.000) between a patient's ICU readmission and the nursing workload on ICU admission and discharge days. Moreover, there was a significant association (p=.006) between the occurrence of medication errors and nursing workload on the day of ICU admission. Furthermore, while assessing the relationships between the occurrence of ICU readmission and patient outcomes, significant effects were observed for the patient's age, diagnosis, acuity score on the day of ICU discharge, isolation precautions on ICU admission and discharge days,

Table 3. Associations between patient demographics and clinical characteristics and adverse events.

Characteristics	Item	Adverse Events	
		ICU Readmission	Medication Error Occurrence
Patient demographics	Age	.000*	.449
	Gender	.303	.021*
Patient characteristics	Diagnosis	.001*	.929
	Acuity score (admission)	.507	.285
	Acuity score (discharge)	.000*	3.66
	NAS score (admission)	.000*	.006*
	NAS score (discharge)	.000*	.439
	Type of ICU admission	.471	.938
	Isolation precaution (admission)	.004*	.386
	Isolation precaution (discharge)	.002*	.850
	ICU length of stay	.000*	.805
	Mechanical ventilation	.031*	.334
	Duration of mechanical ventilation	.000*	.691
	Tracheostomy during ICU stay	.000*	.655
	Discharge shift	.294	.936

Note: ICU: intensive care unit; NAS: Nursing Activities Score. * Significant at P≤.05.

Table 4. Relationships between patients' demographics and clinical characteristics and the nursing workload.

Characteristics	Item	Workload [NAS score]	
		Admission	Discharge
Patient demographics	Age	.995	.000*
	Gender	.008*	.612
Patient characteristics	Diagnosis	.001*	.000*
	Acuity score (admission)	.000*	.000*
	Acuity score (discharge)	.007*	.000*
	Type of ICU admission	.111	.489
	Isolation precaution (admission)	.592	.105
	Isolation precaution (discharge)	.048*	.000*
	ICU length of stay	.000*	.000*
	Mechanical ventilation	.000*	.000*
	Duration of mechanical ventilation	.000*	.000*
	Tracheostomy during ICU stay	.000*	.000*
	Discharge shift	.565	.034*

Note: ICU: intensive care unit; NAS: Nursing Activities Score. * Significant at P≤.05.

length of ICU stay, mechanical ventilation, duration of mechanical ventilation and tracheostomy during ICU stay. However, there were no significant relationships between medication errors and patient outcomes. Table **3** details the associations between the patient demographics and clinical characteristics and adverse events.

Moreover, we observed significant associations between the nursing workload on the days of ICU admission and discharge and patient outcomes, including acuity score at admission and discharge, isolation precautions on ICU discharge day, mechanical ventilation and tracheostomy during ICU stay. There was also a significant relationship between the nursing workload on the day of ICU discharge and the discharge shift. We examined the correlation coefficients to identify correlations between the nursing workload on the ICU admission and discharge days and length of ICU stay and mechanical ventilation duration. There was a moderate positive relationship between the nursing workload on ICU admission and discharge days and length of ICU stay (r=.336 and r=.323 for admission and discharge days, respectively). In addition, there was a moderate positive relationship between the nursing workload on ICU admission and discharge days and the duration of mechanical ventilation (r=.381 and r=.373 for admission and discharge days, respectively) (Table **4**).

4. DISCUSSION

Nursing is a demanding profession, and excessive nursing workloads negatively influence patient outcomes. The present study clarified the relationships between the nursing workload on ICU admission and discharge days and adverse patient events (*i.e*. ICU readmission rate and occurrence of medication errors). We found that the nursing workload on ICU admission and discharge days was associated with the occurrence of medication errors and ICU readmission.

4.1. Nursing Workload on ICU Admission Day

The nursing workload on the day of ICU admission was high. This may be because most patients were admitted with cardiovascular diseases, respiratory disorders or neurology diseases with underlying co-morbidities, all of which required comprehensive medical therapy and intensive nursing care. Similar findings were reported in previous studies [10, 13] that found most patients in the ICU needed long-term special medical and nursing care, such as ventilation support, central line insertion, observing pump machines and drains and administering medications. In addition to direct care responsibilities, indirect care and administrative assignments for newly admitted patients impact the nursing workload [36, 37]. Furthermore, a nurse may spend 2–6.1 hours per shift donning and doffing personal protective equipment, especially in the isolation room, which further increases their workload [38].

The ICU admission process is essential in setting the stage for patient care. Developing comprehensive admission guidelines that encompass thorough patient handovers, meticulous assessments and preparedness for potential emergency interventions is crucial. Effective communication and collaboration among ICU nurses, physicians and bed management teams will facilitate a streamlined admission process, allowing for a smoother transition and comprehensive care from the moment a patient enters the ICU [39].

Nursing workload management is therefore a critical aspect of healthcare practice, particularly in the demanding field of critical care nursing. To ensure optimal patient outcomes, it is essential to establish patient assignment strategies that go beyond simple nurse-to-patient ratios. Healthcare facilities should adopt an approach that considers the severity of a patient's condition and the specific nursing activities required for each case. This personalised approach can significantly improve the allocation of nursing resources and ensure that patients receive an appropriate level of care. Furthermore, it is practical to use a validated tool such as the NAS to assess the nursing workload because it focuses on the time consumed for each nursing task (including direct and indirect care and clinical or administrative assignments). The NAS is used as a tool for arranging nurse-to-patient assignments in many different countries worldwide [11, 15, 40].

Moreover, establishing specialised units, such as geriatric departments that are dedicated to the unique needs of older patients, can ensure that healthcare providers are properly equipped to effectively address the challenges associated with chronic diseases and comorbidities. This approach will optimise patient outcomes and also promote a more holistic approach to healthcare delivery.

4.2. Nursing Workload on ICU Discharge Day

The majority of patients had high NAS scores on the day they were discharged from the ICU, which was consistent with previous findings [20, 21]. A possible reason for the high NAS at ICU discharge in our study may be that many patients were older and had a history of chronic conditions and comorbidities. A previous study [41] reported that patients who were discharged from the ICU with a high nursing workload included those who were bedridden or had a tracheostomy, chronic diseases and comorbidities. Moreover, the high workload on the day of ICU discharge may be explained by the number of responsibilities and tasks ICU nurses must complete before a patient is transferred to a ward, such as communicating with the bed management nurse to book a ward bed, follow-up for laboratory investigations and diagnostic procedures, preparing medication/documentation and handing over the patient to the transferred department. These tasks are time-consuming. It is important to note that if the nurse is also assigned to another patient, the completion of such tasks could affect patient safety and may compromise the quality of care [6, 16, 17].

4.3. Nursing Workload and Adverse Events

The present study highlighted that nurses had a high workload on the days of ICU admission and discharge, and thus we found significant differences between the workload on ICU admission/discharge days and ICU readmission. Similarly, previous studies reported that patients discharged from the ICU with a high nursing workload had a greater probability of being readmitted to the ICU within the same hospitalisation than patients without a high nursing workload [14, 21]. The explanations for the findings in our study were that most ICU readmissions were older patients (mean age of readmitted patients: 60.67 years), patients who required invasive mechanical ventilation and those that were tracheotomised during their ICU stay, which was consistent with previous findings [20, 21]. However, another study [42] reported respiratory failure and circulatory instability were two major causes of ICU readmission, which was inconsistent with our study. Other factors that may be associated with ICU readmission reported in a previous study were comorbidities, length of ICU stay, discharge time (morning shift/night shift) and patients' neurological function (including their Glasgow Coma Scale score) [41]. These findings suggested that to prevent ICU readmissions, healthcare facilities should undertake comprehensive risk assessments for patients who are at a high risk for readmission after discharge. Establishing specialised follow-up programmes for patients transferred to general wards or step-down units may also play a pivotal role in ensuring that patients' needs are adequately met, and that the possibility of premature discharge is minimised [21].

The present study found a significant association between the nursing workload on the day of ICU admission and medication errors. Previous studies reported similar findings [6, 19, 28, 29]. Category B medication errors were the most common errors, with wrong order being the most prevalent error, including the wrong route of administration, missing titration and maximum dose in the order itself, the wrong time and wrong documentation. This was consistent with a previous study [25] that reported wrong order was the common cause of medication errors. However, another study [28] identified the wrong time as a frequent error. This could be explained by patients' condition severity, possible procedures (*e.g.* central line insertion, intubation), the need to stabilise the patient and other indirect and administrative tasks. Poor communication, lack of knowledge, inexperience and fatigue were other commonly reported causes of medication errors [25].

These findings suggested that ICU nurses should be encouraged to adopt a double-check system for medication administration, which is consistent with the established '7 rights' of medication administration. Regularly reviewing and validating patients' medication charts can help identify errors and inconsistencies in orders, dosages, routes and other critical details. Furthermore, embracing technological solutions (*e.g.* automated dispensing cabinets and barcode medication administration systems) may substantially reduce the risk of medication errors and enhance patient safety [43]. Continuous education and training should be integral to nursing practice, especially in the context of patient safety and workload management. Addressing factors that contribute to medication errors, such as poor communication, lack of knowledge, inexperience and fatigue, could be achieved through targeted educational programmes and ongoing professional development opportunities.

In collaboration with healthcare policymakers, healthcare organisations should advocate for evidence-based staffing and workload policies that align with patient acuity and complexity. Conducting research to delve deeper into the intricate relationships between nursing workload and adverse events could inform policy decisions, and ultimately lead to improved patient outcomes and enhanced healthcare delivery. Finally, supporting the nursing workforce is paramount. Ensuring that nurses have access to regular breaks, mental health resources and opportunities for continuous professional development can help mitigate the impact of high workload on patient care and nurses' well-being. By adopting these recommendations, healthcare organisations can cultivate an environment that prioritises patient safety, nurse satisfaction and overall quality of care in critical care settings.

CONCLUSION

In summary, the nursing workload on ICU admission/discharge days is significantly associated with adverse events (*i.e.* ICU readmission and medication error occurrences). A practical strategy to reduce the nursing workload may be calculating the NAS for each patient to clarify the actual time spent by nurses to provide the required care based on the patient's condition, rather than depending on the nurse-to-patient ratio when assigning patients to nurses. Discharge of patients from the ICU demands careful attention to detail. Implementing standardised protocols that encompass effective communication with receiving units, thorough medication and documentation preparation and seamless patient handover can significantly enhance patient safety during the transition from the ICU to a ward. Allowing ICU nurses sufficient time to accomplish these duties before transferring a patient is critical to maintaining the quality of care for the discharged patient and other patients in the ICU. Moreover, the adoption of innovative technologies to improve medication safety and reduce errors could be another approach to help reduce the impact of high nurse workloads in ICU settings.

STRENGTHS AND LIMITATIONS OF THIS STUDY

This study had several strengths, including data collected from both day and night shifts in different ICU settings in three UAE hospitals. This may be the first UAE study to consider the nursing workload and its effects on patient outcomes, with a focus on two consequential issues: ICU readmission and medication errors. This study furthered our understanding of the effects of the nursing workload on ICU admission and discharge days on adverse events, patients' clinical outcomes, the quality of care and patient safety. However, there were some limitations that must be considered. First, this study was conducted in limited settings with a small sample size, meaning it is difficult to generalise our findings. Second, this was a retrospective study that may have an inherent bias. Third, the NAS was not routinely implemented in the study settings, and we calculated this score based on patients' acuity scores and nurses' chartings. Finally, information on patient care in the general wards after ICU discharge was lacking.

AUTHORS' CONTRIBUTION

o Muna Ibrahim Alhosani, Fatma Refaat Ahmed, Nabeel Al Yateem, Hassnaa Shaban Mubarak and Mohannad Eid AbuRuz were involved in the conceptualisation, methodology, software, validation, formal analysis, investigation, resources, data curation, writing (original draft), writing (review and editing), visualisation and project administration.

LIST OF ABBREVIATIONS

ICU	=	Intensive care unit
NAS	=	Nursing Activity Score
NCC MERP	=	National Coordinating Council for Medication Error Reporting and Prevention

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This Study was obtained from the Faculty of Nursing, Applied Science Private University and Research Ethical Committee, University of Sharjah.

HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committees and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Administrative permission was obtained from the Emirates Health Services and ICU heads of departments in the selected hospitals before accessing patients' records.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available with the corresponding author [M.I.A] upon request.

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This research received no funding.

CONFLICT OF INTEREST

The authors declare no conflicts of interest or personal relationships that could have appeared to influence the work reported in this paper.

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