




# Predictors of Early and Late Unplanned Intensive Care Unit Readmission: A Retrospective Cohort Study

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## Abstract

**Purpose:** Intensive care unit (ICU) readmission is considered one of the major quality indicators of critical care. Reducing ICU readmission can improve patients' outcomes and optimize health resources, but there are limited data on the predictors of unplanned ICU readmission. This study aimed to identify the risk factors associated with unplanned ICU readmission within 48 hr (early) and after 48 hr (late) from ICU discharge.

**Design:** Retrospective cohort study.

**Methods:** Data were collected from patients' electronic medical records in a 24-bed medical ICU at a tertiary academic medical center in Busan, South Korea. Among all the patients admitted to the medical ICU ( $n = 1,033$ ) between January 2015 and December 2017, 739 eligible patients were analyzed. A multivariable multinomial logistic regression model was conducted to identify predictors of ICU readmission.

**Findings:** Out of the 739 patients analyzed, 66 (8.9%) were readmitted to the medical ICU: 13 (1.8%) as early readmission and 53 (7.1%) as late readmission. Two significant predictors were identified for early readmission: ICU admission from the ward (odds ratio [OR] = 4.14; 95% confidence interval [CI] 1.25, 13.67) and mechanical ventilation support >14 days (OR = 13.25; 95% CI 1.78, 98.89). For late ICU admission, there were four risk factors: ICU admission from the ward (OR = 2.69; 95% CI 1.44, 5.05), tracheostomy placement (OR = 3.58; 95% CI 1.49, 8.59), mechanical ventilation support >14 days (OR = 4.77; 95% CI 1.67, 13.63), and continuous renal replacement therapy (OR = 4.57; 95% CI 2.42, 8.63).

**Conclusions:** To prevent unplanned ICU readmission in patients at high risk, it is necessary to investigate further the role of clinical judgment and communication within the ICU clinical team and institutional-level support regarding ICU readmission events.

**Clinical Relevance:** Both ICU nurses and nurses in post-ICU settings should be aware of the potential risk factors associated with early and late ICU readmission. Predictors and readmission strategies may be different for early and late readmissions. Prospective multicenter studies are needed to examine how these factors influence post-ICU outcomes.

Patients are usually transferred from intensive care units (ICUs) to step-down units, such as general wards, once they are able to breathe on their own and no longer need hemodynamic monitoring and close observation by the critical care team (Long & Mathews, 2018; Vincent, 2019). Timely discharge from ICU to

post-ICU care settings is essential for many reasons: reducing psychological and physical burden of patients and their caregivers, reducing medical costs, and optimizing healthcare resource allocation (Hirshberg et al., 2019; Ponzoni et al., 2017). However, unplanned ICU readmission can lead to exposure to hospital-acquired

infections, ICU-acquired weakness, and delirium due to extended length of stay in the ICU (Ohnuma, Shinjo, Brookhart, & Fushimi, 2018; Omar, Shirazy, Omar, & Chaari, 2020; Sauro, Soo, Quan, & Stelfox, 2020). Currently, unplanned ICU readmission rates range from 2% to 25.8% worldwide (Jang, Lee, Park, & Lee, 2019; Liu et al., 2017; Ohnuma et al., 2018). Compared with patients admitted to the ICU for the first time, most readmitted patients have poorer prognosis (Lin, Chen, Chao, & Lai, 2018; Rosa, Roehrig, de Oliveira, & Maccari, 2015), require more hands-on care from the medical team (Lin et al., 2018), and show higher in-hospital mortality and longer hospital stays (Lin et al., 2018; Ohnuma et al., 2018). Nevertheless, recent reviews showed that at least 10% of ICU readmissions are potentially preventable (Rojas et al., 2018; Vollam et al., 2018).

Previous studies have shown that older age, male gender, ICU admission diagnosis, admission source, and the Acute Physiology and Chronic Health Evaluation (APACHE) score are related to unplanned ICU readmission (Jang et al., 2019; Liu et al., 2017; Kang, 2016; Ohnuma et al., 2018). In addition, continuous renal replacement therapy (CRRT), mechanical ventilation, time of ICU discharge, length of ICU stay, and presence of tracheostomy are also associated with ICU readmission (Jeong et al., 2019; Jo et al., 2015; Ohnuma et al., 2018; Ponzoni et al., 2017). Unfortunately, identifying the risk factors associated with unplanned ICU readmission remains a significant challenge in critical care (Lin et al., 2018; Liu et al., 2017). Moreover, the main risk factors known to date have been mostly identified in Western studies, and there is no validated scoring system to predict readmission after ICU discharge (Desautels et al., 2017; Pedersen, Meyer, & Uhrenfeldt, 2017). The aforementioned studies suggest that the risk factors vary depending on the time elapsed between ICU discharge and readmission (Desautels et al., 2017; Jang et al., 2019; Lin et al., 2018). One potential explanation for this finding is the variability in the causes and timing of readmission. Only a few studies have determined predictors of unplanned ICU readmissions at different time periods following ICU discharge (Al-Jaghbeer, Tekwani, Gunn, & Kahn, 2016; Ponzoni et al., 2017). Further, there is little information about ICU survivors' illness trajectory during hospitalization.

Rates of ICU readmission within 48 hr have become a metric or a leading performance indicator of the quality of intensive care (Al-Jaghbeer et al., 2016; Desautels et al., 2017; Vollam et al., 2018). Moreover, prior studies have proposed that one way to gauge ICU quality of care is to examine ICU readmission

rates within 48 hr of initial ICU discharge (Brown, Ratcliffe, & Halpern, 2013; van Sluisveld, Bakhshi-Raiez, et al., 2017). The purpose of this study was to provide data necessary to refine strategies to prevent early and late ICU readmissions. Advantages of using a retrospective cohort study are its ability to investigate rare exposures and their causality (Song & Chung, 2010). Therefore, a retrospective cohort study was conducted that aimed to (a) describe ICU readmission rates and patient characteristics according to early (within 48 hr post-ICU discharge) and late (after 48 hr post-ICU discharge) readmission and (b) identify risk factors associated with early and late unplanned ICU readmission.

## Methods

### Study Design, Setting, and Study Population

This retrospective observational cohort study was conducted in a 24-bed medical ICU at a 989-bed tertiary academic hospital in Busan, South Korea. The study population consisted of adult patients (18 years of age or older) consecutively admitted to the medical ICU (MICU) between January 1, 2015, and December 31, 2017. The exclusion criteria were as follows: (a) patients who died during index hospitalization, (b) patients who were transferred to general wards within 2 days, (c) patients who were transferred to the general ward for palliative care measures only, and (d) patients who were admitted to the MICU for short-term observation (postoperative or postprocedural monitoring). Figure S1 shows the patient flow chart describing the process of sample selection.

### Data Collection and Study Variables

A protocol for data extraction from the medical records was developed prior to performing any data collection. Strategies underpinning the protocol comprised the following: (a) a checklist form reviewed by the principal investigator; (b) the use of a coding book guiding data collection of specific variables from the medical records, such as admission diagnosis and reason for readmission; and (c) selection, training, management, and ongoing communication with research assistants.

The components of the checklist were developed based on a literature review (Jo et al. 2015; Kang, 2016; Liu et al., 2017; Ohnuma et al., 2018; Ponzoni et al., 2017). As experts, an MICU nurse manager and a nursing professor reviewed and confirmed the final checklist together with the primary investigator and a coding book with description of detailed steps. The two experts

and the primary investigator had experience in retrospective data collection from medical records and research experience relevant to the study being conducted.

Subsequently, data were collected from the electronic medical records system using the structured checklist with a coding book. Under the supervision of the principal investigator, three research assistants with at least 5 years of clinical experience in the MICU and sufficient research experience to understand their task performed data collection after completing 8 hr of training on extracting clinical information from electronic medical records using a checklist form. Three research assistants were in charge of the protection of health information. In addition, all research assistants were trained on how to manage missing and conflicting data found in the medical records.

The variables in the checklist were as follows: readmission rates, demographics (age and gender), ICU admission information (e.g., ICU admission diagnosis, source of ICU admission, and APACHE II score at discharge), therapeutic characteristics (presence of tracheostomy, mechanical ventilation, and CRRT use during ICU stay), ICU discharge characteristics (time of ICU transfer [daytime vs. nighttime] and length of ICU stay), and readmission characteristics (admission diagnosis, reason for readmission, and APACHE II score at readmission). The APACHE II score was obtained for both ICU admission and readmission as a measure of severity of illness because this score is used to predict mortality at ICU admission, which may also be relevant to assess the risk of readmission (Naved, Siddiqui, & Kahn, 2011).

Readmission was defined as admitting a patient to the same ICU after discharge to a general ward during the same hospitalization. Only the first medical ICU readmission was included in this analysis. To define early vs. late readmission, a time frame of 48 hr was chosen, as readmission within 48 hr post-ICU discharge is a major indicator of care quality (Brown, Ratcliffe, Kahn, & Halpern, 2012).

## Ethical Considerations

This study was approved by the institutional review board (IRB approval number 18-0181). This study adhered to the Declaration of Helsinki, including compliance with ethical principles (General Assembly of the World Medical Association, 2014) throughout the research process and approval of appropriate ethics committees. The requirement for informed consent was waived by the IRB, as this was a retrospective study. Anonymity and data confidentiality were maintained in the process of accessing records, encrypting data, and archiving information.

## Data Analysis

Data were analyzed using IBM SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous data were presented as mean and standard deviation (*SD*), and categorical data were presented as number (percentage). The no readmission, early readmission, and late readmission groups were compared using  $X^2$ , independent *t* test, and one-way analysis of variance. Multinomial logistic regression with the forward variable selection method was conducted to identify the risk factors of early and late readmission. Odds ratios (*ORs*) were estimated along with 95% confidence intervals (*CI*s). A *p* value of .05 or less was considered statistically significant.

## Results

### Baseline Patient Characteristics

A total of 1,033 patients were admitted to the MICU during the study period. After exclusion of 294 patients based on the exclusion criteria, a total of 739 patients were included in the final analysis (see Figure S1). Out of 739 patients, 66 (8.9%) were readmitted to the ICU during the same hospitalization. Among these readmitted patients, 13 (19.7%) were readmitted within 48 hr (early readmission) and 53 (80.3%) were readmitted after 48 hr (late readmission).

Table S1 shows the patients' characteristics. The mean age (*SD*) was 67.71 (13.41) years, and most patients were male ( $n = 416$ , 56.3%). Cardiovascular ( $n = 267$ , 36.1%) and respiratory ( $n = 222$ , 30.0%) conditions accounted for most ICU admission diagnoses. Regarding the source of ICU admission, 501 patients (67.8%) were admitted via the emergency department (ED). The mean APACHE II score was 15.76 (7.12). Moreover, 305 patients (41.3%) required mechanical ventilation during their first MICU admission. Tracheostomy placement was performed in 58 patients (7.8%). CRRT was used in 133 patients (18.0%). Mean ICU length of stay at first discharge was 9.01 (5.72) days, and most patients ( $n = 664$ , 89.9%) were discharged during the daytime.

### Patient Characteristics and Readmission Status

There were significant differences in the source of ICU admission ( $p = .001$ ), tracheostomy ( $p < .001$ ), mechanical ventilation ( $p < .001$ ), and CRRT ( $p < .001$ ) according to the readmission status (Table S2). However, there were no significant differences in age, gender, admission diagnosis, APACHE II score, time

of ICU discharge, or length of ICU stay between the early readmission, late readmission, and no readmission groups.

### Causes of Readmission in Early and Late Readmission Groups

As shown in Table S3, there were significant differences in the reason for readmission between the early and late readmission groups ( $X^2 = 5.359$ ,  $p = .029$ ). Aggravation of first admission was reported by 11 patients (84.6%) in the early readmission group and 26 (49.1%) in the late readmission group. However, there was no significant difference in readmission diagnosis or APACHE II scores between the two groups.

### Predictors of Unplanned Early and Late ICU Readmission

Multivariable multinomial logistic regression analysis revealed the risk factors associated with early and late unplanned readmission to the ICU (Table S4). Risk factors for early readmission to ICU were source of ICU admission ( $OR = 4.14$ ; 95% CI 1.25, 13.67) and mechanical ventilator use for more than 14 days ( $OR = 13.25$ ; 95% CI 1.78, 98.89). In terms of late ICU readmission, source of ICU admission ( $OR = 2.69$ ; 95% CI 1.44, 5.05), tracheostomy at ICU ( $OR = 3.58$ ; 95% CI 1.49, 8.59), mechanical ventilator use for more than 14 days ( $OR = 4.77$ ; 95% CI 1.67, 13.63), and CRRT ( $OR = 4.57$ ; 95% CI 2.42, 8.63) were statistically significant predictors.

### Discussion

This retrospective cohort study examined the predictors of ICU readmission to an MICU of a tertiary academic medical center in a metropolitan city of South Korea over 3 years (2015–2017). In this analysis, out of 739 ICU discharge cases, readmission predictors were identified according to two time frames: early ( $\leq 48$  hr post-ICU discharge) and late ( $> 48$  hr post-ICU discharge) readmission. While varying timelines and definitions were used for ICU readmission in previous studies (Elliott, Worrall-Carter, & Page, 2014; Pedersen et al., 2017; Ponzoni et al., 2017), 48 hr was chosen as a cut-off point for early readmission because readmissions within this time frame are known to be associated with ICU interventions and discharge practices (Brown et al., 2012). The ICU readmission rate reported in the present study was 8.9%, which was within the range of 2.5% to 10% reported in previous studies

(Jo et al., 2015; Kareliusson, Geer, & Tibblin, 2015; Kramer, Higgins, & Zimmerman, 2012; Liu et al., 2017).

In the results, two characteristics related to initial ICU admission were associated with both early and late readmission: admission from ward and mechanical ventilation support for more than 14 days. Use of CRRT and tracheostomy placement during initial ICU admission were significant predictors of late readmission. Except for ward admission, these predictors were consistent with the characteristics of chronic critical illness: ICU stay longer than 8 days and one of five clinical conditions, namely mechanical ventilation for at least 96 hr in a single episode of ICU admission; tracheostomy; sepsis and other severe infections with multiple organ failure; ischemic stroke; intracerebral hemorrhage; or traumatic brain injury (Kahn et al., 2015). Considering that anticipated prolonged mechanical ventilation support is one of the most common indicators of tracheostomy placement, the results corroborate previous research identifying prolonged mechanical ventilation support, tracheostomy, and CRRT as major characteristics of unplanned early ICU readmissions after critical illness (Hua, Gong, Brady, & Wunsch, 2015; Pedersen et al., 2017; Rojas et al., 2018). Some studies have reported that providing oral nutrition supplements reduced the risk of ICU or hospital readmissions (Sharma et al., 2018; Stratton, Hébuterne, & Elia, 2013). Thus, it is helpful to assess the nutritional risk for patients who require mechanical support, tracheostomy, and CRRT. Additionally, initial ICU admission from general wards was significantly associated with both early and late readmissions compared with admissions from the ED. This is consistent with previous studies in Korea and other countries (Brown et al., 2012; Jo et al., 2015; Ponzoni et al., 2017). In research on post-ICU discharge risk stratification tools, non-ED admissions showed higher risk scores (Frost et al., 2010; Gajic et al., 2008). This might be due to differences in resources between care settings when detecting and responding to rapidly changing patients' conditions. That is, patients admitted through the ED might have been under closer monitoring and faster decision making than those transferred from general wards. This finding suggests that institution-level efforts to reduce such practice gaps between the ED and general wards are necessary.

In the present study, other known predictors such as age, APACHE II score, and time of ICU discharge (Elliott et al., 2014) were not significantly associated with ICU readmission. This contradicts the association reported by Wong, Parker, Leung, Brigham, and Arbaje (2016) between ICU readmission and higher APACHE II score (or other severity screening tools) during the

same hospitalization in adult patients. With regard to age, the mean age of patients in this study was relatively younger and with a wider range than in previous studies (Lin et al., 2018; Ponzoni et al., 2016), which suggests cautious interpretation when comparing results among multiple studies. Further, such inconsistencies may indicate that potential limitations in the function of severity screening tools in predicting ICU readmission need further investigation. As addressed by Wong et al. (2016) as a limitation to their review, the potential confounding effects of institutional- or individual ICU-level factors have not yet been fully understood.

Unplanned ICU readmission has been recognized as one of the major quality indicators of critical care (Kramer et al., 2012). Despite attention paid to this problem for decades, not much progress has been made in identifying associated mechanisms that could guide practical solutions (Morgan et al., 2020). In the results, none of the major predictors of early or late ICU readmission were deemed modifiable or preventable. Corroborating the results, in a study by Al-Jaghbeer et al. (2016) that evaluated 136 consecutive readmission cases by two independent investigators, 88.2% of readmission cases were considered nonpreventable, but almost half of these nonpreventable admissions were due to existing clinical problems.

## Implications for Research and Clinical Practice

Findings of the present study have several implications for advancing knowledge and clinical practice in nursing. First, refining current screening tools is necessary to better predict and respond to ICU readmission. While it is still important to continue striving to identify modifiable risks using innovative analytic approaches (Barbieri et al., 2020; Rojas et al., 2018), the findings also suggest that the field demands new approaches to better understand the mechanisms surrounding ICU readmission that can have direct implications for daily nursing practice. Second, both education and research need to expand their target to include multidisciplinary clinician teams across various settings. There may be an interplay of clinical judgment and communication between the ICU clinical team and the institutional level in the process of ICU discharge or readmission (van Sluisveld, Bakhshi-Raiez, et al., 2017; van Sluisveld, Oerlemans, et al., 2017), and the role of these potential contextual factors needs further elucidation. Finally, as for clinical practice, nurses need to be further engaged in the decision-making process regarding patients' transition to post-ICU settings. Nurses can contribute to

preventing ICU readmission with early assessments of modifiable risk factors before patients' ICU discharge.

## Limitations

This study had several limitations. First, it was conducted in an MICU in a single tertiary academic medical center; thus, the generalizability of the findings is limited. Second, the proportion of readmission cases was small compared with international data. Multicenter studies with a larger sample will provide opportunities to identify institution-level variabilities. Moreover, in future studies, it is necessary to include detailed patient information such as laboratory data, trends of vital signs, and delirium during both ICU discharge and early post-ICU discharge periods. Third, the checklist used for data extraction was a new tool. It would have been helpful if the checklist had contained additional factors that may contribute to readmission (e.g., type of respiratory issues observed, pre-existing or newly developed comorbid conditions). Fourth, this was a retrospective cohort study, and the influence of unknown confounding factors cannot be disregarded. Finally, early ICU readmissions were defined as those occurring within 48 hr post-ICU discharge. Nonetheless, there is no consensus regarding a time frame properly defining an ICU readmission as early or late; therefore, the time definition of ICU readmission can vary notably.

## Conclusions

Readmissions to the ICU are multifactorial events, but at least one out of 10 ICU readmission cases are known to be potentially preventable. To enhance safety and outcomes after critical illness, healthcare providers must be aware of the main risk factors of ICU readmission while planning discharge to post-ICU settings. Research needs to identify how best to articulate modifiable risk factors and deliver care to reduce the risk of readmission in patients who are at high risk. Furthermore, the degree to which ICU readmissions are preventable, as well as their main causes, need to be further investigated.

### Clinical Resources

- American Association of Critical-Care Nurses. Continuing education activities. <https://www.aacn.org/education/>
- Critical Care Societies Collaborative. Transition to practice. <https://ccsconline.org/optimizing-the-workforce/transition-to-practice>

- European Federation of Critical Care Nursing Associations. Clinical practice. <https://www.efccna.org/clinical-practice/info-clinical-practice>
- Society of Critical Care Medicine. Critical connections archives. <https://www.sccm.org/Communications/Critical-Connections/Archives>

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## Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Supplementary Material