

Predictors of successful discharge from intensive care units in older adults aged 80 years or older: A population-based study



Pei-Yi Wang^{a,b}, Naomi Takemura^c, Xinyi Xu^c, Denise Shuk Ting Cheung^c,
Chia-Chin Lin^{a,c,d,*}

^a School of Nursing, College of Nursing, Taipei Medical University, Taipei, Taiwan

^b Department of Nursing, National Cheng Kung University Hospital, Tainan, Taiwan

^c School of Nursing, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong

^d Alice Ho Miu Ling Nethersole Charity Foundation Professor in Nursing, Hong Kong

ARTICLE INFO

Article history:

Received 3 January 2019

Received in revised form 27 March 2019

Accepted 13 April 2019

Keywords:

Aged
Critical care
Intensive care
Octogenarians
Oldest old
80 and over

ABSTRACT

Background: We determined the long-term outcomes of adult intensive care unit (ICU) patients and investigated the predictors of successful discharge for ≥ 6 months among older adults aged ≥ 80 years in Taiwan.

Objectives: To identify the predictors of ICU admission in patients aged ≥ 80 years and the predictors of and optimal cutoff predictive discharge score (PDS) for ICU successful discharge in patients aged ≥ 80 years.

Design: A population-based retrospective cohort study.

Settings and participants: Medical records of 282,269 individuals aged ≥ 80 years collected from the Taiwan National Health Insurance Research Database from 2001 to 2013.

Methods: Demographic and clinical parameters, Charlson's comorbidity index (CCI), hospital type, and post-discharge outcomes of ICU patients aged ≥ 80 years were obtained from their medical records. Multivariable logistic regression was used to analyze and identify the predictors of successful discharge and treatments received by critically ill patients aged ≥ 80 years admitted to the ICU. The optimal cutoff PDS for successful discharge in older adults were calculated by Youden Index.

Results 65,756 ICU admissions were documented, of which 21% ($n = 13,825$) were for adults aged ≥ 80 years. The successful discharge rate among ICU patients aged ≥ 80 years (57.2%) was significantly lower than that among those aged 18–64 and 65–79 years (81.7% and 71.5%, respectively). Multivariable logistic regression analyses revealed the following predictors of successful discharge for ≥ 6 months after ICU admission in adults aged ≥ 80 years: younger age (adjusted odds ratio [OR] = 0.95, 95% confidence interval [CI] = 0.94–0.96), shorter ICU length of stay (adjusted OR = 0.90, 95% CI = 0.88–0.92), lower CCI (adjusted OR = 0.92, 95% CI = 0.90–0.93), and no life-sustaining treatments received (Cardiopulmonary resuscitation: adjusted OR = 0.75, 95% CI = 0.68–0.84; mechanical ventilation: adjusted OR = 0.63, 95% CI = 0.57–0.71; use of inotropic agents: adjusted OR = 0.37, 95% CI = 0.34–0.41). The optimal cutoff PDS in older adults was 6 (area under the receiver operating characteristic curve = 0.73, 95% CI = 0.72–0.74).

Conclusion: This is the first population-based study investigating the post-discharge outcomes of ICU patients aged ≥ 80 years. Advanced age was a predictive factor of unsuccessful discharge from the ICU. Nevertheless, more than half of this vulnerable population survived for at least 6 months after discharge. Therefore, age should not be the sole criterion when considering ICU admission and deciding curative treatments for critically ill older adults. Comprehensive assessment and effective communication with patients and their families are also crucial in clinical decision-making for critically ill older adults.

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* Corresponding author at: School of Nursing, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Pokfulam, Hong Kong.
E-mail address: cclin@hku.hk (C.-C. Lin).

What is already known about the topic?

- ICU admission rate is increasing among the growing very old population.
- Clinical evidence indicates that critical care physicians are reluctant to admit older patients because of their poor perceived outcomes.
- No consensus has been reached regarding whether age should be the predictor of successful discharge in ICU patients aged ≥ 80 years.

What this paper adds

- Multiple factors (e.g., younger age, shorter ICU length of stay, lower Charlson comorbidity index, and no life-sustaining treatments received) predict successful discharge in older ICU patients. Age should not be the sole criterion when considering ICU admission and deciding curative treatments in critically ill patients aged ≥ 80 years.
- Given the long-term effects of ICU stay, multifaceted evaluation and comprehensive medical assessment should be conducted when considering the admission of very old patients.

1. Introduction

Globally, among the older population, the proportion of people aged ≥ 80 years is increasing faster than that of those aged < 80 years (United Nations, 2017) and the proportion of people aged ≥ 80 years is estimated to triple from 962 million in 2017 to 2.1 billion in 2050. Moreover, life expectancy has nearly doubled in the past 100 years (United Nations, 2018). Despite promising longevity, advanced age is associated with more comorbidities and greater frailty, resulting in poorer quality of life and a higher hospitalization rate among very old individuals (Docherty et al., 2016).

Similar to the admission rate for many other medical units, the intensive care unit (ICU) admission rate is increasing; the rate for adults aged ≥ 80 years increases by 5.6% per year according to the Australian and New Zealand Intensive Care Society Adult Patient Database (Bagshaw et al., 2009; Boumendil and Guidet, 2006). However, studies in developed countries have suggested that ICU admission may fail to improve or may even worsen the quality of life and survival of critically ill elderly patients (Boumendil et al., 2011; Docherty et al., 2016; Heyland et al., 2015). Critically ill adults aged ≥ 80 years have higher hospital and long-term mortality rates than those aged 65–79 years; however, they have shorter ICU length of stay (LOS) and lower treatment intensity (Boumendil et al., 2005; Docherty et al., 2016). In addition, two-thirds of older ICU survivors continue to experience post-critical illness disability after discharge (Brummel et al., 2015). Therefore, improving clinical decision-making for ICU admission in this age group is critical to more effectively allocate healthcare resources and enhance quality of care.

Clinical decision-making in the ICU setting is complicated and challenging. Most critically ill adults aged ≥ 80 years receive life-sustaining treatments in the ICU; however, 70% of these patients prefer palliative care to aggressive interventions (Somogyi-Zalud et al., 2002). Emergency and critical-care physicians are reluctant to consider ICU admission for this population because of their frailty and poor perceived outcomes, and nonreferral is strongly associated with age (Garroute-Orgeas et al., 2009). Although some studies have reported that ICU interventions have no benefit for very old patients (Boumendil et al., 2011; Garroute-Orgeas et al., 2006), other studies have suggested that age should not be the criterion for clinical decision-making for ICU admission

(Boumendil et al., 2005; Chelluri et al., 1992). Well-selected old patients have favorable short-term prognoses and long-term outcomes after discharge from the ICU (Boumendil et al., 2005). Studies have reported that 42% of very old ICU patients survived for at least 1 year after discharge and that 26% achieved physical recovery with high quality of life (Andersen et al., 2015; Heyland et al., 2015).

No large-scale study has determined the long-term outcomes of older ICU patients. Furthermore, no consensus has been reached regarding whether age should be the predictor of successful discharge in ICU patients aged ≥ 80 years. This population-based study attempted to fill this research gap by analyzing data from the Taiwan National Health Insurance (NHI) Research Database (NHIRD).

In this study, we measured the ICU admission and successful discharge rates in three age groups (18–64, 65–79, and ≥ 80 years), identified the predictors of ICU admission in patients aged ≥ 80 years, and identified the predictors of and optimal cutoff predictive discharge score (PDS) for ICU successful discharge in patients aged ≥ 80 years.

2. Methods

2.1. Study population

The medical record of each patient was extracted from the Taiwan NHIRD, a comprehensive and reliable research database, containing the electronic medical records of all insurant (comprising 99.77% of Taiwan residents) in the NHI program since its launch in 1995 (National Health Insurance Administration, 2017). The disease diagnoses recorded in the NHIRD have been validated and are highly accurate (Cheng et al., 2011). In this retrospective cohort study, the study population was derived from a random sample of all insurants in the NHIRD from 2001 to 2013. These data, from 2001 to 2013, are the most recent data available to researchers. The disease characteristics described in this study are similar to those reported in Taiwan by (Tu et al., 2018). The profile of very old patients (aged ≥ 80 years), including mean age, sex, ICU admission diagnosis, and mean ICU LOS, in our study is also comparable to that in a recent transnational study that was conducted from 2016 to 2017 and involved 311 ICUs from 21 European countries (Flaatten et al., 2017). In the present study, the inclusion criteria were age of at least 18 years ($n = 7,840,997$) and charged ICU room and board fees ($n = 65,756$). Medical treatment records during hospitalization were screened to identify patients eligible for this study. Patients with incomplete information were excluded. Data on demographic characteristics (including sex, age, and prior LOS within the past year) and disease characteristics (including Charlson comorbidity index [CCI], ICU LOS, primary hospitalization diagnosis, and life-sustaining treatments received) of elderly individuals aged ≥ 80 years admitted to the ICU ($n = 13,825$) were collected and analyzed. Ethical approval of this study was exempted due to the nature of the study.

2.2. Statistical analysis

Categorical variables are expressed as numbers and percentages, whereas continuous variables are expressed as means and standard deviations. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were computed. The normality of data was assessed using the Kolmogorov–Smirnov test; variance in the potential predictors of successful discharge among ICU patients aged ≥ 80 years was subsequently evaluated using the chi-square and Mann–Whitney U tests. Multivariable logistic regression was used to identify the predictors of successful discharge and treatments received by critically ill patients aged

≥80 years admitted to the ICU. In this study, reference categories were selected on the basis of disease prevalence. The most common and challenging diagnoses in the ICUs in well-developed countries are severe sepsis and septic shock, associated with significant morbidity and mortality (Angus et al., 2001; Gonçalves-Pereira et al., 2014). Hence, infectious disease was selected as the reference category. The Hosmer–Lemeshow goodness-of-fit test was adopted to adjust the risk prediction in each year, and the results are presented in adjusted odds ratio (OR) and 95% confidence interval (CI).

The PDS was calculated for each potential predictor of successful ICU discharge among elderly adults aged ≥80 years. Variances in variables, including sex, age, CCI, and hospital location and accreditation, were analyzed using multiple logistic regression. Beta (β) coefficients, calculated using multiple logistic regression, indicate the point score for each variance (see Supplementary 2). For instance, if the patient did not receive cardiopulmonary resuscitation (CPR), mechanical ventilation, vasopressors, or hemolysis, the patient was scored 0; if the patient received any of the aforementioned treatments, the patient was scored 1. The PDS is the sum of the score for each variance, and a lower PDS indicates a higher possibility of successful discharge from the ICU (Sullivan et al., 2004).

The area under the receiver operating characteristic (ROC) curve (AUC) was used to calculate the discrimination ability of the PDS for predicting successful discharge in adults aged ≥80 years. The AUC ranged from 0 to 1; a higher AUC indicated higher discrimination ability. The discrimination ability was interpreted as acceptable, high, and excellent when the AUC was 0.7–0.8, 0.8–0.9, and 0.9–1.0, respectively. Youden's index, calculated using the formula of (sensitivity + specificity – 1), was used to predict the cutoff PDS for predicting successful discharge among critically ill patients aged ≥80 years. The value ranged from 0 to 1, and the value closest to 1 denoted the highest sensitivity and specificity (Fluss et al., 2005; Hart, 2016). All statistical analyses were performed using SAS (version 9.4; SAS Inc., Cary, NC, USA), and $p < .05$ was considered significant.

2.3. Variable definitions

2.3.1. ICU admission rate

The ICU admission rate was defined as the ratio of patients charged ICU room and board fees during the first hospitalization in a calendar year to the total number of hospitalized patients in that year. Being charged ICU room and board fees indicated that the individual received medical treatment in the ICU.

2.3.2. Successful discharge

ICU patients who survived for 6 months or more after discharge from the hospital were considered to be successfully discharged (Conti et al., 2011).

2.3.3. Prior LOS

Prior LOS was defined as the total length of hospital stay in the 365 days prior to the admission date of the patient's first hospitalization of the year.

2.3.4. CCI

The CCI, also known as Charlson–Deyo comorbidity index, was calculated from comorbidities identified using International Classification of Diseases, Ninth Edition (ICD-9) codes in the primary and secondary diagnosis records for all inpatient and outpatient visits 1–12 months before ICU admission (Wu et al., 2010). The revised CCI based on the hazard ratios of individual comorbidities for mortality was used (Deyo et al., 1992; Quan et al., 2011).

2.3.5. Hospital characteristics

Hospital characteristics, including hospital location and accreditation, were recorded. Hospital location was divided into urban, suburban, and rural based on the development stratification of the Taiwan township (Liu et al., 2006). According to accreditation, hospitals were classified into academic medical centers, metropolitan hospitals, or local community hospitals.

3. Results

From 2001 to 2013, 282,269 patients aged ≥80 years were identified from the NHIRD, accounting for 3.6% of all patients aged ≥18 years ($n = 7,840,997$). Of the included 282,269 elderly individuals, 30.1% ($n = 85,032$) received inpatient services, and 16.3% of inpatient admissions ($n = 13,825$) were ICU admissions (Supplementary 1). At ICU admittance, among adults aged ≥80 years, the mean age was 85.1 years, and 51.8% were men (Table 1).

3.1. ICU admission and successful discharge rates

In total, 65,756 patients were admitted to the ICU; of them, 29,780, 22,151, and 13,825 were aged 18–64, 65–79, and ≥80 years, respectively, and had ICU admission rates of 0.46%, 2.09%, and 4.90%, respectively (Supplementary 1). Of the 13,825 ICU patients aged ≥80 years, 7,905 (57.2%) were successfully discharged from the hospital. The successful discharge rate among ICU patients aged ≥80 (57.2%) was significantly lower than that in adults aged 18–64 and 65–79 years (81.7% and 71.5%, respectively; $p < .0001$; Fig. 1).

3.2. Predictors of ICU admission in older adults

Multivariable logistic regression analyses revealed the following predictors of ICU admission in adults aged ≥80 years: high CCI, infectious disease as the primary diagnosis, and treatment in an urban or local community hospital (Table 1). With a 1-year increase in age, the risk of ICU admission increased by 2% (adjusted OR = 1.02, 95% CI = 1.02–1.03). With every 1-point increase in CCI, the risk of ICU admission increased by 5% (adjusted OR = 1.05, 95% CI = 1.04–1.06). The risk of ICU admission in critically ill patients

Table 1
Predictors of ICU admission among elderly individuals aged ≥80 years ($N = 85,023$).

Variable	ICU Admission ($n = 13,825$) n (%)	Multivariable	
		Adjusted OR (95% CI)	p
Sex			
Male	7,162 (8.4)	Ref	
Female	6,663 (7.8)	1.04 (1.00–1.08)	.09
Age (mean ± SD)	85.10 ± 4.10	1.02 (1.02–1.03)	<.0001
CCI ¹ (mean ± SD)	1.55 ± 1.99	1.05 (1.04–1.06)	<.0001
Last-year LOS (mean ± SD)	8.50 ± 28.53	1.00 (1.00–1.00)	.27
Main Diagnosis			
Circulation system diseases	4,155 (4.9)	0.93 (0.86–1.01)	.09
Respiratory system diseases	3,763 (4.4)	0.67 (0.62–0.73)	<.0001
Digestive system diseases	1,230 (1.4)	0.34 (0.31–0.38)	<.0001
Injury or poison	1,277 (1.5)	0.40 (0.36–0.44)	<.0001
Infection disease	1,111 (1.3)	Ref	Ref
Others	2,289 (2.7)	0.22 (0.20–0.24)	<.0001
Hospital type			
Academic medical centers	3,809 (4.5)	1.32 (1.24–1.41)	<.0001
Metropolitan hospitals	7,196 (8.5)	1.68 (1.59–1.77)	<.0001
Local community hospitals	2,820 (3.3)	Ref	Ref
Urbanization			
Urban	10,477 (12.3)	1.15 (1.01–1.31)	.03
Suburban	2,779 (3.3)	1.13 (0.99–1.28)	.07
Rural	3,348 (3.9)	Ref	Ref

SD: Standard deviation; OR: odds ratio; CI: confidence interval, CCI¹: Charlson comorbidity index modified by Quan; LOS: length of stay; ICU: intensive care unit.

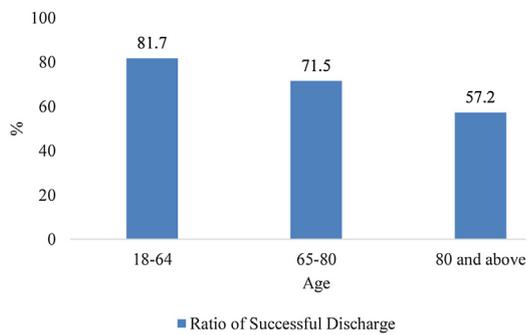


Fig. 1. Comparison of the ratios of successful ICU discharge in three age groups.

was higher in academic medical centers (adjusted OR = 1.32, 95% CI = 1.24–1.41) and metropolitan hospitals (adjusted OR = 1.68, 95% CI = 1.59–1.77) than in local community hospitals. The risk was also higher in hospitals in urban areas (adjusted OR = 1.15, 95% CI = 1.01–1.31) than in hospitals in rural areas.

3.3. Predictors of successful discharge

The predictors of successful discharge for ≥ 6 months were younger age, shorter ICU LOS, lower CCI, and no life-sustaining treatments received (Table 2). With a 1-year increase in age, the chance of successful discharge for at least 6 months decreased by 5% (adjusted OR = 0.95, 95% CI = 0.94–0.96); with a 1-day increase in ICU LOS, the probability decreased by 10% (adjusted OR = 0.90, 95% CI = 0.88–0.92). A higher CCI score reflected a lower probability of successful discharge (adjusted OR = 0.92, 95% CI = 0.90–0.93). The probability was also lower in ICU patients who received CPR (adjusted OR = 0.75, 95% CI = 0.68–0.84), mechanical ventilation (adjusted OR = 0.63, 95% CI = 0.57–0.71), vasopressors (adjusted

OR = 0.37, 95% CI = 0.34–0.41), or dialysis (adjusted OR = 0.26, 95% CI = 0.16–0.44).

3.4. Cutoff PDS

Supplementary 3 illustrates the ROC curve predicting successful discharge for ≥ 6 months among critically ill patients aged ≥ 80 years. The AUC (which indicated the discrimination ability) of the PDS was 0.73 (95% CI = 0.72–0.74). The optimal cutoff PDS to determine successful ICU discharge in patients aged ≥ 80 years was 6 (sensitivity = 0.70, specificity = 0.59, Youden's index = 0.30; Table 3).

4. Discussion

During the study period, 2001–2013, 4.9% of 282,269 patients aged ≥ 80 years received ICU care. This ICU admission rate is lower than that in previous studies. Research in Australia and New Zealand has shown that 13% of octogenarians would receive ICU care, and the ICU admission rate has been estimated to increase by 5.6% annually (Bagshaw et al., 2009). Some studies have reported ICU admission rates of 7.9%–9.3% in adults aged >80 years (Al-Dorzi et al., 2014; Kaarrola et al., 2006). In our study, the successful discharge rate in ICU patients aged ≥ 80 years was 57.2%. A study in Switzerland described that 78% of elderly ICU patients survived for >6 months after discharge (Conti et al., 2011); another study in Norway demonstrated that the overall 1-year survival rate in ICU patients aged ≥ 80 years was 42% (Andersen et al., 2015). The substantial differences in the successful discharge rate may be because both studies accounted for merely one hospital in the analysis, with a smaller sample size, and the study in Switzerland involved elderly patients with a broader age range (i.e., ≥ 65 years).

A study conducted in the United States demonstrated that over 1998–2008, the mortality rates of cancer, stroke, and diabetes declined as a result of advanced medical care provided to patients

Table 2
Predictors of successful ICU discharge in elderly individuals aged ≥ 80 years (n = 85,023).

Variable	Successful Discharge (n = 7,905) n (%)	Multivariable	
		Adjusted OR (95% CI)	p
Sex			
Male	4,066 (4.8)	Ref	
Female	3,839 (4.5)	1.00 (0.92–1.09)	.92
Age (mean \pm SD)	85.08 \pm 4.04	0.95 (0.94–0.96)	<.0001
CCI ¹ (mean \pm SD)	1.49 \pm 1.78	0.92 (0.90–0.93)	<.0001
Last-year LOS (mean \pm SD)	7.19 \pm 23.73	1.00 (1.00–1.00)	.32
LOS in ICU (mean \pm SD)	2.72 \pm 2.81	0.90 (0.88–0.92)	<.0001
Main Diagnosis			
Circulation system diseases	2,715 (3.2)	1.85 (1.57–2.17)	<.0001
Respiratory system diseases	1,726 (2.0)	1.37 (1.17–1.61)	.0002
Digestive system diseases	820 (1.0)	2.13 (1.74–2.61)	<.0001
Injury or poison	854 (1.0)	1.96 (1.59–2.40)	<.0001
Others	1,332 (1.6)	1.67 (1.40–2.00)	<.0001
Infection	458 (0.5)	Ref	
Hospital type			
Academic medical centers	2,312 (2.7)	1.53 (1.34–1.75)	<.0001
Metropolitan hospitals	4,149 (4.9)	1.22 (1.09–1.36)	.001
Local community hospitals	1,444 (1.7)	Ref	
Urbanization			
Urban	6,093 (7.2)	1.59 (1.22–2.07)	.001
Suburban	1,645 (1.9)	1.42 (1.09–1.86)	.01
Rural	167 (0.2)	Ref	
Treatment (Ref: nontreatment)			
CPR	1,605 (1.9)	0.75 (0.68–0.84)	<.0001
Mechanical ventilation	2,252 (2.7)	0.63 (0.57–0.71)	<.0001
Use of inotropic agents	3,286 (3.9)	0.37 (0.34–0.41)	<.0001
Dialysis	20 (0.02)	0.26 (0.16–0.44)	<.0001
Operation	6,466 (7.6)	1.18 (1.04–1.34)	.01

OR: Odds ratio; CI: confidence interval; CCI¹: Charlson comorbidity index modified by Quan; LOS: length of stay; ICU: intensive care unit; CPR: cardiopulmonary resuscitation.

Table 3

Optimal cutoff PDS for predicting successful ICU discharge in elderly individuals aged ≥ 80 years.

Predictive discharge score	Sensitivity	Specificity	Youden's index
4.00	0.39	0.84	0.23
5.00	0.55	0.72	0.28
6.00 ^a	0.70	0.59	0.30
7.00	0.82	0.43	0.25
8.00	0.91	0.28	0.19

^a Optimal cutoff point.

with these diseases (Batljan and Lagergren, 2004; Crimmins and Beltrán-Sánchez, 2011). However, elderly patients' functional and mental impairments worsened over time. These trends reflect that advanced technology and medical innovations have improved average life expectancy; however, with increased life expectancy, an increasing proportion of elderly adults are living with impaired mobility and function loss. The demand for high-quality medical and nursing care for these patients has consequently increased. Hence, in this study, we identified the following important predictors of ICU admission among critically ill elderly people: age, comorbidity, primary admission diagnosis, and hospital location and accreditation.

In this study, the most frequent ICU diagnoses among elderly people were circulatory and respiratory system diseases. Among patients diagnosed as having cardiovascular diseases, 34.5% were successfully discharged from the ICU; by contrast, only 5.8% of ICU patients diagnosed as having infectious diseases were successfully discharged. Patients with cardiovascular diseases had a higher chance in being successfully discharged from ICUs than patients with infectious diseases. Infection was associated with increased hospital mortality as well as ICU and hospital LOS, and infection as the primary diagnosis was a predictor unsuccessful discharge (Burchardi and Schneider, 2004; Gonçalves-Pereira et al., 2014; Levy et al., 2012). Moreover, infection has been shown to be independently associated with a higher risk of death in elderly people (Vosylius et al., 2005), and very old patients demonstrated significantly increased ICU mortality than younger patients with severe sepsis or septic shock (Nasa et al., 2012). With the effects of aging, older patients are more susceptible to infections and may have poorer outcomes after infection develops. This may be attributed to multiple associated comorbidities, such as organ dysfunction, age-related alteration in immune responses, more severe presentation of diseases, impaired health functional status, and different therapeutic approaches for elderly people (Nasa et al., 2012; Vosylius et al., 2005). Studies in the United States and France have indicated that the most common ICU diagnoses are cardiovascular diseases and sepsis (Fuchs et al., 2012; Orsini et al., 2015; Somme et al., 2003), which is consistent with our findings. In this study, ICU admission risk in patients aged ≥ 80 years was higher in academic medical centers and metropolitan hospitals than in district hospitals. ICU admission risk in patients aged ≥ 80 years was significantly higher in urban hospitals than in rural hospitals. The findings demonstrated that owing to the abundant healthcare resources available and higher quality treatments provided in academic medical centers than in local community hospitals, patients admitted to academic medical centers are more likely to survive to be discharged from the ICU, resulting in more desirable outcomes.

In the present study, we identified the following predictors of successful ICU discharge for ≥ 6 months: younger age, shorter ICU LOS, lower CCI, shorter LOS in the prior year, no life-sustaining treatments received, and receiving surgical interventions. A primary goal of ICU care is to decrease LOS to improve quality of care; ICU LOS is a strong predictor of successful discharge among critically ill elderly people. In our study, the mean ICU LOS in

successfully discharged octogenarians was 2.72 (± 2.81) days. This result is similar to the findings of previous studies, in which the mean ICU LOS among adults aged >80 years was 1.8–4.6 days (Andersen et al., 2015; Ball et al., 2017; Orsini et al., 2015; Villa et al., 2016), with the highest mean LOS being 6 days (Flaatten et al., 2017). Octogenarians who survived for >1 year after ICU discharge had a mean ICU LOS of 1.9 days (Andersen et al., 2015). One study conducted in Spain indicated that for octogenarians with ICU LOS of >4 days, the OR of their 1-year post-discharge poor functional status would be as high as 5.58 (Villa et al., 2016). The ICU LOS is strongly associated with post-discharge outcomes; thus, shorter ICU LOS reflects a higher possibility that the patient would be successfully discharged and would have a higher functional status.

In addition to the ICU LOS, age and CCI were important predictors of successful ICU discharge in adults aged >80 years. In these ICU patients, with a 1-year increase in age, the successful discharge rate decreased by 5%; with a 1-day increase in ICU LOS, the successful discharge rate decreased by 10%. Our findings are consistent with those of a previous study, which found that compared with critically ill patients aged ≤ 74 years, the ORs of 6-month post-ICU discharge survival in the age groups of 80–84 and ≥ 85 years were 0.27 and 0.12, respectively (Conti et al., 2011). The findings demonstrate that among critically ill older adults, the probability of successful ICU discharge for >6 months is lower. Furthermore, our study found that with a 1-point increase in CCI, the risk of successful ICU discharge was 0.91. Conti et al. (2011) found that critically ill patients with the comorbidities of malignant tumor (OR = 0.33), heart failure (OR = 0.32), chronic kidney disease (OR = 0.52), or cirrhosis (OR = 0.26) had much lower chances of successful discharge from the ICU for >6 months (Conti et al., 2011). In summary, in this study, advanced age, increased ICU LOS, and high CCI were correlated with a low risk of successful ICU discharge for >6 months. Other assessment tools of illness severity, such as Acute Physiology and Chronic Health Evaluation (APACHE) II, should be applied in further studies.

Another crucial finding of this study is the optimal cutoff point for predicting successful discharge for ≥ 6 months in older adults. Here, the cutoff PDS was 6 (AUC = 0.73), which meant that if the PDS of a ICU patient aged >80 was less than 6, the possibility of successful discharge was 73%. The current study is the first study to reveal this finding and to discuss successful discharge predictors.

Of ICU patients aged ≥ 80 years in this study, 57.18% were successfully discharged for >6 months. The mean prior-year LOS in these patients was 7.19 (± 23.73) days, which is lower than that in patients discharged unsuccessfully. These results demonstrated that the health status of successfully discharged patients was higher than that of unsuccessfully discharged patients. Some studies have indicated that age should be a factor considered for clinical decision-making for ICU admission (Heyland et al., 2015), and emergency medicine physicians also believe that it is inappropriate for critically ill elderly adults to be admitted to the ICU (Garrouste-Orgeas et al., 2009). However, some researchers have asserted that it is the most important to perform thorough medical assessment before ICU admission (Boumendil and Guidet, 2006; Boumendil et al., 2004). If a critically ill elderly adult aged >80 has a favorable baseline health status and is only mildly affected by chronic illnesses, the medical team should carefully assess the patient's physical and mental status. In a previous study, the overall health status was poor among individuals aged ≥ 80 years, and their ICU mortality rate was high (Flaatten et al., 2017). Nonetheless, 26% of octogenarians could return to baseline mobile functions 1 year after ICU discharge (Heyland et al., 2015).

In our study, among ICU patients aged ≥ 80 years, approximately 60% were discharged successfully and survived for >6 months. The results of this study can be used as a reference by medical staff to determine whether patients aged ≥ 80 years should be admitted

to the ICU. We recommend that when treating critically ill older adults, age should not be used as the only criterion for ICU admission and curative treatments decision-making, as it is not the sole predictor of successful ICU discharge (Boumendil et al., 2005; Garrouste-Orgeas et al., 2009). A number of factors were found to increase the chance of successful ICU discharge that being lower CCI, shorter ICU LOS, patients who were not receiving aggressive treatments such as CPR, vasopressors, mechanical ventilation, and hemodialysis. However, those who received aggressive treatments might have a higher illness severity level, contributing to the comparatively lower survival rates. Thorough medical assessment considering the long-term effects of ICU treatments should be the primary criterion for ICU admission. The healthcare team should first evaluate disease severity (Kass et al., 1992) and the risk-benefit ratio of receiving aggressive interventions and then decide whether to admit the elderly individual. Communicating with critically ill patients and their families to understand their values and preferences is crucial in medical decision-making. Clinicians should ensure elderly patient's quality of life when providing aggressive ICU treatments to them.

5. Limitations

This study was a secondary database analysis that used Taiwan NHIRD. The large sample size and strong representation are the strengths of this study. Our study accurately reflected the complex situation of critically ill adults aged ≥ 80 years, and this study discussed the unexplored topic of successful discharge predictors in this population.

This study has limitations. First, the statistics from the national database are mostly extracted from medical claims, and the database does not reflect the detailed clinical status of each patient. Our study would be more comprehensive if clinical assessment tools, such as the APACHE II, Sequential Organ Failure Assessment, or Simplified Acute Physiology Score II, were applied. Second, the NHIRD does not contain information on patients and their families' subjective values, such as advance directive, satisfaction toward ICU care and staff, and health-related quality of life of patients. Third, information on the decision-making process among the healthcare team, patients, and their family was unavailable. For instance, advance care planning or informal family meetings for discussing the treatment plan might occur when the patient is in critical condition. Fourth, research data could only be retrieved till 2013; however, not many differences have been found in patients' medical records in a recent European transnational study (Flaatten et al., 2017) and a recent Taiwan study (Tu et al., 2018). Finally, information on patient's health status, functional mobility, and quality of life after their discharge from the hospital was unavailable.

6. Conclusion

This is the first population-based study to investigate the outcomes of ICU patients aged ≥ 80 years. Advanced age was a predictive factor of unsuccessful ICU discharge. Nevertheless, more than half of this vulnerable population survived for at least 6 months after discharge. Therefore, age should not be the sole criterion for decision-making for ICU admission and curative treatments in critically ill older adults; comprehensive assessment and effective communication with patients and families are also crucial in clinical decision-making for critically ill older adults.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

None.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.ijnurstu.2019.04.007>.

References

- Al-Dorzi, H.M., Tamim, H.M., Mundekkadani, S., Sohail, M.R., Arabi, Y.M., 2014. Characteristics, management and outcomes of critically ill patients who are 80 years and older: a retrospective comparative cohort study. *BMC Anesthesiol.* 14, 126.
- Andersen, F.H., Flaatten, H., Klepstad, P., Romild, U., Kvåle, R., 2015. Long-term survival and quality of life after intensive care for patients 80 years of age or older. *Ann. Intensive Care* 5 (1), 53.
- Angus, D.C., Linde-Zwirble, W.T., Lidicker, J., Clermont, G., Carcillo, J., Pinsky, M.R., 2001. Epidemiology of severe sepsis in the United States: analysis of incidence, outcome, and associated costs of care. *Crit. Care Med.* 29 (7), 1303–1310.
- Bagshaw, S.M., Webb, S.A., Delaney, A., George, C., Pilcher, D., Hart, G.K., Bellomo, R., 2009. Very old patients admitted to intensive care in Australia and New Zealand: a multi-centre cohort analysis. *Crit. Care* 13 (2), R45.
- Ball, I.M., Bagshaw, S.M., Burns, K.E., Cook, D.J., Day, A.G., Dodek, P.M., Kutsogiannis, D.J., Mehta, S., Muscedere, J.G., Turgeon, A.F., Stelfox, H.T., Wells, G.A., Stiell, I.G., 2017. Outcomes of elderly critically ill medical and surgical patients: a multicentre cohort study. *Can. J. Anaesth.* 64 (3), 260–269.
- Batjan, I., Lagergren, M., 2004. Inpatient/outpatient health care costs and remaining years of life—effect of decreasing mortality on future acute health care demand. *Soc. Sci. Med.* 59 (12), 2459–2466.
- Boumendil, A., Guidet, B., 2006. Elderly patients and intensive care medicine. *Intensive Care Med.* 32 (7), 965–967.
- Boumendil, A., Maury, E., Reinhard, I., Luquel, L., Offenstadt, G., Guidet, B., 2004. Prognosis of patients aged 80 years and over admitted in medical intensive care unit. *Intensive Care Med.* 30 (4), 647–654.
- Boumendil, A., Aegerter, P., Guidet, B., 2005. Treatment intensity and outcome of patients aged 80 and older in intensive care units: a multicenter matched-cohort study. *J. Am. Geriatr. Soc.* 53 (1), 88–93.
- Boumendil, A., Latouche, A., Guidet, B., 2011. On the benefit of intensive care for very old patients. *Arch. Intern. Med.* 171 (12), 1116–1117.
- Brummel, N.E., Balas, M.C., Morandi, A., Ferrante, L.E., Gill, T.M., Ely, E.W., 2015. Understanding and reducing disability in older adults following critical illness. *Crit. Care Med.* 43 (6), 1265–1275.
- Burchardi, H., Schneider, H., 2004. Economic aspects of severe sepsis. *Pharmacoeconomics* 22 (12), 793–813.
- Chelluri, L., Pinsky, M.R., Grenvik, A.N., 1992. Outcome of intensive care of the "oldest-old" critically ill patients. *Crit. Care Med.* 20 (6), 757–761.
- Cheng, C.L., Kao, Y.H.Y., Lin, S.J., Lee, C.H., Lai, M.L., 2011. Validation of the National Health Insurance Research Database with ischemic stroke cases in Taiwan. *Pharmacoepidemiol. Drug Saf.* 20 (3), 236–242.
- Conti, M., Friolet, R., Eckert, P., Merlani, P., 2011. Home return 6 months after an intensive care unit admission for elderly patients. *Acta Anaesthesiol. Scand.* 55 (4), 387–393.
- Crimmins, E.M., Beltrán-Sánchez, H., 2011. Mortality and morbidity trends: is there compression of morbidity? *J. Gerontol. B Psychol. Sci. Soc. Sci.* 66 (1), 75–86.
- Deyo, R.A., Cherkin, D.C., Ciol, M.A., 1992. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J. Clin. Epidemiol.* 45 (6), 613–619.
- Docherty, A.B., Anderson, N.H., Walsh, T.S., Lone, N.I., 2016. Equity of access to critical care among elderly patients in Scotland: a national cohort study. *Crit. Care Med.* 44 (1), 3–13.
- Flaatten, H., De Lange, D.W., Morandi, A., Andersen, F.H., Artigas, A., Bertolini, G., Boumendil, A., Cecconi, M., Christensen, S., Faraldi, L., Fjølner, J., Jung, C., Marsh, B., Moreno, R., Oeyen, S., Öhman, C.A., Pinto, B.B., Soliman, I.W., Szczekliak, W., Valentin, A., Watson, X., Zaferidis, T., Guidet, B., 2017. The impact of frailty on ICU and 30-day mortality and the level of care in very elderly patients (≥ 80 years). *Intensive Care Med. Exp.* 43 (12), 1820–1828.
- Fluss, R., Faraggi, D., Reiser, B., 2005. Estimation of the Youden Index and its associated cutoff point. *Biol. J.* 47 (4), 458–472.
- Fuchs, L., Chronaki, C.E., Park, S., Novack, V., Baumfeld, Y., Scott, D., McLennan, S., Talmor, D., Celi, L., 2012. ICU admission characteristics and mortality rates among elderly and very elderly patients. *Intensive Care Med.* 38 (10), 1654–1661.
- Garrouste-Orgeas, M., Timsit, J.F., Montuclard, L., Colvez, A., Gattoliat, O., Philippart, F., Rigal, G., Misset, B., Carlet, J., 2006. Decision-making process, outcome, and 1-year quality of life of octogenarians referred for intensive care unit admission. *Intensive Care Med.* 32 (7), 1045–1051.
- Garrouste-Orgeas, M., Boumendil, A., Pateron, D., Aegerter, P., Somme, D., Simon, T., Guide, B., 2009. Selection of intensive care unit admission criteria for patients aged 80 years and over and compliance of emergency and intensive care unit physicians with the selected criteria: an observational, multicenter, prospective study. *Crit. Care Med.* 37 (11), 2919–2928.

- Gonçalves-Pereira, J., Pereira, J., Ribeiro, O., Baptista, J., Froes, F., Paiva, J.-A., 2014. Impact of infection on admission and of the process of care on mortality of patients admitted to the Intensive Care Unit: the INFAUCI study. *Clin. Microbiol. Infect.* 20 (12), 1308–1315.
- Hart, P.D., 2016. Receiver operating characteristic (ROC) curve analysis: a tutorial using body mass index (BMI) as a measure of obesity. *J. Phys. Act. Res.* 1, 5–8.
- Heyland, D., Cook, D., Bagshaw, S.M., Garland, A., Stelfox, H.T., Mehta, S., Dodek, P., Kutsogiannis, J., Burns, K., Muscedere, J., Turgeon, A.F., Fowler, R., Jiang, X., Day, A.G., 2015. The very elderly admitted to ICU: a quality finish? *Crit. Care Med.* 43 (7), 1352–1360.
- Kaarilola, A., Tallgren, M., Pettilä, V., 2006. Long-term survival, quality of life, and quality-adjusted life-years among critically ill elderly patients. *Crit. Care Med.* 34 (8), 2120–2126.
- Kass, J.E., Castriotta, R.J., Malakoff, F., 1992. Intensive care unit outcome in the very elderly. *Crit. Care Med.* 20 (12), 1666–1671.
- Levy, M.M., Artigas, A., Phillips, G.S., Rhodes, A., Beale, R., Osborn, T., Vincent, J.-L., Townsend, S., Lemeshow, S., Dellinger, R.P., 2012. Outcomes of the Surviving Sepsis Campaign in intensive care units in the USA and Europe: a prospective cohort study. *Lancet Infect. Dis.* 12 (12), 919–924.
- Liu, C.Y., Hung, Y.T., Chuang, Y.L., Chen, Y.J., Weng, W.S., Liu, J.S., Liang, K.Y., 2006. Incorporating development stratification of Taiwan townships into sampling design of large scale health interview survey. *J. Health Manag.* 4 (1), 1–22.
- Nasa, P., Juneja, D., Singh, O., Dang, R., Arora, V., 2012. Severe sepsis and its impact on outcome in elderly and very elderly patients admitted in intensive care unit. *J. Intensive Care Med.* 27 (3), 179–183.
- National Health Insurance Administration, Ministry of Health and Welfare, 2017. National Health Insurance Coverage Ratio. . (Accessed 26 December 2017) https://www.gender ey.gov.tw/gecdb/Stat_Statistics_DetailData.aspx?sn=u4-ceyDJ9iGzBYUGIJCoz7w%3D%3D&d=Rv%2B7HVE3GXFi8TeyUcZrw%3D%3D.
- Orsini, J., Butala, A., Salomon, S., Studer, S., Gadhia, S., Shamian, B., Prajapati, R., Blaak, C., 2015. Prognostic factors associated with adverse outcome among critically ill elderly patients admitted to the intensive care unit. *Geriatr. Gerontol. Int.* 15 (7), 889–894.
- Quan, H., Li, B., Couris, C.M., Fushimi, K., Graham, P., Hider, P., Januel, J.M., Sundararajan, V., 2011. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. *Am. J. Epidemiol.* 173 (6), 676–682.
- Somme, D., Mailliet, J.M., Gisselbrecht, M., Novara, A., Ract, C., Fagon, J.Y., 2003. Critically ill old and the oldest-old patients in intensive care: short-and long-term outcomes. *Intensive Care Med.* 29 (12), 2137–2143.
- Somogyi-Zalud, E., Zhong, Z., Hamel, M.B., Lynn, J., 2002. The use of life-sustaining treatments in hospitalized persons aged 80 and older. *J. Am. Geriatr. Soc.* 50 (5), 930–934.
- Sullivan, L.M., Massaro, J.M., D'Agostino Sr., R.B., 2004. Presentation of multivariate data for clinical use: the Framingham Study predictive discharge score functions. *Stat. Med.* 23 (10), 1631–1660.
- Tu, C.-S., Chang, C.-H., Chang, S.-C., Lee, C.-S., Chang, C.-T., 2018. A decision for predicting successful extubation of patients in intensive care unit. *Biomed Res. Int.* 2018 doi:<http://dx.doi.org/10.1155/2018/6820975> Article ID: 6820975.
- United Nations, 2017. World Population Ageing. . (Accessed 22 December 2018) https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Highlights.pdf.
- United Nations, 2018. Ageing. . (Accessed 22 December 2018) <http://www.un.org/en/sections/issues-depth/ageing/>.
- Villa, P., Pintado, M.C., Luján, J., González-García, N., Trascasa, M., Molina, R., Cambroner, J.A., de Pablo, R., 2016. Functional status and quality of life in elderly intensive care unit survivors. *J. Am. Geriatr. Soc.* 64 (3), 536–542.
- Vosylius, S., Sipylaite, J., Ivaskevicius, J., 2005. Determinants of outcome in elderly patients admitted to the intensive care unit. *Age Ageing* 34 (2), 157–162.
- Wu, S.C., Chen, J.S., Wang, H.M., Hung, Y.N., Liu, T.W., Tang, S.T., 2010. Determinants of ICU care in the last month of life for Taiwanese cancer decedents, 2001 to 2006. *Chest* 138 (5), 1071–1077.