Development of a scoring system as reference tool to support ICU triage

Lawrence Lau[1], Clement CC Leung[1], Harriet HY Kong[1], Emily WS Cheung[1], Michele MY Tang[1], Fu-loi Chow[1]

Abstract

***Background*: Triage is pivotal in intensive care for patient safety and resource allocation. The admission algorithm has been shown to correlate with the appropriateness of ICU admission and offer decision aid when facing challenges in times of scarce critical care resources. This study aimed to explore the development of a reference tool to support triage decisions for admission to the ICU.**

***Methods*: In this retrospective observational study, the Intensive Care Triage Score (ICTS) was generated as a reference to correlate with the triage decision made by clinical judgment. ICU admission would be advised for ICTS below 6. The primary outcome was ICU admission. The secondary outcomes included ICU, hospital, 90-day, and 1-year mortality. The receiver operating characteristic curve was used to assess the performance of ICTS.**

***Results*: A total of 1664 patients were included in the analysis. There were 1204 patients (72.4%) admitted to the ICU; 680 of 738 (92%) with ICTS below 6 were admitted to the ICU. The hospital mortality of the whole cohort was 25.1%; there was a positive correlation between ICTS and hospital mortality. The area under the receiver operating characteristic curve (AUC) of ICTS in predicting hospital mortality for all patients was 0.754 (95% CI 0.728-0.780). The correlation between ICTS and hospital mortality was observed in patients admitted and not admitted to the ICU.**

***Conclusion*: Developing a scoring system as a reference tool would be useful for ICU triage.**

Key words: Comorbidity, mortality, triage, ICU outcome, frailty.

Introduction

Demand for intensive care unit (ICU) resources often exceeds supply. Triage is needed regularly and is pivotal for patient safety and outcome. (1) Triage decision involves balancing the risks and benefits for a specific patient and the implications for other patients when resources are limited. Under-triage (i.e., not admitting patients who are likely to benefit from ICU care) implies patients fail to receive the care needed, thus jeopardizing the outcome; over-triage (i.e., admitting patients who are unlikely to benefit from ICU care) leads to potentially harmful interventions, inappropriate resource allocation, and diverting care from needful patients. (2) The framework is described in detail in the ICU admission, discharge, and triage guidelines of the Society of Critical Care Medicine. (3)

Severity of illness scoring systems have been developed to evaluate ICU performance, but very few are useful for individual patients in triage. (4,5) The triage decision for ICU admission incorporates factors including severity and reversibility of acute illness, functional status and comorbidity, physician experience, and ICU bed availability. (6) Despite consensus and guidelines, inconsistencies are noted, and there is no agreement on the survival cutoff for

[1] Intensive Care Unit, Caritas Medical Centre, Hong Kong Special Administrative Region

Address for correspondence:
Dr. Lawrence Lau
Intensive Care Unit, Caritas Medical Centre
111 Wing Hong Street, Shamshuipo, Hong Kong Special Administrative Region
Tel: +85264343845
Email: ll225@ha.org.hk

triage. (7) Besides, recommendations for the triage of patients to intensive care may not be followed. (8) However, the ICU admission algorithm has demonstrated higher interrater reliability and correlated with the physician's judgment of the appropriateness of ICU admission. (9) Implementation of the decision-aid tool was found to be associated with a reduction in inappropriate triage. (10) In recent years, the growing importance of standardized triage tools in the context of increasing demand for ICU resources was experienced globally and locally during the public health crisis. (11,12) An expert panel report of the task force for mass critical care and the American College of Chest Physicians provided an implementation guide for regional allocation and triage of scarce essential care resources in coronavirus disease 2019 (COVID-19). (13)

The Intensive Care Triage Score (ICTS) is a scoring system that accounts for patients' acute illness on presentation and chronic comorbidities. This study aimed to explore the development of ICTS as a reference tool for ICU triage.

Methods

The study was conducted in a 12-bed ICU of a Hong Kong district hospital, serving a population of about half a million. (14)

The ICTS included 30 variables with a score ranging from 0 to 50, a higher score indicating a lower likelihood of benefit from intensive care (**Table 1**). These variables were chosen based on literature review, expert consensus, and clinical experience. (15,16) In collaboration and with the support of the Information Technology team, ICTS was developed and incorporated into an electronic form in the ICU consultation and booking system available on the computer in the ICU and every ward in the hospital. Communication within the ICU team and promulgation to all clinical departments were performed before formal implementation was established in 2021.

The consulting specialty doctor completed the electronic ICU consultation form and communicated by phone with the ICU doctor for every ICU consultation. After assessing the patient, the ICU physician entered the relevant variables into the electronic ICU consultation form to obtain ICTS as a reference to correlate with the triage decision by clinical judgment. The system would not allow entries for related conditions to avoid overestimating the total score. By adding (age - 40) divided by 10, the ICTS was generated automatically. ICU admission would be advised for patients with ICTS below 6. However, patients having high ICTS might be offered ICU admission if they were judged to be able to benefit from intensive care. On the contrary, ICU admission would be declined if there was no expected reversibility for recovery even when ICTS was low. At clinical handover, an electronic review of vital signs, laboratory results, imaging, premorbid conditions, and ICTS was performed to verify the appropriateness of triage. If non-admission carried ICTS below 6, electronic review plus clinical assessment of the patient by an ICU fellow was mandatory within 24 hours.

We included ICU consultations for adult patients (age ≥18 years) between 1st January 2021 and 31st December 2021. The consultation leading to every ICU admission was included, and only the first consultation was included in the analysis for non-admission. Consultations for admission to higher dependency units or special care units and patients triaged in these units after ICU consultations were excluded. Inter-rater reliability testing was conducted for 5% of the included sample to assess consistency in scoring among different ICU fellows. Survival outcomes of all patients were available from the electronic patient record in the corporate computer system. The study was approved by the Clinical Research Ethics Committee of the Hospital Authority with reference no. KW/EX-22-004 (167-04).

Statistical analysis

Continuous variables were expressed by median and interquartile range (IQR). Categorical values were presented in frequencies and percentages. The association between categorical data was tested using the chi-square test. The association between continuous variables was tested using the Mann-Whitney U test. The outcomes were expressed in terms of mortality in the ICU, in hospital, at 90 days and one year, starting from the day of hospital admission. p-values less than 0.05 were considered statistically significant. Statistical analysis was performed using the Statistical Package for Social Science (SPSS)® Version 21.0 for Windows.

Results

A total of 2227 consultations were retrieved from the electronic ICU consultation system (**Figure 1**). Fifty-six consultations of the same patient in the same hospital admission were repeated. A total of 1664 patients were included in the analysis.

Demographics

Of patients in all consultations, 21.5% had no acute or chronic illnesses (**Table 2**). The most common comorbidity was diabetes mellitus; 593 patients (36.3%) were diabetic with or without organ damage. There were 316 patients (19.0%) who had chronic kidney diseases of stage 3 or above; 103 patients (6.2%) had cardiac arrest from pulseless electrical activity (PEA), asystole, or cardiopulmonary resuscitation (CPR) for more than 20 minutes. The burden of chronic illnesses was significantly lower in patients admitted to ICU.

Mortality

The mean age of patients admitted to the ICU was younger (66.6±15.5 vs 74.7±16.1, p<0.001). ICTS was lower among patients admitted to the ICU than those triaged (5.07 vs 8.86, p<0.001) (**Table 3**). The hospital mortality of the entire cohort was 25.1%. The ICU mortality was 6.8%. The hospital mortality of patients admitted to the ICU was significantly lower than those triaged (14.5% vs 53.0%, p<0.001). The 90-day and one-year mortality of patients admitted to the ICU were also lower than those triaged (16.7% vs 58.3% for 90-day mortality and 25.5% vs 68.3% for one-year mortality, p<0.001).

ICTS and ICU admission

The rate of ICU admission was 92% for ICTS below 6 (680 out of 738 patients), 65% for ICTS 6 to 10 (475 out of 727 patients), and 25% for ICTS 11 or above (49 out of 199 patients). The proportion of ICU patients with ICTS below 6 (56.5%) was higher than those with ICTS 6 to 10 (39.5%) (**Table 4**).

ICTS and mortality

A positive correlation between ICTS and mortality was observed (**Figure 2**). Hospital mortality was found to be correlated with ICTS, age, and comorbidities (**Table 5**). In patients admitted to the ICU, hospital mortality was 9.0% for ICTS below 6, 20.4% for ICTS 6 to 10, and 32.7% for ICTS 11 or above. In patients triaged and not admitted to the ICU, hospital mortality was 22.4% for ICTS below 6, 52.4% for ICTS 6 to 10, and 66.0% for ICTS 11 or above (**Table 6**).

Long term survival

The findings of the area under the receiver operating characteristic curve (AUC) of ICTS in predicting hospital, 90-day mortality, and one-year mortality for all patients were 0.754 (95% CI 0.728-0.780), 0.771 (95% CI 0.747-0.795), and 0.782 (95% CI 0.760-0.804), respectively; for ICU admission were 0.675 (95% CI 0.634-0.716), 0.700 (95% CI 0.662-0.739), and 0.714 (95% CI 0.681-0.746), respectively; and for non-admission were 0.656 (95% CI 0.606-0.705), 0.676 (95% CI 0.626-0.726), and 0.741 (95% CI 0.692-0.789), respectively (**Figure 3**). The AUC suggested that ICTS better predicted long-term survival in all patients, ICU admission, and non-admission.

The findings of the AUC of the Acute Physiology And Chronic Health Evaluation (APACHE) II score in predicting hospital, 90-day mortality, and one-year mortality for patients admitted to the ICU were 0.794 (95% CI 0.758-0.830), 0.777 (95% CI 0.742-0.812), and 0.747 (95% CI 0.715-0.719), respectively. The AUC suggested that APACHE II performed better than ICTS in predicting hospital outcomes, but its performance in predicting mortality decreased over time.

Discussion

ICU triage by ICTS

Our study demonstrated that up to 92% of patients with ICTS below 6 were managed in ICU. The patients admitted to the ICU were younger, had better premorbid status, and had a lower burden of chronic illness. They were more likely to benefit from intensive care. If these patients were not admitted to the ICU, review and clinical assessment by ICU fellows would ensure that the triage decision was proper and patients would receive appropriate care. As a reference, ICTS was known to the triage decision-maker to safeguard admission for patients who would benefit from ICU care. The result confirmed good compliance with using ICTS as a tool for reference in ICU triage and review.

Previous studies have shown that delayed or declined ICU admission for critically ill patients could lead to increased mortality. (17-21) Junior doctors may tend to reject ICU admission due to less experience in recognizing signs of deterioration or in predicting the course of illness among sick patients. (22) In our study, there were 13 deaths among patients not admitted to the ICU with ICTS below 6; twelve of these patients had prolonged cardiac arrest, and another one was in poor condition where surgical intervention was not offered. The finding supported that ICTS promoted consistency in triage decisions so that ICU admission would be offered to patients who would benefit from intensive care.

The design of ICTS and weighting of conditions were based on the literature on chronic illnesses associated with poor outcomes. Most items were derived from the Charlson Comorbidity Index (CCI). (16) The medical comorbidities were identified from investigations, imaging, or pathology available in the electronic patient records. The comorbidities and conditions in ICTS were also chosen because these disease items could be confirmed without ambiguity and categorized in mild or severe seriousness. The score had the advantage of being immediately available at the time of triage and served as a pragmatic and timely reference tool at the bedside. The tool is not used independently to determine ICU admission, so it may be criticized as doing self-fulfilling prophesy. However, ICTS aims to safeguard the provision of ICU care to the young and fit and to rethink the limitations of medicine to the old and frail.

The weighting was adjusted according to the advances in medicine so that patients suffering from chronic illnesses would be offered ICU admission under appropriate triage. For example, patients infected with human immunodeficiency virus (HIV) had better prognosis after the era of antiretroviral therapy. (23) Likewise, advances in molecular targets such as epidermal growth factor receptor (EGFR) inhibitors have improved outcomes for patients with metastatic lung cancers. (24) Besides, immunotherapy with programmed death 1 (PD-1) and programmed death ligand 1 (PD-L1) immune checkpoint inhibitors may induce adverse reactions that warrant ICU admission. (25) Nevertheless, advanced cancers not amendable to targeted therapy still carry a worse prognosis. (26-29)

Contrary to the assessment based on the severity of acute illness, (7,30-32) ICTS has chosen to consider mainly chronic diseases and the age of the referred patients. The two acute conditions on presentation included in ICTS were non-shockable rhythm in cardiac arrest and cardiopulmonary resuscitation (CPR) of more than 20 minutes, as well as hospital stay for more than 14 days before ICU consultation. Our study found higher mortality in patients who had cardiac arrest (21.8% vs 1.0%, $p<0.001$) and hospital stay for over 2 weeks before ICU consultation (11.7% vs 4.5%, $p<0.001$). In a local study, patients with non-shockable rhythms out of hospital cardiac arrest had a mortality of 85%, and only 5% had good neurological outcomes. (33) For patients with a hospital stay of 3 weeks before ICU admission, mortality was up to 50% in a study in the United Kingdom. (34)

Unlike another triage tool using the Sequential Organ Failure Assessment (SOFA) score, (31) we believed that chronic diseases, in addition to acute illnesses in the aging population, would influence triage decisions in clinical practice. The AUC showed that ICTS performed better in the long-term mortality prediction in all patients, including ICU admission and non-admission patients. In contrast, APACHE II performed better in predicting hospital mortality in ICU patients. APACHE II performed better than ICTS in predicting hospital mortality in ICU patients, likely because higher weight was given to acute conditions in severity adjustment scoring. However, APACHE II's performance in the mortality prediction decreased over time. Our results showed that ICTS correlated with hospital mortality and long-term survival, making it a conceivable reference for gauging comorbidities burden on patient outcomes.

Performance of ICTS at triage cutoff

Our study found that 27.6% of ICU referrals were triaged, lower than 33.5% and 38.0% from two other ICU studies in Hong Kong. (30,35) However, whether the triaged patients in those studies were subsequently managed in high-dependency and special care units was unknown. In American studies, the percentage of triaged patients varied from 20% to 57%, and mortality of those patients was 18% to 36%. (36,37) For low-priority patients under priority 3, according to the guidelines of the Society of Critical Care Medicine in 1999, a local study showed that triaged patients had a high mortality of 62.1%. (35) Our study showed a comparable mortality of 53% for triaged patients at a relatively low percentage of ICU non-admission. The observation might have resulted from a complex interaction of factors, including the threshold of initiating ICU consultations, the experience of the intensivist, the availability of critical care resources, and patient management outside the ICU. (38) A local study remarked that triaged patients had higher mortality after correcting the severity of illness by comparing the standardized mortality ratio (SMR). Still, patients triaged based on futility had higher mortality at a lower SMR. (30) This area deserves further research.

In addition, ICU admission was offered 65% at ICTS 6 to 10 and 25% at ICTS 11 or above for patients who might benefit from support and treatment in ICU. The result verified that clinical judgment was exercised and that ICTS was a reference tool in triage decisions. Nevertheless, a high mortality rate among patients with ICTS 11 or above could alert healthcare teams to discuss with patients and families about prognosis and care plan as supported by the prediction of one-year mortality in all patients by ICTS.

A systematic review has shown that computerized clinical decision support systems improved practitioner performance in systems serving diagnostic, reminder, disease management, and drug dosing or prescribing functions. (39) Similarly, the integration of ICTS into ICU triage has enhanced ICU supervision and communication within the ICU team, across consulting specialties, and among patients and families. However, meticulous review and feedback are required to maintain consistency in the appropriateness of ICU triage. The process implies challenges in terms of feasibility in healthcare settings, clinician acceptance, technological constraints, and resource input. Prospective validation is needed to evaluate the predictive accuracy and utility of ICTS. Refinement and adaptations of the scoring system would be necessary based on feedback after applying ICTS in a real-world implementation.

Limitations

This study had the following limitations. Firstly, it was a retrospective study on reference tool development from a single center; the results may not be generalizable to other ICUs. Secondly, there was no universal definition of good premorbid status. ICTS below 6 was taken as the reference cutoff; clinical experience of other specialties may not share the same view. Triage cut-off at higher ICTS will result in more ICU admissions for patients with higher disease burdens, translating into significant resource implications. Thirdly, some conditions, such as malnutrition, may be subject to inter-observer variability and bias. Objective parameters like body weight and body mass index would be helpful but may not be available in ICU consultation. However, an ICU review would include available results from clinical examination, blood tests, and imaging results to obtain a more precise assessment. Fourthly, only the first consultation in non-admission was included to avoid potential bias from cumulative clinical information in patients who had repeated ICU consultations. (7,22,35) Given that there were only 56 repeated consultations among 1664 ICU consultations, the effect on the results would be insignificant. Fifthly, acute diagnoses were not analyzed to assess ICTS performance in different disease categories; this information may help to refine ICTS performance. Sixthly, important outcomes after critical illness in terms of ICU-acquired weakness, organ and cognitive dysfunction were not accessible. (40) Finally, ICTS was developed as a prototype scoring system that does not follow any mathematical model; a prospective study for validation will refine the performance of ICTS.

Conclusion

Triage is both a science and an art. The severity of acute illness and resource availability continue to affect triage decisions. ICTS is designed as a reference tool to support triage and review. Applying information technology and electronic systems will enhance clinical practice in intensive care. As artificial intelligence is changing clinical practice in the areas of making diagnoses, predicting outcomes, and planning treatment, it is foreseeable that intensive care physicians should retain understanding and accountability in clinical decision-making.

Our study shows the prevalence of co-morbid conditions in critically ill patients in ICU consultation and triage. Increased burden of comorbidities, as indicated by ICTS, is associated with higher mortality. ICTS demonstrates the potential to enhance consistency and objectivity in ICU triage decisions. Developing a reference tool for ICU triage will be necessary and deserves further evaluation and validation that would ultimately enhance patient care in ICUs worldwide.

Disclosure of conflict of interest

All the authors had no potential conflicts with pharmaceutical or device companies, and the study did not receive any funding.

Table 1. The acute and chronic illnesses and score weights included in ICTS

Score weights	1 point	2 points	3 points
	Chronic pulmonary disease	MRSA or multidrug-resistant organism	Severe lung disease (FEV1<50% predicted, or on long term oxygen)
	History of acute coronary syndrome	Pre-ICU hospital length of stay >2 weeks	Poor heart function (e.g. ejection fraction ≤20%)
	Congestive heart failure	Leukemia or myeloma	Immunosuppression
	Peripheral vascular disease/aortic aneurysm	Lymphoma	Acquired immunodeficiency syndrome
	Connective tissue disease	Tumor without metastases	Metastatic malignancy
	Mild liver disease without portal hypotension	Malnutrition or obvious muscle wasting	Liver cirrhosis
	Peptic ulcer disease in recent one year	Moderate renal disease (GFR<60 ml/min)	End-stage renal failure
	Diabetes mellitus without organ damage	Diabetes mellitus with end-organ damage	Palliative or no definitive treatment
	TIA or stroke with mild or no residual deficit	Hemiplegia	PEA, asystole, or CPR≥20 minutes
	Clinical frailty scale 4 or mild dementia	Clinical frailty scale 5 or moderate dementia	Clinical frailty scale 6 or severe dementia

Legend: ICTS=Intensive Care Triage Score; TIA=transient ischemic attack; MRSA=methicillin-resistant Staphylococcus aureus; ICU=intensive care unit; GFR=glomerular filtration rate; FEV1=forced expiratory volume in 1 second; PEA=pulseless electrical activity; CPR=cardiopulmonary resuscitation.

Table 2. Characteristics and comorbidities of 1664 patients in ICU consultations

Acute and chronic illnesses	All (n=1664)		ICU (n=1204)		Non-ICU (n=460)		p-value
	n	%	n	%	n	%	
No relevant acute or chronic illness	357	21.5	333	27.7	24	5.2	<0.001
Chronic pulmonary disease	156	9.4	99	8.2	57	12.4	0.009
Severe COPD (FEVI less than 50% predicted)	31	1.9	10	0.8	21	4.6	<0.001
History of acute coronary syndrome	170	10.2	106	8.8	64	13.9	0.002
Congestive heart failure	159	9.6	94	7.8	65	14.1	<0.001
Poor heart function (LVEF<20%)	39	2.3	21	1.7	18	3.9	0.009
Peripheral vascular disease/aortic aneurysm	68	4.1	39	3.2	29	6.3	0.005
Connective tissue disease	26	1.6	14	1.2	12	2.6	0.033
Mild liver disease without portal hypertension	125	7.5	95	7.9	30	6.5	0.343
Liver cirrhosis	58	3.5	36	3.0	22	4.8	0.075
Peptic ulcer disease in recent 1 year	19	1.1	12	1.0	7	1.5	0.367
Diabetes without organ damage	465	27.9	352	29.2	113	24.6	0.058
Diabetes with end-organ damage	128	7.7	80	6.6	48	10.4	0.009
TIA or stroke with mild or no residual deficit	234	14.1	167	13.9	67	14.6	0.715
Clinical frailty scores 4 or mild dementia	132	7.9	89	7.4	43	9.3	0.187
Clinical frailty scores 5 or moderate dementia	186	11.2	84	7.0	102	22.2	<0.001
Clinical frailty scores 6 or severe dementia	195	11.7	60	5.0	135	29.3	<0.001
MRSA or multidrug-resistant organism	5	3.5	31	2.6	28	6.1	0.001
Pre-ICU hospital length of stay more than 2 weeks	105	6.3	52	4.3	53	11.5	<0.001
Leukemia or myeloma	9	0.5	6	0.5	3	0.7	0.702
Lymphoma	5	0.3	3	0.2	2	0.4	0.536
Tumor without metastasis	51	3.1	39	3.2	12	2.6	0.505
Metastatic malignancy	72	4.3	40	3.3	32	7.0	0.001
Malnutrition or obvious muscle wasting	113	6.8	39	3.2	74	16.1	<0.001
Moderate renal disease	212	12.7	113	9.4	99	21.5	<0.001
End stage renal failure	104	6.3	83	6.9	21	4.6	0.079
Hemiplegia	40	2.4	11	0.9	29	6.3	<0.001
Immunosuppression	37	2.2	27	2.2	10	2.2	0.932
Acquired immunodeficiency syndrome	3	0.2	2	0.2	1	0.2	0.825
Palliative care or no definitive treatment	26	1.6	4	0.3	22	4.8	<0.001
PEA, asystole, or CPR more than 20 minutes	103	6.2	17	1.4	86	18.7	<0.001

Legend: ICU=intensive care unit; COPD=chronic obstructive pulmonary disease; FEV1=forced expiratory volume in 1 second; LVEF=left ventricle ejection fraction; TIA=transient ischemic attack; MRSA=methicillin-resistant Staphylococcus aureus; PEA=pulseless electrical activity; CPR=cardiopulmonary resuscitation.

Table 3. Demographic characteristics and mortality of 1664 patients in ICU consultations

Characteristics	All (n=1664)	ICU (n=1204)	Non-ICU (n=460)	p-value
Age (years), mean±SD	68.8±16.3	66.6±15.8	74.7±16.1	<0.001
Gender (male), n (%)	1044 (62.7%)	758 (63.0%)	286 (62.2%)	0.768
APACHE II score, median±IQR		18±12		
ICTS, mean±SD	6.13±3.55	5.07±3.04	8.86±3.37	<0.001
Specialties, n (%)				
- Medical	630 (37.9%)	411 (34.1%)	219 (47.6%)	
- Surgical	431 (25.9%)	348 (28.9%)	83 (18.0%)	
- Accident and emergency	362 (21.8%)	243 (20.2%)	119 (25.9%)	
- Orthopaedics and traumatology	184 (11.1%)	147 (12.2%)	37 (8.0%)	
- Ophthalmology	56 (3.4%)	54 (4.5%)	2 (0.4%)	
- Dental and maxillofacial surgery	1 (0.1%)	1 (0.1%)	0 (0%)	
ICU mortality, n (%)		82 (6.8%)		
Hospital mortality, n (%)	418 (25.1%)	174 (14.5%)	244 (53.0%)	<0.001
90-day mortality, n (%)	469 (28.2%)	201 (16.7%)	268 (58.3%)	<0.001
1-year mortality, n (%)	621 (37.3%)	307 (25.5%)	314 (68.3%)	<0.001

Legend: ICU=intensive care unit; APACHE=Acute Physiology And Chronic Health Evaluation; ICTS=Intensive Care Triage Score; SD=standard deviation.

Table 4. Rate of ICU admission by ICTS

ICTS	All (n=1664)		ICU admission (n=1204)		Rate of admission in specific ICTS (%)
	n	%	n	%	
0	93	5.6	82	6.8	88.2
1	72	4.3	67	5.6	93.1
2	121	7.3	117	9.7	96.7
3	154	9.2	138	11.5	89.6
4	150	9.0	140	11.6	93.3
5	148	8.9	136	11.3	91.9
6	179	10.7	140	11.6	78.2
7	150	9.0	109	9.0	72.7
8	165	9.9	104	8.6	63.0
9	127	7.6	74	6.1	58.3
10	106	6.4	48	4.0	45.3
11 or above	199	11.9	49	4.1	24.6
0-5	738	44.4	680	56.5	92.0
6-10	727	43.7	475	39.5	65.3

Legend: ICU=intensive care unit; ICTS=Intensive Care Triage Score.

Table 5. Characteristics and comorbidities of 1664 patients in ICU consultations by hospital survival

Characteristics	All (n=1664)	Hospital survival (n=1246)	Hospital death (n=418)	p-value
Age (years), mean±SD	68.7±16.4	66.8±16.7	75.0±13.3	<0.001
Gender (male), n (%)	1044 (62.7%)	772 (62.0%)	272 (65.1%)	0.255
ICTS, mean±SD	6.12±3.56	5.3±3.3	8.5±3.2	<0.001
Comorbidities, n (%)				
- No relevant acute or chronic illness	357 (21.5%)	332 (26.6%)	25 (6.0%)	<0.001
- Chronic pulmonary disease	156 (9.4%)	100 (8.0%)	56 (13.4%)	0.001
- Severe COPD (FEVI less than 50% predicted)	31 (1.9%)	19 (1.5%)	12 (2.9%)	0.078
- History of acute coronary syndrome	170 (10.2%)	108 (8.7%)	62 (14.8%)	<0.001
- Congestive heart failure	159 (9.6%)	109 (8.7%)	50 (12.0%)	0.053
- Poor heart function (LVEF<20%)	39 (2.3%)	23 (1.8%)	16 (3.8%))	0.020
- Peripheral vascular disease/aortic aneurysm	68 (4.1%)	43 (3.5%)	25 (6.0%)	0.024
- Connective tissue disease	26 (1.6%)	13 (1.0%)	13 (3.1%)	0.003
- Mild liver disease without portal hypertension	125 (7.5%)	95 (7.6%)	30 (7.2%)	0.764
- Liver cirrhosis	58 (3.5%)	34 (2.7%)	24 (5.7%)	0.004
- Peptic ulcer disease in recent 1 year	19 (1.1%)	10 (0.8%)	9 (2.2%)	0.025
- Diabetes without organ damage	465 (27.9%)	344 (27.6%)	121 (28.9%)	0.598
- Diabetes with end-organ damage	128 (7.7%)	99 (7.9%)	29 (6.9%)	0.503
- TIA or stroke with mild or no residual deficit	234 (14.0%)	175 (14.0%)	59 (14.1%)	0.972
- Clinical frailty scores 4 or mild dementia	132 (7.9%)	99 (7.9%)	33 (7.9%)	0.974
- Clinical frailty scores 5 or moderate dementia	186 (11.2%)	100 (8.0%)	86 (20.6%)	<0.001
- Clinical frailty scores 6 or severe dementia	195 (11.7%)	113 (9.1%)	82 (19.6%)	<0.001
- MRSA or multidrug-resistant organism	59 (3.5%)	35 (2.8%)	24 (5.7%)	0.005
- Pre-ICU hospital length of stay more than 2 weeks	105 (6.3%)	56 (4.5%)	49 (11.7%)	<0.001
- Leukemia or myeloma	9 (0.5%)	6 (0.5%)	3 (0.7%)	0.569
- Lymphoma	5 (0.3%)	1 (0.1%)	4 (1.0%)	0.005
- Tumor without metastasis	51 (3.1%)	37 (3.0%)	14 (3.3%)	0.697
- Metastatic malignancy	72 (4.3%)	39 (3.1%)	33 (7.9%)	<0.001
- Malnutrition or obvious muscle wasting	113 (6.8%)	55 (4.4%)	58 (13.9%)	<0.001
- Moderate renal disease	212 (12.7%)	138 (11.1%)	74 (17.7%)	<0.001
- End-stage renal failure	104 (6.3%)	78 (6.3%)	26 (6.2%)	0.977
- Hemiplegia	40 (2.4%)	28 (2.2%)	12 (2.9%)	0.471
- Immunosuppression	37 (2.2%)	24 (1.9%)	13 (3.1%))	0.155
- Acquired immunodeficiency syndrome	3 (0.2%)	3 (0.2%)	0 (0%)	0.315
- Palliative care or no definitive treatment	26 (1.6%)	6 (0.5%)	20 (4.8%)	<0.001
- PEA, asystole, or CPR more than 20 minutes	103 (6.2%)	12 (1.0%)	91 (21.8%)	<0.001

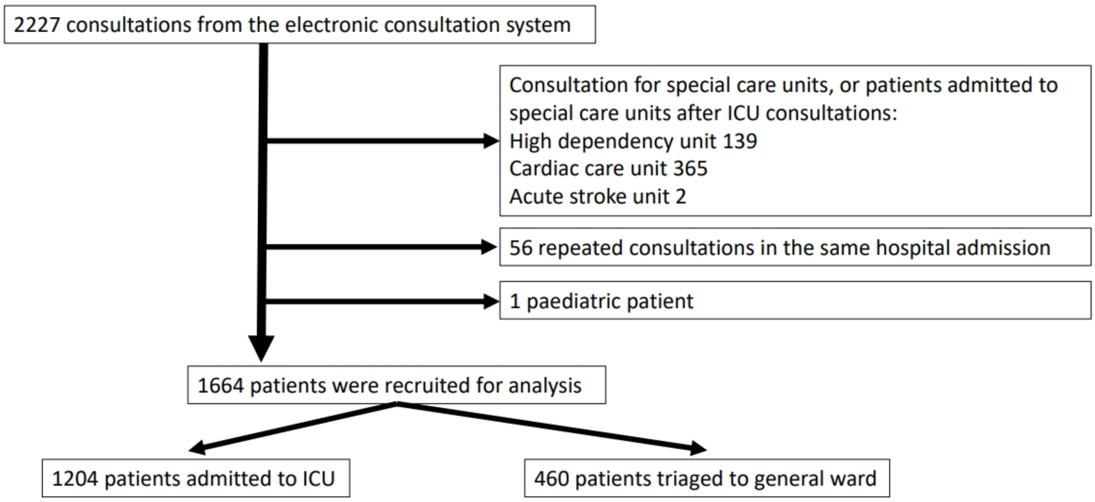
Legend: ICU=intensive care unit; SD=standard deviation; ICTS=Intensive Care Triage Score; COPD=chronic obstructive pulmonary disease; FEV1=forced expiratory volume in 1 second; LVEF=left ventricle ejection fraction; TIA=transient ischemic attack; MRSA=methicillin-resistant Staphylococcus aureus; PEA=pulseless electrical activity; CPR=cardiopulmonary resuscitation.

Table 6. Hospital mortality of patients by ICTS

ICTS	All		ICU		Non-ICU	
	n	Mortality rate	n	Mortality rate	n	Mortality rate
0	3	3.2	3	3.7	0	0
1	4	5.6	4	6.0	0	0
2	5	4.1	5	4.3	0	0
3	13	8.4	11	8.0	2	12.5
4	23	15.3	19	13.6	4	40
5	26	17.6	19	14.0	7	58.3
6	40	22.3	21	15.0	19	48.7
7	40	26.7	24	22.0	16	39.0
8	52	31.5	21	20.2	31	50.8
9	51	40.2	18	24.3	33	62.3
10	46	43.4	13	27.1	33	56.9
0-5	74	10.0	61	9.0	13	22.4
6-10	229	31.5	97	20.4	132	52.4
11 or above	115	57.8	16	32.7	99	66.0
Total	418	25.1	174	14.5	244	53.0

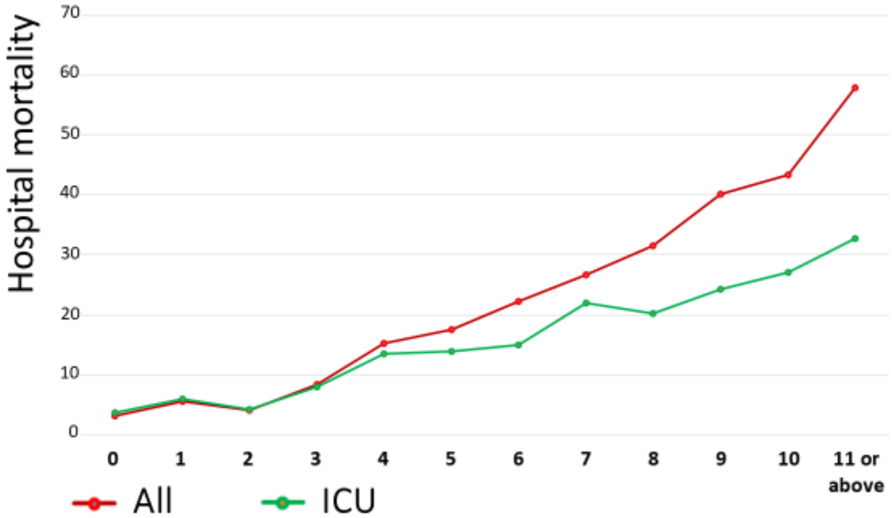
Legend: ICTS=Intensive Care Triage Score; ICU=intensive care unit.

Figure 1. Consultations from the electronic consultation system and patients recruited for analysis



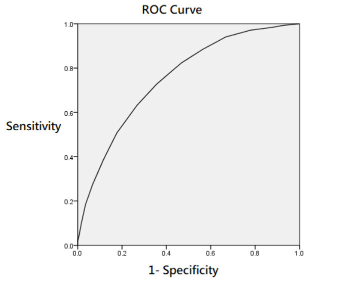
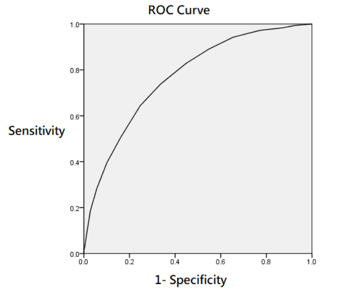
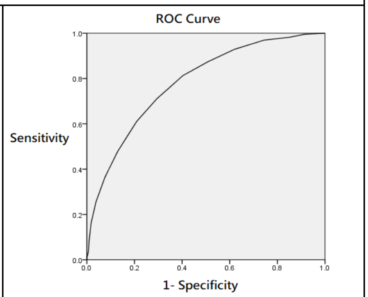
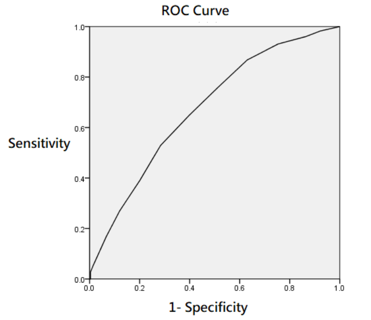
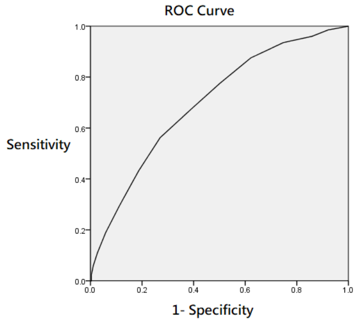
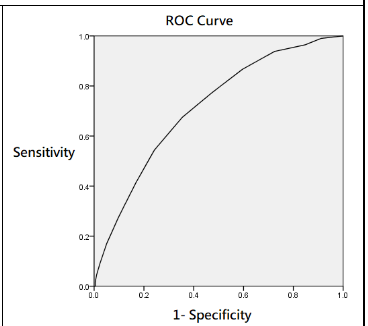
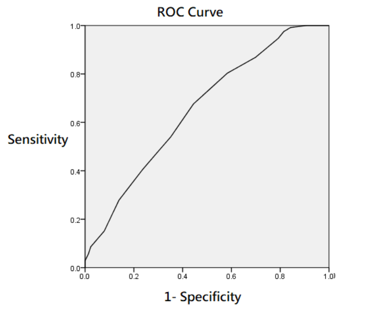
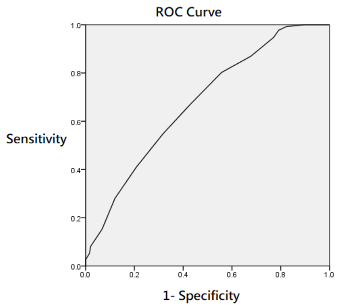
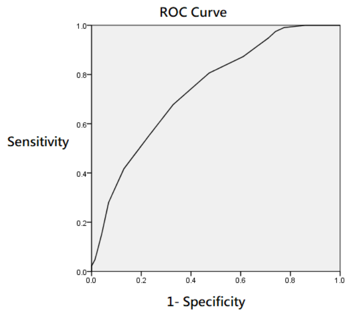
Legend: ICU=intensive care unit.

Figure 2. Hospital mortality of patients by ICTS



Legend: ICTS=Intensive Care Triage Score; ICU=intensive care unit.

Figure 3. Receiver operating characteristic curves of ICTS and APACHE II in the prediction of hospital, 90-day, and 1-year mortality

ICTS for prediction of mortality in all patients		
 Hospital mortality AUC: 0.754 (95% CI 0.728-0.780)	 90-day mortality AUC: 0.771 (95% CI 0.747-0.795)	 1-year mortality AUC: 0.782 (95% CI 0.760-0.804)
ICTS for prediction of mortality in ICU patients		
 Hospital mortality AUC: 0.675 (95% CI 0.634-0.716)	 90-day mortality AUC: 0.700 (95% CI 0.662-0.739)	 1-year mortality AUC: 0.714 (95% CI 0.681-0.746)
ICTS for prediction of mortality in non-ICU patients		
 Hospital mortality AUC: 0.656 (95% CI 0.606-0.705)	 90-day mortality AUC: 0.676 (95% CI 0.626-0.726)	 1-year mortality AUC: 0.741 (95% CI 0.692-0.789)

<table>
<tr><th colspan="3">APACHE II for prediction of mortality in ICU patients</th></tr>
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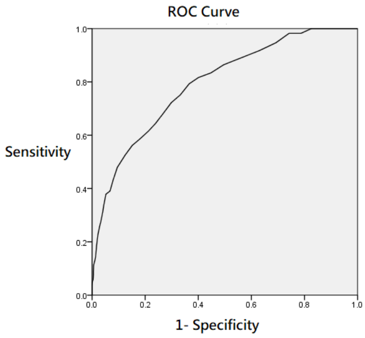
<td>


Hospital mortality
AUC: 0.794 (95% CI 0.758-0.830)
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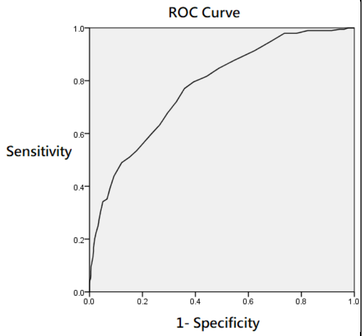

90-day mortality
AUC: 0.777 (95% CI 0.742-0.812)
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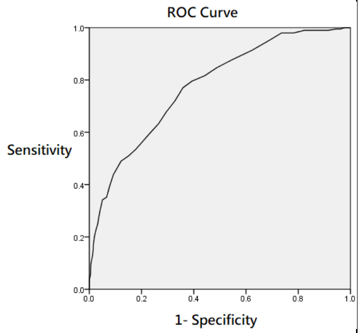

1-year mortality
AUC: 0.747 (95% CI 0.715-0.719)
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Legend: ICTS=Intensive Care Triage Score; APACHE=Acute Physiology And Chronic Health Evaluation; AUC=area under the receiver operating characteristic curve; ICU=intensive care unit.

References

1. Sprung CL, Baras M, Iapichino G, Kesecioglu J, Lippert A, Hargreaves C, et al. The Eldicus prospective, observational study of triage decision making in European intensive care units: part I--European Intensive Care Admission Triage Scores. Crit Care Med 2012;40:125-31.
2. Blanch L, Abillama FF, Amin P, Christian M, Joynt GM, Myburgh J, et al. Triage decisions for ICU admission: Report from the Task Force of the World Federation of Societies of Intensive and Critical Care Medicine. J Crit Care 2016;36:301-5.
3. Nates JL, Nunnally M, Kleinpell R, Blosser S, Goldner J, Birriel B, et al. ICU Admission, Discharge, and Triage Guidelines: A Framework to Enhance Clinical Operations, Development of Institutional Policies, and Further Research. Crit Care Med 2016;44:1553-602.
4. Quintairos A, Pilcher D, Salluh JIF. ICU scoring systems. Intensive Care Med 2023;49:223-5.
5. Bouch DC, Thompson JP. Severity scoring systems in the critically ill. Continuing Education in Anaesthesia Critical Care and Pain. 2008;8:181-5.
6. Gopalan PD, Pershad S. Decision-making in ICU - A systematic review of factors considered important by ICU clinician decision makers with regard to ICU triage decisions. J Crit Care 2019;50:99-110.
7. Sprung CL, Geber D, Eidelman LA, Baras M, Pizov R, Nimrod A, et al. Evaluation of triage decisions for intensive care admission. Crit Care Med 1999;27:1073-9.
8. Azoulay E, Pochard F, Chevret S, Vinsonneau C, Garrouste M, Cohen Y, et al. Compliance with triage to intensive care recommendations. Crit Care Med 2001;29:2132-6.
9. Ramos JG, Perondi B, Dias RD, Miranda LC, Cohen C, Carvalho CR, et al. Development of an algorithm to aid triage decisions for intensive care unit admission: a clinical vignette and retrospective cohort study. Crit Care 2016;20:81.
10. Ramos JGR, Ranzani OT, Perondi B, Dias RD, Jones D, Carvalho CRR, et al. A decision-aid tool for ICU admission triage is associated with a reduction in potentially inappropriate intensive care unit admissions. J Crit Care 2019;51:77-83.
11. Bouwmans P, Brandts L, Hilbrands LB, Duivenvoorden R, Vart P, Franssen CFM, et al. The Clinical Frailty Scale as a triage tool for ICU admission of dialysis patients with COVID-19: an ERACODA analysis. Nephrol Dial Transplant 2022;37:2264-74.
12. Joynt GM, Leung AKH, Ho CM, So D, Shum HP, Chow FL, et al. Admission triage tool for adult intensive care unit admission in Hong Kong during the COVID-19 outbreak. Hong Kong Med J 2022;28:64-72.
13. Maves RC, Downar J, Dichter JR, Hick JL, Devereaux A, Geiling JA, et al. Triage of Scarce Critical Care Resources in COVID-19 An Implementation Guide for Regional Allocation: An Expert Panel Report of the Task Force for Mass Critical Care and the American College of Chest Physicians. Chest 2020;158:212-25.
14. Census and Statistics Department, the Government of the Hong Kong Special Administrative Region. Population and Household Statistics Analysed by District Council District [Internet]. 2022 [cited 2024 Mar 23]. Available from: https://www.censtatd.gov.hk/en/wbr.html?ecode=B11303012022AN22&scode=150
15. Haas B, Wunsch H. How does prior health status (age, comorbidities and frailty) determine critical illness and outcome? Curr Opin Crit Care 2016;22:500-5.
16. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373-83.
17. Cardoso LTQ, Grion CMC, Matsuo T, Anami EHT, Kauss IAM, Seko L, et al. Impact of delayed admission to intensive care units on mortality of critically ill patients: a cohort study. Crit Care 2011;15:R28.
18. Kiekkas P, Tzenalis A, Gklava V, Stefanopoulos N, Voyagis G, Aretha D. Delayed Admission to the Intensive Care Unit and Mortality of Critically Ill Adults: Systematic Review and Meta-analysis. Biomed Res Int 2022;2022:4083494.
19. Metcalfe MA, Sloggett A, McPherson K. Mortality among appropriately referred patients refused admission to intensive-care units. Lancet 1997;350:7-11.
20. Oliveira EG, Garcia PC, Citolino Filho CM, de Souza Nogueira L. The influence of delayed admission to intensive care unit on mortality and nursing workload: a cohort study. Nurs Crit Care 2019;24:381-6.
21. Phua J, Ngerng WJ, Lim TK. The impact of a delay in intensive care unit admission for com-

munity-acquired pneumonia. Eur Respir J 2010;36:826-33.
22. Garrouste-Orgeas M, Montuclard L, Timsit J-F, Reignier J, Desmettre T, Karoubi P, et al. Predictors of intensive care unit refusal in French intensive care units: a multiple-center study. Crit Care Med 2005;33:750-5.
23. Dickson SJ, Batson S, Copas AJ, Edwards SG, Singer M, Miller RF. Survival of HIV-infected patients in the intensive care unit in the era of highly active antiretroviral therapy. Thorax 2007;62:964-8.
24. Lee I-H, Yang C-Y, Shih J-Y, Yu C-J. Tyrosine Kinase Inhibitors Improved Survival of Critically Ill EGFR-Mutant Lung Cancer Patients Undergoing Mechanical Ventilation. Biomedicines 2021;9:1416.
25. Toffart A-C, Meert A-P, Wallet F, Gibelin A, Guisset O, Gonzalez F, et al. ICU admission for solid cancer patients treated with immune checkpoint inhibitors. Ann Intensive Care 2023;13:29.
26. Guidelines for intensive care unit admission, discharge, and triage. Task Force of the American College of Critical Care Medicine, Society of Critical Care Medicine. Crit Care Med 1999;27:633-8.
27. Assi HI, Halim NA, Alameh I, Khoury J, Nahra V, Sukhon F, et al. Outcomes of Patients with Malignancy Admitted to the Intensive Care Units: A Prospective Study. Crit Care Res Pract 2021;2021:4792309.
28. Epstein AS, Yang A, Colbert LE, Voigt LP, Meadows J, Goldberg JI, et al. Outcomes of ICU Admission of Patients With Progressive Metastatic Gastrointestinal Cancer. J Intensive Care Med 2020;35:297-302.
29. Fisher R, Dangoisse C, Crichton S, Whiteley C, Camporota L, Beale R, et al. Short-term and medium-term survival of critically ill patients with solid tumours admitted to the intensive care unit: a retrospective analysis. BMJ open 2016;6:e011363.
30. Joynt GM, Gomersall CD, Tan P, Lee A, Cheng CA, Wong EL. Prospective evaluation of patients refused admission to an intensive care unit: triage, futility and outcome. Intensive Care Med 2001;27:1459-65.
31. Lienhart H, List W, Rheinberger K, Bodas M. What Happens When it Comes to Triage? A Study Evaluating the Effects of a Prioritisation of Intensive Care Unit Patients in Case of Scarce Resources. Int J Crit Care Emerg Med 2022;8:146.
32. Wilkinson DJC. Frailty Triage: Is Rationing Intensive Medical Treatment on the Grounds of Frailty Ethical? Am J Bioeth 2021;21:48-63.
33. Tak AYW, Wa YW, Hung ALK, Loi CF, Tsai P, Sum CH, et al. Therapeutic hypothermia after cardiac arrest: A survey of practice in the intensive care units (ICU) in Hong Kong. Crit Care Shock 2013;16:90-9.
34. Flavin K, Hall D, Marshall G, Zolfaghari P. Pre-ICU length of hospital stay is a predictor of hospital but not ICU mortality. Crit Care 2015;19(Suppl 1):P527.
35. Shum H-P, Chan K-C, Lau C-W, Leung AK-H, Chan K-W, Yan W-W. Triage decisions and outcomes for patients with Triage Priority 3 on the Society of Critical Care Medicine scale. Crit Care Resusc 2010;12:42-9.
36. Orsini J, Butala A, Ahmad N, Llosa A, Prajapati R, Fishkin E. Factors influencing triage decisions in patients referred for ICU admission. J Clin Med Res 2013;5:343-9.
37. Vanhecke TE, Gandhi M, McCullough PA, Lazar MH, Ravikrishnan KP, Kadaj P, et al. Outcomes of patients considered for, but not admitted to, the intensive care unit. Crit Care Med 2008;36:812-7.
38. Ling L, Ho CM, Ng PY, Chan KCK, Shum HP, Chan CY, et al. Characteristics and outcomes of patients admitted to adult intensive care units in Hong Kong: a population retrospective cohort study from 2008 to 2018. J Intensive Care 2021;9:2.
39. Garg AX, Adhikari NKJ, McDonald H, Rosas-Arellano MP, Devereaux PJ, Beyene J, et al. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. JAMA 2005;293:1223-38.
40. Herridge MS, Azoulay E. Outcomes after Critical Illness. N Engl J Med 2023;388:913-24.

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