

# Characteristics Associated with Length of Stay in Intensive Care Unit for Cancer Patients in China: A Nationwide Retrospective Cohort Study

Guoxing Zhang<sup>1</sup>, Haitao Liu<sup>2</sup>, Rui Xia<sup>3</sup>, Li Zhang<sup>4</sup>, Kaizhong Liu<sup>5</sup>, Dongmin Zhou<sup>6</sup>, Xuezhong Xing<sup>7</sup>, Haifeng Liu<sup>1</sup> On behalf of the Cancer Critical Care Medicine Committee of the Chinese Anti-Cancer Association

<sup>1</sup>Department of Critical Care Medicine, Jilin Cancer Hospital, Chang Chun, Jilin, People's Republic of China; <sup>2</sup>Department of Critical Care Medicine, Harbin Medical University Cancer Hospital, Harbin, Heilongjiang, People's Republic of China; <sup>3</sup>Department of Critical Care Medicine, Tianjin Medical University Cancer Institute and Hospital, Tianjin, People's Republic of China; <sup>4</sup>Department of Critical Care Medicine, Hubei Cancer Hospital, Wuhan, Hubei, People's Republic of China; <sup>5</sup>Department of Critical Care Medicine, Zhejiang Tumor Hospital, Hangzhou, Zhejiang, People's Republic of China; <sup>6</sup>Department of Critical Care Medicine, HeNan Tumor Hospital, Zhengzhou, Henan, People's Republic of China; <sup>7</sup>Department of Critical Care Medicine, Cancer Hospital of Chinese Academy of Medical Sciences, Beijing, People's Republic of China

Correspondence: Haifeng Liu, Department of Critical Care Medicine, Jilin Cancer Hospital, 1066 Jinhu Road, Chang Chun, Jilin, 130021, People's Republic of China, Email hflydw@163.com; Xuezhong Xing, Department of Critical Care Medicine, Cancer Hospital of Chinese Academy of Medical Sciences, 17 Panjiayuan Nanli, Chaoyang District, Beijing, 100020, People's Republic of China, Email xingxuezhong@cicams.ac.cn

**Introduction:** Cancer patients can receive specialized care and monitoring at intensive care unit (ICU). However, prolonged ICU stay may increase medical expenses and risk of complications.

**Methods:** To assess characteristics associated with length of stay (LOS) at ICU in Chinese cancer patients, a retrospective cohort study was conducted at 33 ICUs in China between May and July 2021. Cancer patients' demographics, medical history, disease severity, cancer types, status and treatments at the admission, death or survival, and LOS were documented. Characteristics associated with the LOS were determined by the bivariable and multivariable linear regression analyses.

**Results:** The study included 1488 cancer patients, with a median age of 63 (interquartile range [IQR]: 56–72) years old, and 61.4% of patients were men. The median LOS was 4 (IQR, 2–7) days. Chronic renal failure, delirium, sepsis, renal replacement therapy, mechanical ventilation, sedatives, and feeding method were significantly associated with the LOS. Subgroup analysis indicated that chronic renal failure, delirium, sepsis, renal replacement therapy, mechanical ventilation, and feeding method (enteral with or without parenteral feeding) were associated with the LOS in patients who survived to be discharged from ICU. Only the feeding method was associated with the LOS in patients who died.

**Conclusion:** A clinical history of chronic renal failure, along with specific conditions and treatments administered during admission, was significantly associated with the LOS at ICU for cancer patients overall.

**Keywords:** cancer, length of stay, intensive care unit, death

## Introduction

Cancer is one of the most common causes of death worldwide,<sup>1</sup> and its incidence is also expected to rise.<sup>2</sup> Cancer patients may become critically ill due to their underlying medical diseases, surgical procedures, or anti-cancer therapies-associated complications. Close monitoring and medical management in the intensive care unit (ICU) could potentially enhance morbidity and mortality outcomes for these patients.<sup>3</sup> Specialized oncology ICUs have been designed to provide advanced medical and nursing care for cancer patients.<sup>4</sup> These oncology ICUs have sophisticated equipment, with dedicated well-trained staff, to provide critical care and life support. However, the hospitalization in the ICU is expensive and may use numerous medical resources. This may not only impact patients and their families but also have broader implications for public healthcare systems.<sup>5</sup> The length of stay (LOS) at ICU was reported to be associated with high

medical expenses.<sup>6</sup> In addition, prolonged ICU stay could also lead to a high risk of complications.<sup>7,8</sup> Hence, understanding the characteristics associated with the LOS at ICU may improve the quality of care for patients, as well as optimizing the medical resources to benefit the overall patient population.

Numerous studies have been performed to determine characteristics associated with prolonged ICU stay. It was reported that certain laboratory test results, comorbidities, disease severity, and treatments could all influence the LOS at ICU.<sup>9,10</sup> Compared with patients with other diseases, cancer patients require special medical care, as they commonly are older with multiple medical conditions. Their management mainly involves multimodal treatments, and the adverse effects of therapeutic approaches are noteworthy. Recent studies have demonstrated an upward trend of ICU admission for cancer patients.<sup>4,11</sup> However, characteristics affecting the LOS at ICU in cancer patients have been understudied.

We have previously performed a nationwide multicenter retrospective cohort study and reported characteristics and mortality in 33 ICUs in China.<sup>12</sup> The present study used the same data and aimed to assess characteristics associated with the LOS at ICU in cancer patients, in order to optimize the medical resource utilization and improve healthcare for cancer patients.

## Materials and Methods

### Study Design and Participants' Selection

This multicenter retrospective cohort study was conducted in 33 ICUs across China, and ethical approval was obtained from the ethics committee of Jilin Cancer Hospital. The study was conducted following the ethical requirement to protect patient data confidentiality and in strict compliance with the principles of the Declaration of Helsinki.

The inclusion criterion was cancer patients at the ICU between May and July 2021. The exclusion criteria were as follows: 1) patients who opted to discharge themselves from the ICU against medical advice; or 2), patients with incomplete medical records. For patients with multiple ICU admissions, only data from the first ICU admission were recorded.

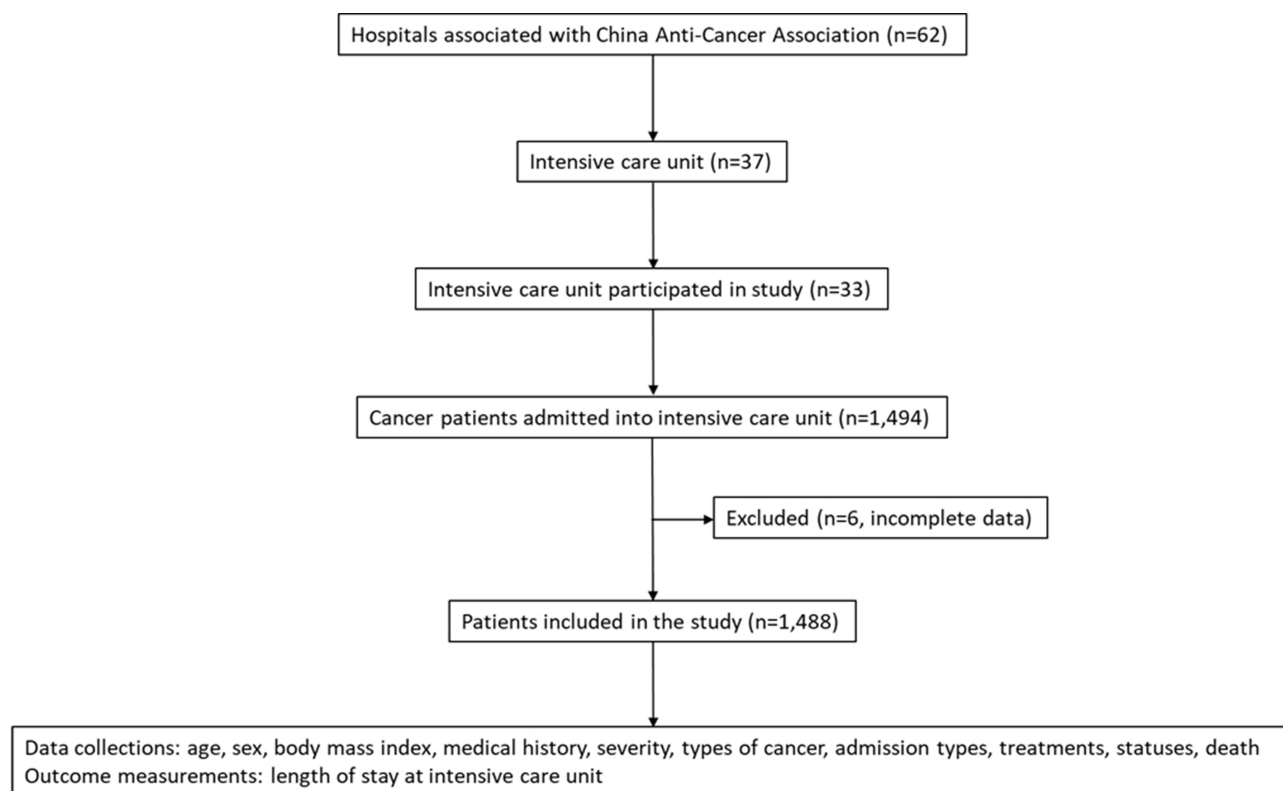
### Data Collection

Data collection was carried out as reported previously.<sup>12</sup> Briefly, age, sex, medical history, weight, height, the Acute Physiology and Chronic Health Evaluation (APACHE) II score, type of admission (emergency versus elective), type of cancer, cancer treatment at or before the ICU admission, and patients' status and treatment at the ICU admission were recorded. In addition, death or survival until ICU discharge was documented.

The primary outcome was LOS at ICU, which was defined as the total number of days from ICU admission to either discharge or death.

### Statistical Analysis

Based on the results of normality tests, continuous data were presented as mean  $\pm$  standard deviation or median with interquartile range (IQR). Categorical data were expressed as number and percentage. An initial bivariable analysis was conducted to assess the associations between various patient characteristics and LOS at ICU. Variables showing a statistically significant association with the outcome variable ( $P < 0.05$ ) were subsequently included as independent variables in the multivariable linear regression analysis, and LOS at ICU served as the dependent variable. The multivariable regression analysis was conducted to explore the relationship between a dependent variable (ICU length of stay) and multiple independent variables. Given the potential differences in factors influencing LOS at ICU between patients who died in the ICU and those who survived to discharge, subgroup analysis was performed. Patients were stratified into two groups based on their ICU outcomes (deceased or discharged alive), and bivariable and multivariable linear regression analyses were conducted separately for each subgroup to identify characteristics independently associated with LOS at ICU. Statistical analysis was conducted using SPSS 22.0 software (IBM, Armonk, NY, USA), with statistical significance set at  $P < 0.05$ .



**Figure 1** Patients' enrollment flowchart.

## Results

### Participants' Characteristics

We included 1488 cancer patients from 33 ICUs in the final analysis in the present study (Figure 1). Their median age was 63 (IQR, 56–72) years old, 61.4% (913) were men, and the median LOS was 4 (IQR, 2–7) days (Table 1). The most common medical history was hypertension (473 patients, 31.8%), and the most prevalent cancer type was gastrointestinal cancer (583

**Table 1** Characteristics of Study Participants with Cancer Admitted to the Intensive Care Unit (N=1488)

Characteristics	N (%) or Median (IQR)
Age, years	63(56–72)
Sex	
Male	913(61.4%)
Body mass index, kg/m <sup>2</sup>	22.6(20.0–24.8)
Medical history*	
Hypertension	473(31.8%)
Diabetes mellitus	212(14.3%)
Coronary artery disease	122(8.2%)
Congestive heart failure	23(1.5%)
Chronic obstructive pulmonary disease	35(2.4%)
Autoimmune disease	11(0.7%)
Chronic renal failure	44(3.0%)
Chronic liver disease	21(1.4%)

(Continued)

**Table 1** (Continued).

Characteristics	N (%) or Median (IQR)
Severity	
APACHE II	13.5(8–17)
Type of admission	
Emergency	922(62.0%)
Elective	566(38.0%)
Type of cancer*	
Hematology	56(3.8%)
Genitourinary	78(5.2%)
Gastrointestinal	583(39.2%)
Head and neck	138(9.3%)
Pulmonary and mediastinum	301(20.2%)
Gynecology	160(10.8%)
Musculoskeletal	16(1.1%)
Hepatobiliary and pancreas	129(8.7%)
Unknown‡	27(1.8%)
Cancer treatments at or before ICU admission*	
Surgery	790(53.1%)
Chemoradiation therapy	162(10.9%)
Targeted therapy	28(1.9%)
Immunotherapy	14(0.9%)
More than two treatments	278(18.7%)
None	216(14.5%)
Status and treatments at ICU admission†	
Delirium	82(5.5%)
Sepsis	940(63.2%)
Mechanical ventilation	657(44.2%)
Renal replacement therapy	82(5.5%)
Shock	412(27.7%)
Sedatives	437(29.4%)
Analgesics	437(29.4%)
Feeding methods	
EN	388(26.1%)
PN	474(31.9%)
EN+PN	610(41.0%)

**Notes:** The type of cancer does not represent all disease categories due to the limited number of patients in some disease types. \*The total percentages may not add up to 100% due to rounding. †A patient may have more than one of the listed conditions. ‡Documentation in the medical charts was unclear.

**Abbreviations:** APACHE, Acute Physiology and Chronic Health Evaluation; EN, enteral nutrition; ICU, intensive care unit; IQR, interquartile range; PN, parenteral nutrition.

patients, 39.2%). Nearly two-thirds of patients (922 patients, 62.0%) required emergency ICU admission, while slightly more than half (790 patients, 53.1%) underwent surgery. At the admission to ICUs, 63.2% (940) of patients had sepsis.

## Characteristics Associated with LOS in Oncology ICU

Bivariable analysis indicated that chronic renal failure, APACHE II, type of ICU admission, cancer treatments administered at or prior to ICU admission (such as surgery and immunotherapy), recorded statuses and treatment methods at ICU admission, and feeding methods were all associated with LOS at ICU (Table 2). In the multivariable linear regression, which included characteristics significantly linked with LOS from the bivariable analysis, a medical history of chronic

**Table 2** Bivariable Analysis of Characteristics Associated with the Length of Stay at Oncology Intensive Care Unit in Cancer Patients

Characteristics	Regression Coefficient	95% CI	P
Age	0.00	-0.02-0.03	0.773
Sex	-0.13	-0.80-0.54	0.710
Body mass index	-0.09	-0.17-0.00	0.052
Medical history			
Hypertension	-0.13	-0.83-0.58	0.726
Diabetes	0.33	-0.61-1.26	0.493
Coronary artery disease	-0.29	-1.48-0.91	0.636
Congestive heart failure	1.58	-1.07-4.24	0.241
Chronic obstructive pulmonary disease	1.98	-0.17-4.14	0.072
Autoimmune disease	2.93	-0.89-6.75	0.133
Chronic renal failure	3.11	1.19-5.04	0.002
Chronic liver disease	0.78	-2.0-3.55	0.583
Severity			
APACHE II	0.19	0.14-0.23	<0.001
Type of admission	-2.59	-3.25- -1.93	<0.001
Type of cancer	0.13	-0.03-0.28	0.106
Cancer treatments at or before ICU admission	0.36	0.20-0.52	<0.001
None (ref.)			
Surgery	-1.98	-2.93- -1.02	<0.001
Chemoradiation therapy	0.45	-0.84-1.74	0.494
Targeted therapy	2.19	-0.31-4.69	0.085
Immunotherapy	3.94	0.51-7.37	0.024
More than two treatments	-0.62	-1.75-0.51	0.279
Status and treatments at ICU admission			
Delirium	3.05	1.63-4.48	<0.001
Sepsis	3.68	3.03-4.33	<0.001
Mechanical ventilation	2.97	2.33-3.61	<0.001
Renal replacement therapy	4.07	2.65-5.49	<0.001
Shock	2.39	1.67-3.11	<0.001
Sedatives	3.64	2.95-4.34	<0.001
Analgesics	3.29	2.59-3.99	<0.001
Feeding methods			
PN (ref.)			
EN	1.45	0.59-2.30	0.001
EN+PN	2.68	1.92-3.44	<0.001

**Abbreviations:** APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; EN, enteral nutrition; ICU, intensive care unit; PN, parenteral nutrition.

renal failure and specific statuses and treatments at ICU admission, such as delirium, sepsis, renal replacement therapy, mechanical ventilation, enteral feeding (with or without parenteral feeding), and the use of sedatives, were found to be significantly associated with prolonged LOS at ICU (Table 3).

## Subgroup Analysis

In subgroup analysis, the median LOS was 6 (IQR: 3-12) days for patients who died in the ICU (n = 88) and 4 (IQR: 2-7) days for those who survived to be discharged from ICU (n = 1400). In bivariable and multivariable linear regression analyses (Tables 4 and 5), among patients who died in the ICU, only the feeding method (enteral feeding with or without parenteral feeding) was significantly associated with the prolonged LOS. Regarding patients who survived to be discharged from ICU, a medical history of chronic renal failure and certain status at the ICU admission, ie, delirium, sepsis, renal

**Table 3** Multivariable Linear Regression Analysis of Characteristics Associated with the Length of Stay at Oncology Intensive Care Unit in Cancer Patients

Characteristics	Regression Coefficient	95% CI	P
Chronic renal failure (Yes vs No)	2.80	0.99–4.60	0.002
APACHE II	0.01	–0.04–0.06	0.663
Type of admission (Emergency vs Elective)	–0.33	–1.13–0.47	0.421
Cancer treatments			
None (ref.)			
Surgery	–0.24	–1.24–0.77	0.645
Chemoradiation therapy	0.46	–0.76–1.68	0.457
Targeted therapy	1.59	–0.74–3.93	0.181
Immunotherapy	2.71	–0.52–5.93	0.100
More than two treatments	0.030	–1.05–1.11	0.961
Status and treatments at ICU admission			
Delirium	2.04	0.70–3.38	0.003
Sepsis	2.13	1.37–2.89	<0.001
Mechanical ventilation	1.54	0.63–2.43	0.001
Renal replacement therapy	2.30	0.89–3.72	0.001
Shock	0.62	–0.15–1.39	0.114
Sedatives	1.42	0.14–2.70	0.029
Analgesics	–0.25	–1.50–0.99	0.690
Feeding methods			
EN (vs PN)	1.76	0.94–2.58	<0.001
EN+PN (vs PN)	2.25	1.52–2.97	<0.001

**Notes:** Model fit: R<sup>2</sup>=0.17, F=17.57 (P<0.001), residual mean=2.56<sup>-16</sup>, standard deviation=0.996.

**Abbreviations:** APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; EN, enteral nutrition; ICU, intensive care unit; PN, parenteral nutrition.

**Table 4** Bivariable Analysis of Characteristics of Cancer Patients Who Died or Survived to Be Discharged from Intensive Care Unit

Characteristics	Died (N=88)			Survived (N=1400)		
	Regression Coefficient	95% CI	P	Regression Coefficient	95% CI	P
Age	0.09	–0.08–0.26	0.302	0.00	–0.03–0.02	0.759
Sex	1.05	–3.61–5.70	0.656	–0.13	–0.78–0.53	0.706
Body mass index	0.23	–0.38–0.84	0.452	–0.09	–0.17– –0.00	0.044
Medical history						
Hypertension	–0.29	–5.30–4.72	0.909	–0.04	–0.72–0.64	0.904
Diabetes	0.19	–6.97–7.35	0.957	0.41	–0.49–1.31	0.370
Coronary artery disease	3.70	–4.87–12.27	0.393	–0.45	–1.61–0.7	0.440
Congestive heart failure	–4.77	–25.22–15.68	0.644	1.94	–0.61–4.49	0.136
Chronic obstructive pulmonary disease	13.08	–1.21–27.37	0.072	1.32	–0.77–3.41	0.217
Autoimmune disease	-	-	-	3.16	–0.43–6.75	0.085
Chronic renal failure	–2.03	–11.39–7.33	0.667	3.52	1.59–5.44	<0.001
Chronic liver disease	–3.76	–24.21–16.7	0.716	1.05	–1.63–3.73	0.441
Severity						
APACHE II	–0.08	–0.34–0.17	0.528	0.19	0.14–0.23	<0.001
Type of admission	–2.32	–12.73–8.08	0.658	–2.33	–2.97– –1.70	<0.001
Type of cancer	1.03	0.09–1.96	0.031	0.03	–0.12–0.18	0.711

(Continued)

**Table 4** (Continued).

Characteristics	Died (N=88)			Survived (N=1400)		
	Regression Coefficient	95% CI	P	Regression Coefficient	95% CI	P
Cancer treatments at or before ICU admission						
None (ref.)						
Surgery	-2.48	-8.95-3.99	0.488	-1.61	-2.56- -0.66	0.001
Chemoradiation therapy	-3.99	-10.23-2.26	0.208	1.01	-0.27-2.30	0.127
Targeted therapy	-2.14	-11.99-7.71	0.667	2.82	0.23-5.40	0.033
Immunotherapy	17.46	-2.99-37.91	0.093	3.07	-0.29-6.42	0.073
More than two treatments	1.33	-4.45-7.12	0.648	-0.70	-1.82-0.42	0.219
Status and treatments at ICU admission (Yes vs No)						
Delirium	0.30	-9.07-9.67	0.949	3.22	1.84-4.61	<0.001
Sepsis	4.09	-3.41-11.58	0.281	3.47	2.84-4.09	<0.001
Mechanical ventilation	4.47	-0.72-9.66	0.090	2.66	2.03-3.29	<0.001
Renal replacement therapy	-0.35	-5.36-4.66	0.890	4.44	2.89-5.99	<0.001
Shock	-0.84	-5.65-3.96	0.728	2.21	1.48-2.93	<0.001
Sedatives	3.96	-0.44-8.36	0.077	3.35	2.66-4.04	<0.001
Analgesics	3.33	-1.03-7.68	0.133	3.02	2.33-3.71	<0.001
Feeding methods						
PN (ref.)						
EN	4.81	-0.42-10.05	0.071	1.26	0.43-2.09	0.003
EN+PN	7.04	2.19-11.89	0.005	2.50	1.75-3.24	<0.001

**Note:** -few or no observation in this subgroup.

**Abbreviations:** APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; EN, enteral nutrition; ICU, intensive care unit; PN, parenteral nutrition.

replacement therapy, mechanical ventilation, and feeding methods (enteral feeding with or without parenteral feeding), were positively associated with the prolonged LOS at ICU.

## Discussion

In the present study, the median LOS was 4 (IQR, 2-7) days at ICU, which was slightly shorter than those reported previously (global wise 5.7, Asia patients 6.7).<sup>13</sup> It was found that chronic renal failure, delirium, sepsis, renal replacement therapy, mechanical ventilation, feeding method, and sedatives, and were significantly positively associated with the prolonged LOS in cancer patients. In cancer patients who survived to be discharged from ICU, chronic renal failure, delirium, sepsis, renal replacement therapy, mechanical ventilation, and feeding method were positively associated with the prolonged LOS at ICU. Physicians and hospital administrators should consider these factors to optimize the ICU efficiency and drive quality improvements.

In recent years, cancer patients were often considered inappropriate candidates for ICU admission due to their low survival rates.<sup>4</sup> However, with rapid advances in the new anti-cancer treatments and organ-supportive cares, cancer patients' survival rates have significantly improved. Recent studies have reported an upward trend of ICU admission in cancer patients.<sup>4,11</sup> However, cancer patients typically require lengthy expensive treatments. The use of organ-supportive devices, such as mechanical ventilator and hemodialysis, is costly. With the limited number of ICU beds, the early identification of patients who may require prolonged ICU stay might help to tailor the treatments to patients with special needs and achieve more cost-effective use of ICU services.

A recent multicenter study conducted in Australia indicated that several pre-existing medical diseases, such as congestive heart failure, kidney disease, peptic ulcer, and coronary artery disease, were associated with the prolonged LOS at ICU.<sup>14</sup> In terms of kidney disease, a higher degree of kidney dysfunction was linked to a longer ICU stay.<sup>15</sup> In the present study, among the documented medical histories, only chronic renal failure was found to be associated with a longer ICU stay in cancer

**Table 5** Multivariable Linear Regression Analysis of Cancer Patients Who Died or Survived to Be Discharged from Intensive Care Unit

Characteristics	Died (N=88)			Survived (N=1400)		
	Regression Coefficient	95% CI	P	Regression Coefficient	95% CI	P
Body mass index	0.22	-0.49-0.94	0.534	0.01	-0.07-0.09	0.805
Chronic renal failure (Yes vs No)	3.68	-8.02-15.37	0.532	3.11	1.30-4.91	0.001
APACHE II	0.20	-0.1-0.51	0.190	0.02	-0.03-0.08	0.445
Type of admission (Emergency vs Elective)	-1.95	-12.83-8.93	0.721	-0.34	-1.12-0.44	0.396
Type of cancer	0.95		0.063	-0.001		0.939
Hematology (ref.)						
Genitourinary	-0.80	-14.33-12.72	0.906	-2.59	-4.64- -0.54	0.013
Gastrointestinal	9.07	-2.19-20.33	0.113	-0.85	-2.54-0.83	0.321
Head and neck	2.40	-16.71-21.51	0.803	-2.29	-4.16- -0.42	0.016
Pulmonary and mediastinum	1.77	-9.12-12.65	0.746	-1.32	-3.04-0.39	0.130
Gynecology	-0.47	-13.81-12.87	0.944	-0.68	-2.49-1.14	0.465
Musculoskeletal	4.84	-12.53-22.22	0.579	-3.23	-6.77-0.3	0.073
Hepatobiliary and pancreas	16.35	4.31-28.38	0.009	-1.19	-3.09-0.71	0.219
Cancer treatments at or before ICU admission	0.26		0.683	-0.03		0.712
None (ref.)						
Surgery	-0.75	-8.05-6.55	0.838	-0.18	-1.21-0.84	0.723
Chemoradiation therapy	-2.81	-10.52-4.9	0.469	0.83	-0.4-2.07	0.185
Targeted therapy	-0.13	-10.84-10.58	0.981	2.10	-0.35-4.55	0.094
Immunotherapy	15.99	-5.48-37.47	0.142	1.75	-1.53-5.04	0.296
More than two treatments	1.56	-5.53-8.65	0.662	-0.34	-1.44-0.75	0.538
Status and treatments at ICU admission (Yes vs No)						
Delirium	-1.04	-12.13-10.05	0.852	2.39	1.07-3.71	<0.001
Sepsis	0.10	-9.56-9.77	0.983	1.90	1.15-2.64	<0.001
Mechanical ventilation	5.78	-2.96-14.52	0.191	1.63	0.71-2.54	<0.001
Renal replacement therapy	-0.70	-6.85-5.46	0.822	2.88	1.32-4.44	<0.001
Shock	-2.28	-8.28-3.72	0.451	0.54	-0.23-1.31	0.166
Sedatives	-1.00	-13.13-11.13	0.869	1.17	-0.09-2.44	0.069
Analgesics	2.09	-7.92-12.09	0.678	-0.27	-1.5-0.96	0.665
Feeding methods						
EN (vs PN)	8.49	1.58-15.39	0.017	1.67	0.8-2.53	<0.001
EN+PN (vs PN)	11.24	5.11-17.36	0.001	2.12	1.39-2.85	<0.001

**Notes:** "Died" model fit:  $R^2=0.38$ ,  $F=1.51$  ( $P=0.096$ ), residual mean= $3.26^{-16}$ , standard deviation= $0.915$ . "Survived" model fit,  $R^2=0.18$ ,  $F=12.07$  ( $P<0.001$ ), residual mean= $2.98^{-16}$ , standard deviation= $0.995$ .

**Abbreviations:** APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; EN, enteral nutrition; ICU, intensive care unit; PN, parenteral nutrition.

patients, specifically in those who survived to be discharged from the ICU. Furthermore, renal replacement therapy was significantly linked to the prolonged LOS at ICU in these patients. Chronic renal disease has been reported to be more prevalent in cancer patients than the general population.<sup>14,16</sup> The incidence of cancer was also higher in patients with chronic renal disease.<sup>17</sup> There might be an intrinsic close association between renal disease and cancer because patients with renal failure mainly have increased chronic inflammation reactions and oxidative stress, with accumulation of toxic compounds in the body, contributing to the development or deterioration of other serious diseases, thereby causing prolonged treatments and hospitalization at the ICU.<sup>18</sup> This suggests that clinicians should pay special attention to cancer patients with chronic renal disease. Additional intensive management and special care for these patients may shorten their LOS at ICU.

Delirium refers to a severe rapid deterioration of mental status, which typically happens in patients with critical illness.<sup>19</sup> Up to 40% of patients at the ICU might experience delirium.<sup>20</sup> Patients with delirium frequently require close monitoring and complicated management, extending treatment duration. Delirium could significantly prolong the LOS at

ICU and increase medical expenses.<sup>20</sup> In the present study, it was revealed that delirium at the admission to ICU was closely associated with the prolonged LOS, which could be accompanied by higher expenses and medical resource utilization. Delirium patients may more frequently receive sedative medication, which is consistent with a longer ICU stay arising from the sedative use achieved in the present study. Sharma et al implemented a daily ICU sedative vacation protocol (a daily short-term cessation of sedation) that reduced the LOS and improved the mortality rate.<sup>21</sup> Given the potential for missed or delayed diagnosis of delirium,<sup>22</sup> it becomes crucial to assess not only the medical condition but also cancer patients' mental status during their ICU admission when estimating the duration of their ICU stay.

Sepsis globally stands out as the prevailing diagnosis at ICU.<sup>23</sup> The present study also revealed that nearly two-thirds of patients (63.2%) had sepsis at the time of ICU admission. Patients with sepsis mainly have multiple organ failure and require multidisciplinary treatments, including prolonged antibiotic therapy, renal replacement therapy, and mechanical ventilation. Sepsis and severity of sepsis have been associated with the LOS at ICU,<sup>24,25</sup> with prompt and appropriate sepsis treatment significantly decreasing the LOS at ICU,<sup>26</sup> aligning with findings of the present study. Robust sepsis management is crucial in these patients with cancer and sepsis.

Previous studies have demonstrated that early enteral nutrition could shorten the LOS at ICU.<sup>27–30</sup> The results of the present study indicated that cancer patients who received enteral nutrition had a longer LOS than cancer patients who received parenteral nutrition. The mixed feeding method (parenteral nutrition and enteral nutrition) exhibited the longest ICU stay. These results were observed in all patients, as well as in the subgroup analysis of patients who either died in the ICU or survived to be discharged from ICU. The underlying cause of the prolonged ICU stay in cancer patients with enteral nutrition or mixed feeding method remains elusive. Compared with the parenteral feeding, the enteral feeding is more physiological with fewer complications to provide more balanced nutrition support. Patients with critical illnesses, excluding cancer, may experience quicker recovery and earlier discharge from the ICU when provided with enteral feeding. However, in cancer patients, the enteral feeding can prolong their lives, while it does not necessarily let them recover faster from the terminal cancer, ultimately leading to the prolonged ICU stay. The results of the present study indicated that factors influencing the LOS could significantly differ in patients with or without cancer. Cancer patients may have certain unique characteristics influencing their LOS at ICU and treatment course. However, further studies are warranted to deeply assess those influential characteristics.

Subgroup analysis of patients who either died in the ICU or survived to be discharged revealed that only the feeding method was associated with LOS in those who died in the ICU. These patients generally had a prolonged ICU stay, with their status and treatments during the ICU stay, rather than at admission, indicating a stronger association with both their length of stay and mortality. This suggests that clinicians should carefully weigh the benefits and costs of aggressive ICU treatment versus palliative care management, particularly in resource-limited settings. In patients who survived, the characteristics associated with a longer ICU stay were similar to those found in the entire cohort (except sedatives), highlighting the importance of these factors when assessing the length of ICU stay in cancer patients.

The present study has several strengths, including a large sample size and nationwide data collection from 33 hospitals across different regions of China. However, it also has limitations, such as its retrospective design, potential selection bias, and missing data (eg, cancer stage). Some variables, such as disease diagnosis (delirium, sepsis), were obtained through medical record reviews, which could introduce information bias. In the subgroup analysis, the deceased group consisted of only 88 patients, which might lead to unreliable results. We identified certain clinical conditions, such as chronic renal failure and delirium, that were associated with LOS at ICU, potentially influenced by their underlying mechanisms. However, these underlying disease mechanisms (eg, inflammation, metabolic changes) were unavailable in the medical records for our retrospective study, limiting further analysis. Hospital length of stay can be affected by various factors, including ICU bed availability, which may vary across regions and countries, potentially influencing patient outcomes and LOS.<sup>31,32</sup> Unfortunately, we did not have data on ICU bed availability in this retrospective study, and thus, the results might not be applicable to hospitals with differing resource settings, such as those with varying bed availability. These unmeasured variables could contribute to the low  $R^2$  values found in the multivariable regression models. Our findings should be validated in other clinical settings, as treatment approaches and healthcare resources for cancer patients may vary across countries, potentially resulting in significant differences in LOS at ICU.<sup>33</sup>

## Conclusions

In conclusion, the LOS at ICU was associated with the clinical history of chronic renal failure and medical conditions, including delirium and sepsis, as well as treatments (mechanical ventilation, renal replacement therapy, utilization of sedatives, and feeding method) in cancer patients overall. Among patients who survived to be discharged from the ICU, chronic renal failure, delirium, sepsis, renal replacement therapy, mechanical ventilation, and feeding methods (enteral with or without parenteral feeding) were associated with prolonged LOS. In contrast, only the feeding method was associated with LOS in patients who died in the ICU. When admitting a cancer patient to the ICU, clinicians should consider these characteristics and implement appropriate management strategies to optimize healthcare resources.

## Approval of the Research Protocol by an Institutional Reviewer Board

The study protocol was approved by the ethics committee of Jilin Cancer Hospital.

## Abbreviations

APACHE, Acute Physiology and Chronic Health Evaluation; EN, Enteral nutrition; ICU, Intensive care unit; IQR, Interquartile range; PN, Parenteral nutrition.

## Informed Consent

Written informed consent was waived due to the retrospective design of the study.

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## Author Contributions

All authors made a significant contribution to this research, including the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the research.

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