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# Outcomes for Patients with Sepsis Following Admission to the Intensive Care Unit Based on Health Insurance Status: A Study from the Medical Information Mart for Intensive Care-III (MIMIC-III) Database

Authors' Contribution:  
Study Design A  
Data Collection B  
Statistical Analysis C  
Data Interpretation D  
Manuscript Preparation E  
Literature Search F  
Funds Collection G

ABCDEF 1 **Ying Zhou**  
BCE 2 **Di Yang**  
E 2 **Qiang Fu**  
E 1 **Tao Chen**  
E 1 **Yong Chen**  
EG 1 **Chuangdong Zheng**

1 Department of Anesthesia, The Third People's Hospital of Chengdu, Chengdu, Sichuan, P.R. China  
2 Department of Anesthesia, Sichuan Provincial People's Hospital, Chengdu, Sichuan, P.R. China

**Corresponding Author:** Ying Zhou, e-mail: [zhouying5800@outlook.com](mailto:zhouying5800@outlook.com)

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**Background:** Previous research has focused on poor outcomes from a lack of insurance, but the effects of different types of insurance for patients with sepsis in the intensive care unit (ICU) have not been well studied. We aimed to investigate whether private health insurance was better than government-run health insurance in the United States in terms of clinical outcomes of patients with sepsis in the ICU.

**Material/Methods:** Patients with sepsis were identified from the Medical information Mart for Intensive Care-III database. Patients were grouped as having private and government-run health insurance. Clinical outcomes were compared in univariate and multivariate analyses. Propensity score match (PSM) and subgroup analysis were used to check the robustness of results.

**Results:** Data from 13,957 patients were extracted. After adjustment by multivariate model, the private insurance group had similar rates of ICU mortality (relative risk [RR] [95% confidence interval CI]=1.052 [0.919–1.205],  $P=.463$ ) and 90-day (RR [95% CI]=.964 [0.885–1.051],  $P=.406$ ) compared with the group with government-run insurance. The private insurance group had longer ICU stays (strictly standardized mean difference=0.092,  $P<.001$ ) and better long-term survival (hazard ratio [95% CI]=0.875 [0.825–0.928],  $P<.001$ ) than the government-run insurance group in the PSM cohorts. Subgroup analysis indicated little variation in results for specific conditions.

**Conclusions:** Patients with sepsis who had private insurance had longer ICU stays but similar ICU mortality and 90-day mortality rates than similar patients with government-run insurance; they seemed to have better long-term survival, but more evidence may be required to support this conclusion.

**MeSH Keywords:** Database • Hospital Mortality • Insurance, Major Medical • Propensity Score • Sepsis • Survival Rate

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## Background

Insurance has proven to be associated with the outcomes of patients who have a variety of clinical conditions [1–3]. Previous research has focused on poor outcomes from a lack of insurance [1,4], but the effects of different types of insurance have not been well-studied. Over the years, health insurance coverage has dramatically increased. In 2008, 85.1% of Americans had insurance, versus 91.2% in 2016. In particular, private health insurance coverage was more prevalent than government-run health insurance coverage (67.5% and 37.3%, respectively). For government-run health insurance coverage, the majority of patients had Medicaid (19.4%) and Medicare (16.7%) [5].

Patients with sepsis in the Intensive Care Unit (ICU) are facing life-threatening conditions; the costs are expensive for both patients and the government. Patients with private insurance are more likely to have aggressive therapy that may not be cost-efficient compared to those with government-run insurance [2,6]. For patients in the ICU, that may mean longer mechanical ventilation, longer stays, and more invasive procedures. Not all aggressive strategies are beneficial, in terms of outcomes to every individual. For public health, distribution of medical resources is always an issue. Moreover, because most individuals with government-run insurance have low incomes, are elderly, or have disabilities [7], social equity must be considered. Thus, it is important to determine if government-run health insurance is as good as private health insurance with regard to outcomes of patients in the ICU.

The aim of this study was to explore the effects (both short- and long-term) of different types of health insurance (private and government-run programs) on outcomes of patients with sepsis in the ICU. We hypothesized that individuals with private insurance would have better outcomes than their counterparts in the ICU who had government-run health insurance.

## Material and Methods

### Data Source and Criteria

The Medical Information Mart for Intensive Care-III (MIMIC-III) database was used to identify adult patients with sepsis admitted to the ICU. It is a large, freely available database comprising deidentified health-related data associated with over 40 000 patients admitted to the critical care units of Beth Israel Deaconess Medical Center between 2001 and 2012 [8]. As a result, the informed consent and approval of the Institutional Review Board were waived.

Inclusion and exclusion criteria were: (1) sepsis diagnosis meeting the Angus criteria – simply, patients were suffering from

a bacterial or fungal infection plus a diagnosis of acute organ dysfunction [9]; (2) age 18 to 89 years old; (3) first admission to the ICU (if there were multiple admissions for the same patient); and (4) insurance type was not “self-pay”. The dataset size is shown in the analysis flow chart.

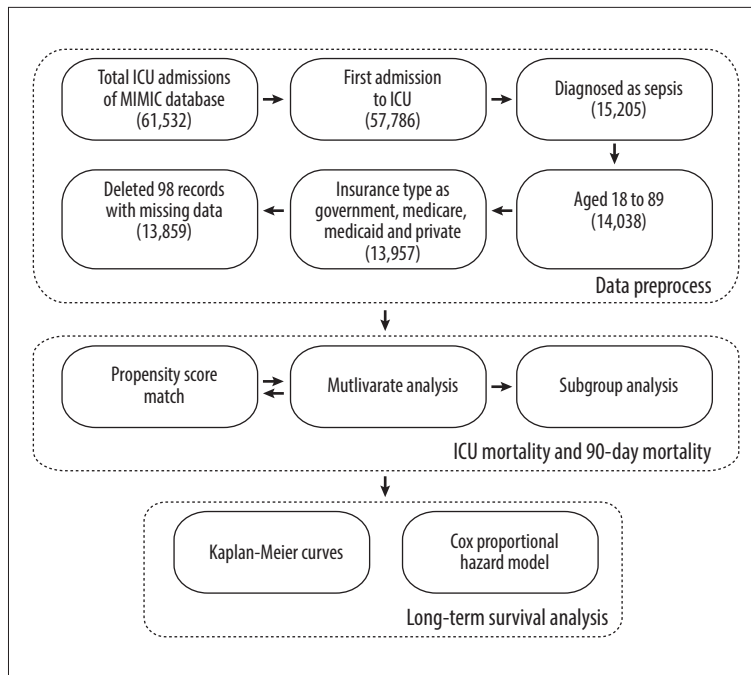
### Feature data for extraction

General information, including admission type (i.e., elective, urgent or emergency, according to the treatment priority); insurance type (i.e., private, government, Medicare and Medicaid); sex; age when admitted to the ICU; first ICU department (i.e., Coronary Care Unit [CCU], Cardiac Surgery Recovery Unit [CSRU], Medical ICU [MICU], Surgical ICU [SICU], or Thoracic Surgery ICU [TSICU]) was extracted from the MIMIC-III database. Medicare and Medicaid were the two main types of government-run insurance. Medicare is a federal program that provides health coverage if an individual is  $\geq 65$  years old or  $< 65$  years old and has a disability, regardless of income, whereas Medicaid is a state and federal program that provides health coverage if an individual has very low income [7]. Thus, we merged government, Medicare, and Medicaid insurances into government-run insurance for further analyses.

Data on disease severity score systems, including Sequential Organ Failure Assessment (SOFA) [10] and Simplified Acute Physiology Score (SAPS) II [11], were also extracted. For comorbidity evaluation, we extracted the Elixhauser score [12]. Data on vasopressor use and mechanical ventilation information in the first 24 hours after admission to the ICU were also extracted as binomial variables (i.e., yes or no); vasopressors included norepinephrine, epinephrine, phenylephrine, vasopressin, dopamine, dobutamine, and milrinone.

### Outcomes data for extraction

The primary outcome for the study was ICU mortality. Secondary outcomes were length of ICU stay, 90-day mortality, and long-term survival. The data were acquired from the Social Security Death Index (SSDI). ICU mortality and 90-day mortality served as binomial variables and were considered a “short-term effect.” The two data sources for the MIMIC-III database had different follow-up times (i.e., 90 days for Metavision and 4 years for CareVue) [8,13,14], that is, if no record of death was found in the SSDI, we consider it was censored at the 90th day after admission to ICU for the Metavision data source or at end of the fourth year after admission to the ICU for the CareVue data source. In this way, we used the time-event data to conduct a survival analysis, which was considered as the “long-term effect.”



**Figure 1.** The analysis flow chart of the current study. Data were extracted from the MIMIC-III database. The number of records for each step are in brackets. Multivariate analysis was applied to both unmatched and matched data, so there is a two-way arrow between the propensity score match and multivariate analysis.

## Statistical methods

Data extracted from the database were first checked for missing data. Since the missing data of all variables were less than 1%, we just deleted the missing data. Baseline data and outcomes grouped by different insurance types – government-run and private – were then summarized for comparison. Continuous data were described by median and quantiles and tested using a nonparametric method (Kruskal-Wallis test), while categorical data were summarized by number and percentages and tested by the chi-square method. Strictly standardized mean differences (SSMDs) were also calculated for all variables. We used multiple methods of analysis to ensure the robustness of our results. First, confounders and lack of balance were adjusted using multivariate analysis and propensity score matching (PSM). The logistic regression model was applied to both methods to calculate the risk ratio for each variable and propensity score for each patient. All variables except outcomes (they were what we predicted) were entered into the model (for propensity score calculation, besides outcomes, insurance type was also not included because it was what we predicted). For PSM, we performed a one-to-one match with calipers less than 0.01 between the two groups and obtained the matched cohorts. The matched cohorts were also compared with univariate and multivariate methods. Second, we performed subgroup analyses for each variable and calculated the risk ratios for both the ICU and 90-day mortality rates. We used forest plots to visualize the subgroup analyses [15]. Finally, the survival analysis was used to compare long-term outcomes between the different types of insurance. Kaplan-Meier curves were plotted and a Cox proportional hazard model

was used to adjust for confounders and calculate hazard ratios. For all comparisons, a  $P < .05$  was considered to have statistical significance.

The database was created on the personal computer of the first author with Postgresql 10.1. Data extraction was achieved with Python 3.6 and SQL sentences. The rest of the data analysis process was performed with R language (version 3.6).

## Results

We retrieved 13 957 records from the MIMIC-III database that met our extractive criteria. We directly excluded 98 records with incomplete data (less than 1% of the entire dataset). The detailed extraction and analysis process is shown in the flowchart in Figure 1. Baseline data and outcomes for the patients, grouped according to insurance type, are summarized in Table 1. Patients with government-run insurance were elderly more likely to be in the CCU and MICU, more likely to present in the Emergency Department, and had higher SAPS II and Elixhauser scores. Comparatively, private insurance patients were more likely to be male, in the SICU and TSICU, to have longer ICU stays, and to be given mechanical ventilation on the first day of admission to the ICU. Without adjusting for confounders, patients with government-run insurance had higher rates of ICU mortality and 90-day mortality.

Table 1 also shows results of PSM of the cohorts. After matching, the two cohorts were balanced for most variables. Rates of ICU mortality and 90-day mortality were not significantly

**Table 1.** Baseline and outcomes of original and propensity-score-matched cohorts with government-run and private insurance.

Insurance type	Unmatched data				Matched data			
	Government-run	Private	P-value	SSMD	Government-run	Private	P-value	SSMD
No.	10205	3654			3418	3418		
Demographic data								
Male (%)	5316 (52.1)	2179 (59.6)	<0.001	0.152	2066 (60.4)	2035 (59.5)	0.459	0.019
Age (Median [IQR])	72.00 [61.00, 80.00]	57.00 [47.00, 63.00]	<0.001	1.020	56.00 [48.00, 65.00]	57.00 [49.00, 63.00]	0.755	0.005
First care unite (%)			<0.001	0.147			0.151	0.063
CCU	1335 (13.1)	392 (10.7)			337 (9.9)	374 (10.9)		
CSRU	819 (8.0)	261 (7.1)			219 (6.4)	246 (7.2)		
MICU	5764 (56.5)	1969 (53.9)			1934 (56.6)	1853 (54.2)		
SICU	1414 (13.9)	605 (16.6)			584 (17.1)	570 (16.7)		
TSICU	873 (8.6)	427 (11.7)			344 (10.1)	375 (11.0)		
Admission type (%)			<0.001	0.096			0.998	0.002
Elective	543 (5.3)	257 (7.0)			237 (6.9)	237 (6.9)		
Emergency	9417 (92.3)	3272 (89.5)			3067 (89.7)	3066 (89.7)		
Urgent	245 (2.4)	125 (3.4)			114 (3.3)	115 (3.4)		
Disease severity evaluations								
SOFA score (median [IQR])	5.00 [3.00, 8.00]	5.00 [3.00, 8.00]	0.218	0.016	5.00 [3.00, 8.00]	5.00 [3.00, 8.00]	0.044	0.029
SAPSII score (median [IQR])	41.00 [33.00, 50.00]	36.00 [27.00, 47.00]	<0.001	0.305	36.00 [28.00, 47.00]	36.00 [27.00, 47.00]	0.850	0.017
Elixhauser score (median [IQR])	11.00 [6.00, 17.00]	10.00 [5.00, 17.00]	<0.001	0.118	11.00 [5.00, 17.00]	10.00 [5.00, 17.00]	0.001	0.068
Vasopressor use in first day (%)	2768 (27.1)	931 (25.5)	0.056	0.037	907 (26.5)	879 (25.7)	0.457	0.019
Mechanical ventilation in the first day (%)	4513 (44.2)	1796 (49.2)	<0.001	0.099	1660 (48.6)	1668 (48.8)	0.865	0.005
Outcomes								
ICU mortality (%)	1480 (14.5)	460 (12.6)	0.005	0.056	427 (12.5)	440 (12.9)	0.663	0.011
Length of ICU stay (median [IQR])	3.84 [1.90, 8.66]	4.53 [2.11, 10.83]	<0.001	0.138	3.96 [1.97, 9.24]	4.46 [2.11, 10.77]	<0.001	0.092
90-day mortality (%)	5993 (58.7)	2006 (54.9)	<0.001	0.077	1928 (56.4)	1899 (55.6)	0.495	0.017

ICU – Intensive Care Unit; IQR – interquartile range; CCU – Cardiac Care Unit; CSRU – Cardiac Surgery Recovery Unit; MICU – Medical Intensive Care Unit; SICU – Surgery Intensive Care Unit; TSICU – Trauma/Surgical Intensive Care Unit; SSMD – strictly standardized mean difference; SOFA – sequential organ failure assessment; SAPSII – Simplified Acute Physiology Score II.

different. However, patients with private insurance had longer ICU stays (SSMD=.092,  $P<.001$ ).

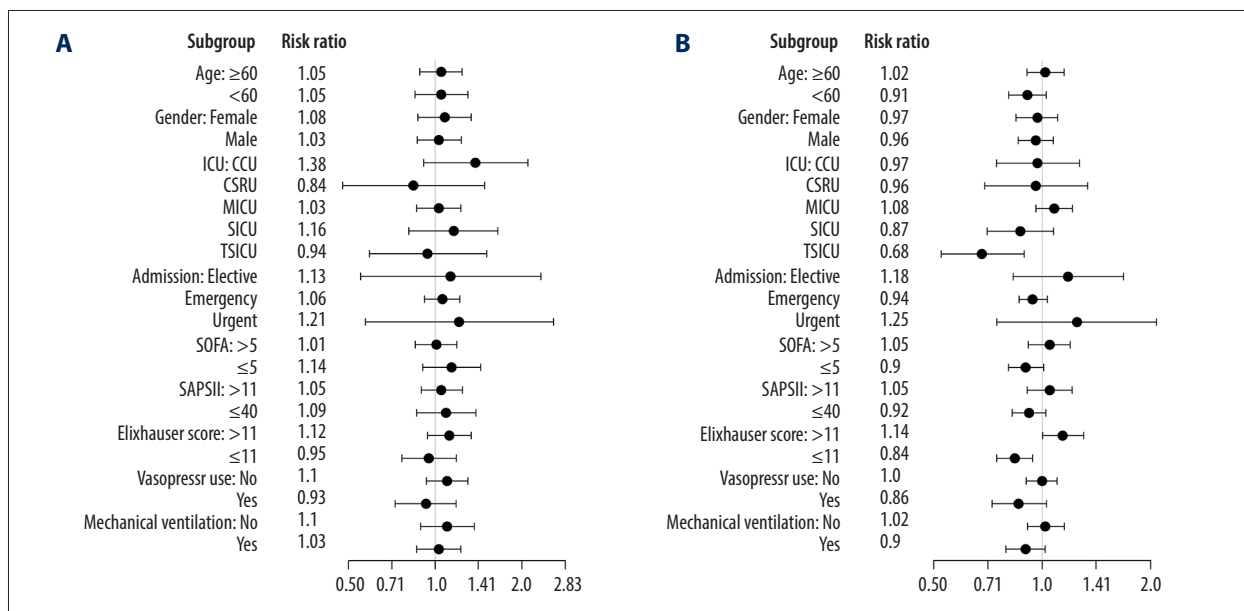
Multivariate analyses of both the original data and matched data are summarized in Table 2. Neither indicated significant

differences in rates of ICU mortality and 90-day mortality between the two insurance groups. Subgroup analysis produced similar results: Few subgroups of variables indicated a significant difference between the two insurance groups (Figure 2).

**Table 2.** Multivariate analysis of private insurance in different cohorts.

Multivariate analysis of private insurance in:	HR/RR (95%CI)	p-Value
ICU mortality (unmatched)*	1.052 (0.919–1.205)	0.463
ICU mortality (matched)*	1.024 (0.876–1.198)	0.764
90-day mortality (unmatched)*	0.964 (0.885–1.051)	0.406
90-day mortality (matched)*	0.987 (0.895–1.088)	0.788
Long-term survival (unmatched)**	0.875 (0.825–0.928)	<0.001
Long-term survival (matched)**	0.886 (0.829–0.948)	<0.001

\* RR calculated with logistic regression model; \*\* HR calculated with cox proportional risk model. HR – hazard ratio; RR – risk ratio; CIs – confidence intervals.



**Figure 2.** Subgroup analysis of association between insurance type and ICU mortality (A) and 90-day mortality (B) rates. The government-run insurance group is the reference group; risk ratios of the private insurance group are displayed and plotted with their 95% CIs on the right (the forest plot). ICU – Intensive Care Unit; CCU – Cardiac Care Unit; CSRU – Cardiac Surgery Recovery Unit; MICU – Medical ICU; SICU – Surgical ICU; TSICU – Thoracic Surgery ICU; SOFA – Sequential Organ Failure Assessment; and SAPS II – Simplified Acute Physiology Score II.

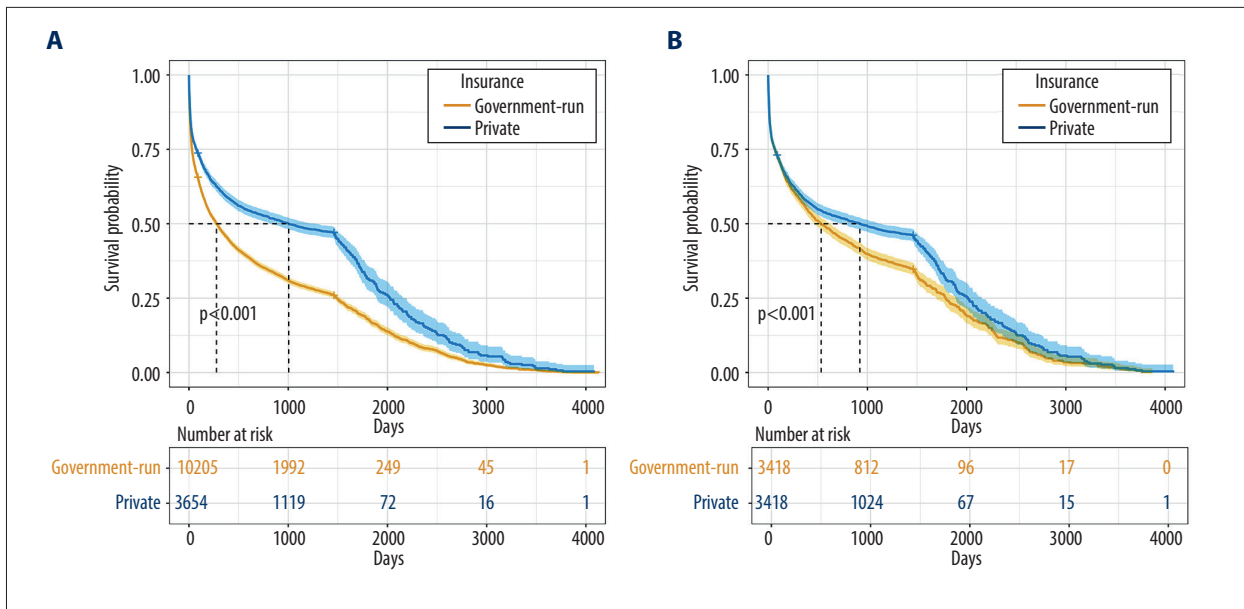
Interestingly, in the long-term survival analysis, median survival time was longer in the private insurance group than in the government-run insurance group, for both the original cohorts (1 005 days vs. 277 days,  $P < .001$ ) and the matched cohorts (924 days vs. 534 days,  $P < .001$ ) (Figure 3). The Cox proportional risk model had similar results, which are shown in Table 2.

## Discussion

We analyzed a public ICU database and explored the effects of different types of insurance types on clinical outcomes of patients with sepsis. We found that patients with private insurance had similar rates of ICU and 90-day mortality but longer

stays in the ICU than patients with government-run insurance. Furthermore, long-term survival was better in the private insurance group than in the government-run insurance group.

Previous research has reported on disparities in healthcare services and treatment for a number of clinical conditions in the United States, depending on patient insurance type [2,16,17]. Fourouquet reported lower use of medical services (e.g., hospital, laboratory, pathology and radiology), laparoscopy, and the emergency room for patients with endometriosis who had public health insurance [16]. However, Fourouquet did not compare the prognosis of patients with public health insurance to those with private health insurance. Similarly, Loehrer did not report a disparity in outcomes in patients with colorectal cancer patients



**Figure 3.** Kaplan-Meier survival curves of patients with different insurance types from the original data (A) and matched data (B). The curves describe the survival probability of each cohort at each day after admission to the ICU to the endpoint (censor or death). Median survival times for the two cohorts from the original data were 277 and 1 005 days, respectively; from the matched data, they were 534 and 924 days, respectively (the horizontal position of the dashed lines). The numbers below the plots refer to the patients at risk of death for every 1 000 days.

based on type of insurance, but he found that patients with government-run insurance had significantly lower rates of resection for colorectal cancer than their counterparts with private insurance [2], which obviously would influence the prognosis. The same trend appeared in infectious disease. Stepanova reported that patients who were positive for Hepatitis C virus were less likely to have private insurance [17], indicating a higher cure rate in that population. In the current study, we found that patients with private insurance had longer ICU stays and were more frequently given mechanical ventilation. All of the above suggest that insurance type influenced clinical decision-making.

Does insurance type affect clinical outcome by changing clinical decision-making? Chakraborty and colleagues analyzed a database of information on patients with acute coronary syndrome and found that the group with private insurance had lower rates of mortality than their counterparts with Medicare and Medicaid [18]. Gabriel et al. analyzed an ICU dataset of patients with nonspecific diagnoses and found that those with private insurance had lower rates of ICU mortality compared to the group with government-run insurance and the non-insured group [19]. Another study of spine trauma found no disparity in mortality rates between insurance types (private vs. government-run) but reported a higher mortality rate for uninsured patients. To the best of our knowledge, there is a lack of evidence about how different insurance types affect outcomes of patients with sepsis. In our research, we found that administration of mechanical ventilation to patients with sepsis on

the first day in the ICU was rarer in the group with government-run insurance. However, rates of ICU and 90-day mortality were not influenced by type of insurance. In addition, significantly shorter ICU stays were observed in the group with government-run insurance. Caring for patients with sepsis in the ICU is expensive, and the economy is another issue behind survival. The evidence provided here may improve cost-benefit decisions in the clinical setting.

In 2016, private health insurance coverage was more prevalent than government-run health insurance coverage (67.5% vs. 37.3%). Government-run insurance is more affordable than private insurance but less flexible. Patients with private insurance have more selection in medical service providers than those who are insured by the government [20]. Furthermore, reimbursement for therapies may be limited under government-run insurance plans. The United States is well known for its heavy burden of medical costs. Studies comparing different types of insurance may provide insights into ways to improve medical policy. Sepsis, because of its rapid progression and requirement for advanced life support, is one of the conditions that most often leads to ICU admission (nearly 20%) [21]. Our research suggests that short-term outcomes are similar in patients with sepsis admitted to the ICU who have private and government-run insurance. However, as the evidence presented indicates, the effect of different insurance type varies among different diseases, which suggests a lot of room for improving the medical insurance system.

In the current study, we retrospectively analyzed information from the MIMIC-III database and compared private and government-run insurance. Confounding factors and uncertain causal relationships were found, although we used multiple methods of analysis to avoid these issues. In the long-term survival analysis, we found that patients with private insurance had longer survival than those who had government-run insurance, but this long-term effect may be unrelated to their sepsis at time of ICU admission. Furthermore, we were unable to determine whether the type of insurance the patients had might have changed during the rest of their lives.

## Conclusions

Analysis of information in the MIMIC-III database indicates that patients with sepsis who had private insurance had longer ICU stays and were more frequently given mechanical ventilation on their first day of admission to the ICU compared with their

counterparts with government-run insurance. However, rates of hospital and 90-day mortality were similar in patients with private versus government-run insurance who were critically ill with sepsis, unlike with conditions such as cancer or chronic diseases. Patients with private insurance had better long-term survival compared than did patients with government-run insurance, which might be affected by factors that were hard to evaluate and for which more evidence is required.

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## Conflicts of interest

None.

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