The risk of suicide in patients with critical illness
A population-based study in Taiwan

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Abstract
The authors investigated retrospectively the association between critical illness and risk of suicide attempts. The data are from Taiwan’s National Health Insurance Research Database. Propensity score matching, multivariable models, Kaplan–Meier analysis, and competing risk analysis were used to explore this association. The authors found that patients having an critical illness were associated with increased risk of suicide attempts after adjusting for risk factors (adjusted hazard ratio = 2.98; 95% confidence interval = 1.46–6.08). Among different subtypes of critical illness, patients with sepsis/septic shock exhibited the highest risk of suicide attempts (adjusted hazard ratio = 3.43, 95% confidence interval = 1.52–7.74). An association between critical illness and suicide attempts was shown. Sepsis/septic shock was found to confer the highest risk in these specific population.

Keywords: critical illness, sepsis, septic shock, suicide

1. Introduction
The enormous improvement in critical care is obvious in past years<sup>[1–3]</sup>; however, the psychologic outcomes among patient surviving critical illness obtained relatively less attention because most physicians and investigators focus more effort on the physiologic mechanism rather than psychological impact.<sup>[4,5]</sup> In the modern society, psychologic disorder is increasingly recognized as a huge global burden and the balance and homeostasis of body-mind or physio-psychological inter-relationship have been proposed.<sup>[6,7]</sup> Indeed, survivors of intensive care are known to be at increased risk of anxiety, depression, and post-traumatic stress disorder, which is associated with increased risk of suicide.<sup>[8,9]</sup> Several reports have shown an increased risk of suicide and self-harm in patients surviving from critical illnesses, acute stroke and acute myocardial infarction. In this regard, to enhance the global care for these groups who surviving critical illness, the author used a well-validated nationwide dataset to explore this issue.<sup>[10]</sup> The paper describes a positive multivariate association between a diagnosis of critical illness and subsequent diagnosis of suicide using a robust database and the big sample size.

2. Methods

2.1. Data source
This retrospective population-based cohort study was designed to assess the relationship between critical illness and the risk of suicide. Data sources conducted in this present study were retrieved from claims data of Taiwan’s National Health Insurance Research Database (NHIRD), which covers approximately 99% of Taiwan residents.<sup>[10]</sup> The National Health Research Institute receives insurance claims data from the National Health Insurance Administration and subsequently compiles them into NHIRD for research purposes since 1995. The NHIRD has been extensively used for epidemiological studies. The data utilized in this current study was the Longitudinal Health Insurance Database (LHID 2000), a subset of the NHIRD. The LHID 2000 consists of 1 million randomly collected samples from the NH system in 2000, and contains historical ambulatory and inpatient care data. Diseases were classified on the basis of the International Classification of Diseases, Ninth Revision, and Clinical Modification (ICD-9-CM).<sup>[11,12]</sup> The accuracy and validity of NHIRD diagnosis codes have been documented. All personal information was encrypted to preserve patient anonymity. This study has been approved by the Research Ethics Committee at China Medical University Hospital (CMUH104-REC2-115(CR-7)).

2.2. Study population
We identified patients who have ever received a critical illness diagnosis from January 1, 2000 to December 31, 2012 as the critical illness group. The critical illness was defined as the following disease: septicemia (ICD-9-CM codes 038), septic shock (ICD-9-CM codes 785.52), acute myocardial infarction (ICD-9-CM codes 410), hemorrhagic stroke (ICD-9-CM codes 430-432) and ischemic stroke (ICD-9-CM 433-438). The index date means the initial diagnostic date of critical illness. Subjects...
without any critical illness during the study period were randomly selected from the same database as the comparison group. Patients under 20 years old or who had a preexisting diagnosis of suicide attempt before the index date were excluded from the study. Patients in the critical illness and non-critical illness cohorts were matched at a ratio of 1:1 on the basis of a propensity score. The propensity score was calculated using the probability of the treatment assignment by using a logistic regression model and included the following baseline variables: year of index, age, and sex.

2.3. Outcome and comorbidities
The outcome of interest in this study was suicide (ICD-9-CM codes E950-E959), including liquid or solid poisoning (ICD-9-CM code E950), charcoal burning and poisoning by gases (ICD-9-CM code E952), hanging (ICD-9-CM code E953), cutting/piercing (ICD-9-CM code E956), jumping from high places (ICD-9-CM code E957), and others (ICD-9-CM codes E951, E954, E955, E958, and E959). All patients were followed from the index date to the occurrence of suicide, death, withdrawal from NHI program, or December 31, 2013, whichever came first. The chronic diseases under consideration included schizophrenic spectrum disorders, depressive disorder, alcohol-related illness, anxiety, mental disorders, insomnia, congestive heart failure, hypertension, diabetes mellitus, vascular diseases, Non-end-stage renal disease, end-stage renal disease, chronic obstructive pulmonary disease, malignancy, autoimmune diseases, and liver cirrhosis. The diagnostic accuracy of comorbidities based on ICD-9 codes has been examined in previous studies. Demographic data of monthly income, urbanization level, and occupation category were also collected.

2.4. Statistical analyses
The baseline demographic/clinical characteristics of the critical illness and the comparison cohorts were compared. A chi-square test and Student’s t-test were used to evaluate the distribution of category and continuous variables for an unmatched cohort. A standardized mean difference (SMD) of 0.10 indicates a negligible difference between the 2 matched cohorts. The incidence rates of suicide were calculated as per 10,000 person-years in both cohorts. The crude hazard ratios and 95% confidence intervals (CIs) of suicide occurrence were estimated using Cox proportional hazard regression. Multivariable models were further adjusted for depression, alcohol-related illness, anxiety, insomnia, and liver cirrhosis. We also examined the association between critical illness and suicide stratified by different subtypes of critical illness. The cumulative incidence of suicide during 12 years of follow-up was estimated for subjects with and without critical illness using Kaplan–Meier analysis, and assessed these differences using a log-rank test. We also considered death as a competing factor to estimate subhazard ratios and 95% CIs using the competing-risks regression models. The SAS 9.4 statistical package (SAS Institute Inc, NC, USA) was used for the statistical analyses. A 2-sided P value <0.05 indicated statistical significance.

3. Results
The demographics for the unmatched and matched cohorts were shown in Table 1. After matching, 48,651 patients in the critical illness cohort and 48,651 patients in the comparison cohort were enrolled in the study with similar distributions of age and gender by the propensity score. The majority of patients were aged 65 years or above, and males accounted for more than half of the patients in each cohort. The mean age was 65.7 ± 15.1 years in the critical illness cohort and 65.6 ± 14.9 in the comparison cohort. Compared with the comparison cohort, patients with critical illness had a significantly higher proportion of all the considered comorbidities (P < .001). The distribution of monthly income, urbanization level, and occupation category differed between the 2 cohorts (P < .001).

Table 2 discloses the incidence and risk of suicide between the critical illness and comparison cohorts with propensity score. At the end of the study period, the overall incidence rates of suicide in critical illness cohort and comparison cohort were 1.58 and 0.41 per 10,000 person-years, respectively. After adjusting for confounding factors, critical illness cohort had a significantly increased risk of suicide than the comparison cohort (adjusted hazard ratio [aHR] = 2.98; 95% CI = 1.46–6.08). Table 2 also shows that patients with alcohol-related illness tended to have a higher risk for suicide (aHR = 3.86; 95% CI = 1.68–8.84).

3.1. Mortality rate
The expected hypothesized association implies that further attention to patient surviving critical illness is mandatory. Additionally, the association appears to be higher with a diagnosis of sepsis/septic shock. Except for the impact of multiple comorbidities on the association, other possible biological links cannot be clearly identified primarily due to the methodology drawback of the investigation. Moreover, it is difficult to see a plausible biological mechanism for this.
and confounding remains likely, making clinical application hard to propose clearly. The authors spend more time justifying this study by discussing potential pathophysiologic overlap between these conditions. People who have sepsis may develop an acute inflammatory response and the concept of systemic inflammation might be associated with suicide attempts despite some investigators might criticize that no sound scientific rationale is provided.  

### Table 1
Comparisons of demographic characteristics and comorbidities in patients with and without critical illness stratified by propensity score matching.

| Critical illness unmatched | P-value | Critical illness matched gender, age, and index year | SMD* |
|---------------------------|---------|-----------------------------------------------------|------|
|                           | (N = 622,882) |                                                   |      |
| Gender                    | (N = 50,122) |                                                   |      |
| Women                     | 314,339 (50.5) | 21,175 (42.3)                                      | 0.03 |
| Men                       | 308,543 (49.5) | 28,947 (57.8)                                      | 0.03 |
| Age stratified ≤49        | 448,106 (71.9) | 7917 (15.8)                                         | 0.006|
|                           | 50–64     | 118,584 (19.0)                                     | 0.004|
|                           | 65+       | 56,192 (9.02)                                      | 0.008|
| Age, mean ± SD            | 42.3 ± 15.0 | 66.4 ± 15.4                                        | 0.008|
| Monthly income            | <15,000 | 147,707 (23.7)                                     | 0.026|
|                           | 15,000–19,999 | 284,729 (45.7)  | 21,784 (44.8) | 0.094|
| Age, mean ± SD†           | <0.001   |                                                   |      |
| Urbanization level§       | 1 (highest) | 194,224 (31.2)                                    | 0.145|
|                           | 2         | 184,525 (29.6)                                    | 0.007|
|                           | 3         | 114,801 (18.4)                                    | 0.02 |
|                           | 4 (lowest) | 129,332 (20.8)                                    |      |
| Occupation category∥      | 0.001    |                                                   |      |
| Comorbidity               | Schizophrenia | 4249 (0.68) | 532 (1.06) | 0.08 |
|                           | Depression  | 18,806 (3.02)                                    | 2194 (4.51) | 0.11 |
|                           | Alcohol-related illness | 15,325 (2.46) | 3766 (7.51) | 0.22 |
|                           | Anxiety     | 65,092 (10.5)                                    | 8796 (17.1) | 0.15 |
|                           | Mental disorders | 40,736 (6.44) | 8565 (17.1) | 0.15 |
|                           | Insomnia    | 175,563 (28.2)                                    | 29,835 (59.5) | 0.28 |
|                           | Congestive heart failure | 503 (0.82) | 6257 (12.5) | 0.08 |
|                           | Hypertension | 92,870 (14.9)                                    | 34,719 (69.3) | 0.48 |
|                           | Diabetes mellitus | 24,688 (3.96) | 13,273 (26.5) | 0.40 |
|                           | Vascular diseases | 41,121 (6.60) | 20,249 (40.4) | 0.36 |
|                           | Non-ESRD CKD | 4292 (0.69) | 419 (0.87) | 0.25 |
|                           | ESRD       | 890 (0.14)                                    | 1250 (2.49) | 0.19 |
|                           | COPD       | 20,002 (3.41)                                    | 12,563 (25.1) | 0.17 |
|                           | Malignancy  | 8150 (1.31)                                    | 5184 (10.3) | 0.25 |
|                           | Autoimmune diseases | 645 (1.04) | 107 (0.21) | 0.02 |
|                           | Liver cirrhosis | 82,833 (13.3) | 12,975 (25.9) | 0.15 |
| Index year                | 2000 | 79,127 (12.7)                                    | 20,774 (42.7) | 0.03 |
|                           | 2001 | 54,018 (8.67)                                    | 4282 (8.90) | 0.06 |
|                           | 2002 | 54,519 (8.73)                                    | 4113 (8.08) | 0.06 |
|                           | 2003 | 55,435 (9.09)                                    | 4164 (8.31) | 0.03 |
|                           | 2004 | 56,112 (9.01)                                    | 4570 (9.12) | 0.03 |
|                           | 2005 | 56,850 (9.13)                                    | 4589 (9.16) | 0.03 |
|                           | 2006 | 58,244 (9.35)                                    | 4619 (9.22) | 0.03 |
|                           | 2007 | 58,590 (9.41)                                    | 4618 (9.21) | 0.03 |
|                           | 2008 | 59,050 (9.58)                                    | 4692 (9.36) | 0.03 |
|                           | 2009 | 60,040 (9.64)                                    | 4567 (9.63) | 0.03 |
|                           | 2010 | 30,299 (4.86)                                    | 4928 (9.83) | 0.03 |

Chi-square test.
COPD = chronic obstructive pulmonary disease, ESRD = end-stage renal disease.
*A standardized mean difference (SMD) of ≤0.10 indicates a negligible difference between the 2 cohorts.
†Student’s t-test.
‡New Taiwan Dollar (NTD), 1 NTD is equal to 0.03 USD.
§The urbanization level was divided by the population density of the residential area into 4 levels, level 1 was the most urbanized and level 4 was the least urbanized.
∥Other occupation categories included those who were primarily retired, unemployed, and low-income populations.

and confounding remains likely, making clinical application hard to propose clearly. The authors spend more time justifying this study by discussing potential pathophysiologic overlap between these conditions. People who have sepsis may develop an acute inflammatory response and the concept of systemic inflammation might be associated with suicide attempts despite some investigators might criticize that no sound scientific rationale is provided. It should be acknowledged that critically ill patients had more serious medical problems which might influence their suicide.
Table 2
The incidences and risk factors for suicide with propensity score matching.

| Variable                          | Event | PY   | Rate* | Crude HR (95% CI) | Adjusted HR† (95% CI) |
|-----------------------------------|-------|------|-------|-------------------|----------------------|
| Critical illness                  |       |      |       |                   |                      |
| No                                | 11    | 269,117 | 0.41| 1.00              | 1.00                 |
| Yes                               | 29    | 183,740 | 1.58| 3.81 (1.90–7.63)** | 2.98 (1.46–6.08)**   |
| Age group, years                  |       |      |       |                   |                      |
| ≤ 49                              | 12    | 83,550 | 1.44| 2.36 (0.96–5.77)   |                      |
| 50–64                             | 8     | 131,196 | 0.61| 1.00              |                      |
| ≥ 65+                             | 20    | 238,111 | 0.84| 1.36 (0.60–3.10)   |                      |
| Gender                            |       |      |       |                   |                      |
| Women                             | 21    | 191,925 | 1.09| 1.51 (0.81–2.80)   |                      |
| Men                               | 19    | 260,032 | 0.73| 1.00              |                      |
| Monthly income‡                  |       |      |       |                   |                      |
| < 15,000                          | 12    | 137,443 | 0.87| 1.00              | 1.00                 |
| 15,000 – 19,999                   | 25    | 212,671 | 1.18| 1.35 (0.68–2.69)   |                      |
| ≥ 20,000                          | 3     | 102,743 | 0.29| 0.34 (0.10–1.19)   |                      |
| Urbanization level§               |       |      |       |                   |                      |
| 1 (highest)                       | 11    | 121,525 | 0.91| 1.00              | 1.00                 |
| 2                                 | 8     | 122,776 | 0.65| 0.72 (0.29–1.79)   |                      |
| 3                                 | 10    | 77,610 | 1.29| 1.42 (0.60–3.35)   |                      |
| 4 (lowest)                        | 11    | 130,946 | 0.84| 0.93 (0.40–2.14)   |                      |
| Occupation category∥             |       |      |       |                   |                      |
| Office worker                     | 15    | 176,848 | 0.85| 1.00              | 1.00                 |
| Laborer                           | 17    | 190,042 | 0.89| 1.06 (0.53–2.11)   |                      |
| Other                             | 8     | 85,967 | 0.93| 1.10 (0.47–2.59)   |                      |
| Comorbidity                       |       |      |       |                   |                      |
| Schizophrenia                     |       |      |       |                   |                      |
| No                                | 39    | 450,014 | 0.87| 1.00              | 1.00                 |
| Yes                               | 1     | 2843  | 3.52| 3.97 (0.55–28.9)   |                      |
| Depression                        |       |      |       |                   |                      |
| No                                | 35    | 429,934 | 0.81| 1.00              | 1.00                 |
| Yes                               | 5     | 22,923 | 2.18| 2.67 (1.04–6.82)*  | 1.29 (0.45–3.71)     |
| Alcohol-related illness           |       |      |       |                   |                      |
| No                                | 32    | 435,845 | 0.73| 1.00              | 1.00                 |
| Yes                               | 8     | 17,012 | 4.70| 6.34 (2.91–13.8)** | 3.86 (1.68–8.84)**   |
| Anxiety                           |       |      |       |                   |                      |
| No                                | 26    | 368,118 | 0.71| 1.00              | 1.00                 |
| Yes                               | 14    | 94,738 | 1.00| 2.34 (1.22–4.50)*  | 1.56 (0.73–3.35)     |
| Mental disorders                  |       |      |       |                   |                      |
| No                                | 37    | 397,714 | 0.93| 1.00              | 1.00                 |
| Yes                               | 3     | 55,143 | 0.54| 0.58 (0.18–1.88)   |                      |
| Insomnia                          |       |      |       |                   |                      |
| No                                | 13    | 234,801 | 0.55| 1.00              | 1.00                 |
| Yes                               | 27    | 218,055 | 1.24| 2.25 (1.16–4.38)*  | 1.42 (0.69–2.90)     |
| Congestive heart failure          |       |      |       |                   |                      |
| No                                | 37    | 426,810 | 0.87| 1.00              | 1.00                 |
| Yes                               | 3     | 26,047 | 1.15| 1.29 (0.40–4.21)   |                      |
| Hypertension                      |       |      |       |                   |                      |
| No                                | 17    | 206,556 | 0.82| 1.00              | 1.00                 |
| Yes                               | 23    | 246,301 | 0.93| 1.13 (0.60–2.12)   |                      |
| Diabetes mellitus                 |       |      |       |                   |                      |
| No                                | 37    | 379,681 | 0.97| 1.00              | 1.00                 |
| Yes                               | 3     | 73,176 | 0.41| 0.42 (0.13,1.35)   |                      |
| Vascular diseases                 |       |      |       |                   |                      |
| No                                | 27    | 319,009 | 0.85| 1.00              | 1.00                 |
| Yes                               | 13    | 133,847 | 0.97| 1.14 (0.59–2.22)   |                      |
| Non-ESRD CKD                      |       |      |       |                   |                      |
| No                                | 38    | 436,371 | 0.87| 1.00              | 1.00                 |
| Yes                               | 2     | 16,486 | 1.21| 1.35 (0.33–5.62)   |                      |
| ESRD                              |       |      |       |                   |                      |
| No                                | 40    | 449,715 | 0.89| 1.00              | 1.00                 |
| Yes                               | 0     | 3142  | 0.00| -                 |                      |
| COPD                              |       |      |       |                   |                      |
| No                                | 30    | 372,507 | 0.81| 1.00              | 1.00                 |
| Yes                               | 10    | 80,350 | 1.24| 1.53 (0.75–3.15)   |                      |
| Malignancy                        |       |      |       |                   |                      |
| No                                | 39    | 437,350 | 0.89| 1.00              | 1.00                 |
| Yes                               | 1     | 15,507 | 0.64| 0.68 (0.09–4.99)   |                      |
| Autoimmune diseases               |       |      |       |                   |                      |
| No                                | 40    | 452,279 | 0.88| 1.00              | 1.00                 |
| Yes                               | 0     | 578   | 0.00| -                 |                      |

(Continued)
attempts, or they might receive it due to injury from their suicide attempts. Both are important confounders that should be considered. Finally, it could also be argued that choosing the critical illness cohort as newly diagnosed may artificially select for those who seek more treatment with more medical visits, making more incidence of suicide attempts in the study group. However, the association remained after incorporating the competing risk methods; additionally, sepsis is more susceptible to suicide attempts among these critically ill subjects, which might bring a new message and novel insights for the physicians caring for these specific groups. The appropriate position of this investigation in the literature might be reported with the above caveats as a justification for future research, and the detailed causal relationship and possible pathophysiological mechanism are strongly motivated.

Table 2
(Continued)

| Variable                  | Event | PY  | Rate* | Crude HR (95% CI) | Adjusted HR† (95% CI) |
|---------------------------|-------|-----|-------|-------------------|----------------------|
| Liver cirrhosis           | No    | 24  | 356,119 | 0.67              | 1.00                 |
|                           | Yes   | 16  | 96,738 | 1.65              | 2.45 (1.30–4.62)**   |

CI = confidence interval, COPD = chronic obstructive pulmonary disease, ESRD = end-stage renal disease, HR = hazard ratio; PY = person-years.

*Incidence rate per 10,000 person-years.
†Multivariable analysis included depression, alcohol-related illness, anxiety, insomnia, and liver cirrhosis.
‡New Taiwan Dollar (NTD), 1 NTD is equal to $0.03 USD.
§The urbanization level was divided by the population density of the residential area into 4 levels, level 1 was the most urbanized and level 4 was the least urbanized.
∥Other occupation categories included those who were primarily retired, unemployed, and low-income populations.

Table 3
Incidences and hazard ratios of suicide between individuals with and without critical illness stratified by demographics and comorbidity with propensity score matching.

Critical illness

| Outcome                  | No                          | Event | PY  | Rate* | Event | PY  | Rate* | Crude HR (95% CI) | Adjusted HR† (95% CI) |
|--------------------------|-----------------------------|-------|-----|-------|-------|-----|-------|-------------------|----------------------|
| Age group, years         | ≤64                         | 3     | 122,652 | 0.24 | 17    | 92,094 | 1.85 | 7.35 (2.15, 25.1)** | 5.52 (1.56, 19.5)** |
|                          | ≥65+                        | 8     | 146,465 | 0.55 | 12    | 91,645 | 1.31 | 2.42 (0.99, 5.93)  | 1.95 (0.79, 4.83)  |
| p for interaction        |                             |       |       |       |       |       |       |                   | 0.31                 |
| Gender                   | Women                       | 6     | 111,080 | 0.54 | 15    | 80,845 | 1.86 | 3.46 (1.34, 8.92)* | 2.71 (1.03, 7.14)*  |
|                          | Men                         | 5     | 15,837  | 0.32 | 14    | 102,895 | 1.36 | 4.13 (1.49, 11.9)** | 3.17 (1.11, 9.09)** |
| p for interaction        |                             |       |       |       |       |       |       |                   | 0.76                 |
| Monthly income‡          | <15,000                     | 5     | 82,892  | 0.60 | 7     | 54,551 | 1.28 | 2.14 (0.68, 6.78)  | 1.65 (0.51, 5.31)  |
|                          | 15,000–19,999               | 4     | 120,538 | 0.33 | 21    | 92,133 | 2.28 | 6.68 (2.29, 19.5)** | 5.37 (1.81, 16.0)** |
|                          | ≥20,000                     | 2     | 66,887  | 0.30 | 1     | 37,056 | 0.27 | 0.91 (0.08, 10.1)  | 0.97 (0.09, 11.1)   |
| p for interaction        |                             |       |       |       |       |       |       |                   | 0.74                 |
| Urbanization level§      | 1 + 2 (higher)              | 7     | 148,847 | 0.47 | 12    | 95,454 | 1.26 | 2.68 (1.05, 6.83)* | 1.98 (0.75, 5.18)  |
|                          | 3 + 4 (lower)               | 4     | 120,270 | 0.33 | 17    | 88,286 | 1.93 | 5.61 (1.89, 16.7)** | 4.57 (1.51, 13.9)** |
| p for interaction        |                             |       |       |       |       |       |       |                   | 0.76                 |
| Occupation category∥     | Office worker               | 5     | 110,074 | 0.45 | 10    | 66,774 | 1.50 | 3.34 (1.14, 9.80)* | 2.44 (0.80, 7.41)  |
|                          | Laborer                     | 3     | 107,983 | 0.28 | 14    | 82,059 | 1.71 | 5.95 (1.71, 20.7)** | 5.30 (1.50, 18.8)** |
|                          | Other                       | 3     | 51,060  | 0.59 | 5     | 34,907 | 1.43 | 2.37 (0.56, 9.93)  | 1.50 (0.34, 6.64)  |
| p for interaction        |                             |       |       |       |       |       |       |                   | 0.89                 |
| Comorbidity¶             | No                          | 2     | 191,830 | 0.47 | 28    | 171,764 | 1.63 | 3.40 (1.60, 7.21)** | -                   |
|                          | Yes                         | 9     | 277,287 | 0.26 | 1     | 11,976 | 0.83 | 3.55 (0.32, 39.2)  | -                   |

CI = confidence interval; HR = hazard ratio; PY person-years.

* Incidence rate per 10,000 person-years.
†Multivariable analysis included depression, alcohol-related illness, anxiety, insomnia, and liver cirrhosis.
‡New Taiwan Dollar (NTD), 1 NTD is equal to $0.03 USD.
§The urbanization level was divided by the population density of the residential area into 4 levels, level 1 was the most urbanized and level 4 was the least urbanized.
∥Other occupation categories included those who were primarily retired, unemployed, and low-income populations.
¶Individuals with schizophrenia, depression, alcohol-related illness, anxiety, mental disorders, insomnia, congestive heart failure, hypertension, diabetes mellitus, vascular diseases, non-end-stage renal disease CKD, end-stage renal disease, chronic obstructive pulmonary disease, malignancy, autoimmune diseases, and liver cirrhosis were classified into the comorbidity group.

*P < .05,
**P < .01,
***P < .001.
Table 4
Comparisons of Incidence, and Hazard Ratios of suicide in different subtypes of critical illness compared to those without critical illness stratified by propensity score matching.

| Variable                  | Event | PY       | Rate*  | Crude HR (95% CI) | Adjusted HR† (95% CI) |
|---------------------------|-------|----------|--------|-------------------|-----------------------|
| **Without propensity score matching** |       |          |        |                   |                       |
| Critical illness          | None  | 291      | 0.72   | 1 (Reference)     | 1 (Reference)         |
| Septicemia, septic shock | 14    | 73,807   | 1.90   | 2.61 (1.53–4.47)*** | 2.53 (1.43–4.47)**    |
| AMI                       | 1     | 13,075   | 0.76   | 1.06 (0.15–7.53) | 1.76 (0.24–13.0)      |
| Hemorrhagic stroke        | 1     | 14,976   | 0.67   | 0.92 (0.13–6.57)  | 1.03 (0.14–7.40)      |
| Ischemic stroke           | 13    | 84,175   | 0.76   | 2.13 (1.22–3.72)** | 2.28 (1.25–4.17)**    |
| **With propensity score matching** |       |          |        |                   |                       |
| Critical illness          | None  | 11       | 0.41   | 1 (Reference)     | 1 (Reference)         |
| Septicemia, septic shock | 14    | 269,117  | 1.93   | 4.60 (2.09–10.2)*** | 3.43 (1.52–7.74)**    |
| AMI                       | 1     | 12,989   | 0.77   | 1.87 (0.24–14.5)  | 1.74 (0.22–13.5)      |
| Hemorrhagic stroke        | 1     | 14,894   | 0.67   | 1.63 (0.21–12.6)  | 1.43 (0.18–11.1)      |
| Ischemic stroke           | 13    | 83,224   | 1.56   | 3.80 (1.70–8.49)** | 3.04 (1.34–6.90)**    |

CI = confidence interval, HR = hazard ratio, PY = person-years.
*Incidence rate per 10,000 person-years.
†Multivariable analysis included depression, alcohol-related illness, anxiety, insomnia, and liver cirrhosis.
**P < .01,
***P < .001.

Figure 1. Cumulative incidence curves of suicide for groups with and without critical illness.
5. Limitations

Despite the idea and data being novel, certain limitations in this study should be addressed. First, the study probably cannot change practice since the limitations of the study and lack of applicability of its findings.

Second, it appears that the disease, comorbidity, and outcomes were identified by the ICD-9 code in the record. Some might worry this may not be overly specific despite this algorithm have been validated previously.

Indeed, the study is based on an insurance database. Therefore, an underestimation of the outcome is likely since those who died shortly or immediately after suicide may not be admitted to the hospital. Finally, the retrospective data-based secondary analysis has certain inherent limitations and the ideal study is prospective with the serial examination, but of course, is tricky to perform.

6. Conclusion

An association between critical illness and suicide attempts was shown. Sepsis/septic shock was found to confer the highest risk in these specific populations.

Author contributions

Wei-Syun Hu - Study concept and design, acquisition of data, analysis and interpretation, drafting of the manuscript, critical revision of the manuscript for important intellectual content, and study supervision. Cheng-Li Lin - acquisition of data, analysis, and interpretation.

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Table 5

Critical illness cohort to non-critical illness cohort subhazard ratio (SHR) of suicide estimated using the competing-risks regression models with propensity score matching.

| Competing risks regression models | Critical illness |
|----------------------------------|-----------------|
|                                  | No              | Yes             |
| Crude SHR (95% CI)               | 1 (Reference)   | 3.81 (1.92–7.55)*** |
| Adjusted SHR (95% CI)            | 1 (Reference)   | 2.98 (1.48–6.02)** |

Crude SHR, relative subhazard ratio; adjusted SHR: multivariable analysis included depression, alcohol-related illness, anxiety, insomnia, and liver cirrhosis (death was also added in the model to measure adjusted SHR).

**P < .01, ***P < .001.