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ORIGINAL

Mental illness after admission to an intensive care unit

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Abstract

Purpose: Survivors of critical illness may be at higher risk of developing subsequent mental illness. We sought to determine the risk of new mental illness diagnoses across a large population of intensive care unit (ICU) survivors compared with hospitalized patients.

Methods: Population-based study (2005–2015) conducted in adults hospitalized in Ontario, Canada. The primary exposure was ICU admission for ≥ 48 h; secondary exposures were ICU procedures including mechanical ventilation and duration of ICU. The primary outcome was mental illness diagnosed during the year after hospital discharge. To account for case mix differences between ICU and other hospitalized patients, sensitivity analyses were conducted restricting to six pre-specified diagnoses that can lead to hospitalization with or without ICU.

Results: 1,847,462 patients survived hospitalization, of whom 121,101 were admitted to ICU for ≥ 48 h. ICU patients had a higher rate of new mental illness diagnoses in the year after discharge compared to hospitalized patients (17 vs. 15%, adjusted hazard ratio (aHR) 1.08, 95% CI 1.07–1.10). In analyses restricted to pre-specified most responsible diagnoses, the increased risk associated with ICU was only significant for patients with pneumonia. Among ICU survivors, exposure to mechanical ventilation (aHR: 1.08; 95% CI 1.05–1.12) or longer ICU stays (aHR: 1.004 per day; 95% CI 1.003–1.005) increased the risk of new mental illness diagnosis.

Conclusions: ICU was associated with a marginally increased risk of mental illness diagnosis after hospitalization that was often no longer apparent when reason for admission was considered. Patients exposed to mechanical ventilation or longer ICU stays may be at higher risk of subsequent mental illnesses.

Keywords: Post intensive care syndrome, Critical illness, Depression, Anxiety, Hospitalization

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Introduction

More than 5 million patients require admission to an intensive care unit (ICU) across North America each year for treatment of critical illness [1]. Historically, survival outcomes for these patients were poor [2]. However, due to improvements in treatments and admission of a greater number of patients with lower acuity of illness, more than 80% of the patients now survive their ICU admission [3]. Understanding the impact of critical illness and ICU admission on long-term outcomes for these survivors has become an important area of research [4].

Long-term complications that have been observed among ICU survivors have been collectively termed the post intensive care syndrome (PICS) [5], and occur across three domains: physical impairment, cognitive impairment, and mental illness [4, 6, 7]. The estimated incidence of new mental illness after ICU admission has varied widely across studies, likely stemming from differences in study inclusion criteria and approaches used to detect mental illness. For example, some studies have relied on patient self-reports of mental illness symptoms [8–10], or did not exclude pre-existing mental illnesses [3, 9]. Other studies relied only on mental illness diagnoses made by psychiatrists, which are likely highly specific but may miss many patients who are treated by other practitioners including family physicians [9, 11, 12].

Our objective was to determine the incidence of new mental illness diagnoses identified by psychiatrists and general practitioners during 1-year of follow-up of a population-based cohort of patients who required ICU admission, compared to hospitalized patients who were not admitted to ICU. Our secondary objective was to measure the association between specific ICU exposures and subsequent mental illness diagnosis. We hypothesized that patients who require an ICU admission have a higher incidence of new mental illness diagnosis after discharge compared to patients who are hospitalized, but who do not require an ICU admission, and that exposure to certain ICU interventions, for example mechanical ventilation, tracheostomy, and percutaneous feeding tubes, are also associated with a higher risk.

Take-home message

This study shows that the increased risk of mental illness diagnosis associated with ICU admission was often no longer apparent when the reason for admission was considered. However, patients who were exposed to mechanical ventilation or longer ICU stays may be at higher risk of subsequent mental illnesses.

Methods

Data sources

We created the study cohort using four population-based Ontario health databases contained at the Institute of Clinical Evaluative Sciences (ICES). ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement. These databases included the Canadian Institute of Health Information (CIHI) Discharge Abstract Database (DAD) that contains information on all acute-care hospitalizations, the CIHI National Ambulatory Care Reporting System (NACRS) database with information about emergency department visits, the Ontario Health Insurance Program (OHIP) database with information about all fee-for-service physician billings, and the Ontario Mental Health Reporting System (OMHRS) database with information about admissions to designated mental health beds at all institutions across the Province. These datasets were linked using unique encoded identifiers and analyzed at ICES.

Study participants

We included patients if they were aged 18 years or older and survived a hospitalization (index hospitalization) between April 1st, 2005 to March 31st, 2015. Our objective was to determine the impact of ICU exposure on the risk of developing a new mental illness, so we excluded patients with evidence of a mental illness diagnosis or dementia in the year prior to hospitalization. We also excluded patients who were admitted to hospital with conditions that are known to increase the risk of subsequent mental illness diagnosis, including traumatic brain injury, cardiac surgery, stroke, cardiac arrest, and pregnancy (Online Table E1) [13–17].

Outcomes

The primary outcome was the diagnosis of a mental illness during 1 year of follow-up after hospital discharge. The date of the first diagnosis of a mental illness was considered the event date if the patient had multiple encounters related to mental illness during follow-up. Mental illness diagnoses made in the outpatient setting, for example in psychiatrist or family physician offices, were detected using previously validated algorithms applied to the OHIP database that included all forms of mental illness including depression, anxiety, substance abuse and social problems (Online Tables E2-E3) [18, 19]. Diagnoses made in the emergency department or during subsequent hospital admissions were detected using previously validated International Classification of Disease (ICD) 10-CA codes (Online Table E4) [18, 20]. We

identified patients admitted to designated mental health beds using the OMHRS database [18].

Exposures

The primary exposure was admission to an ICU for greater than 48 h during hospitalization. The comparison was admission to hospital, but without ICU admission. ICU admission and discharge times were identified using Special Care Unit (SCU) codes that have high accuracy [20–22]. In an additional analysis to account for differences in case mix between patients admitted to ICU and hospitalized patients not requiring ICU, we restricted the cohort to individuals with six most responsible diagnoses that can lead to hospitalization with or without ICU admission. These 6 diagnoses were identified using ICD 10-CA codes (Online Table E5): pneumonia, asthma, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), sepsis, and severe sepsis. These restricted cohort analyses were conducted to ascertain the incremental risk of new mental illness diagnoses among patients with the same most responsible diagnosis for that hospitalization.

As a secondary objective, we evaluated several categories of exposures that may occur in the ICU, including mechanical ventilation, tracheostomy insertion, other pulmonary procedures (chest-tube insertion or bronchoscopy), cardiovascular procedures (pulmonary artery catheter insertion, trans-venous pacemaker insertion, aortic balloon pump insertion), percutaneous feeding tube insertion, and initiation of new dialysis. These were identified using Canadian Classification of Illness Intervention codes or OHIP codes [20–24]. We also examined duration of ICU stay as an independent exposure variable to consider the potential for a dose–response relationship.

Statistical analysis

Baseline characteristics were assessed using standardized differences (greater than 0.1 was considered important), since *P* values can be misleading when comparing small, but clinically unimportant differences in studies with large sample sizes.

We used a Fine and Gray competing risk regression model to estimate the cumulative incidence of mental illness diagnoses during 1 year from hospital discharge while accounting for the competing risk of death; and considered admission to ICU as the main exposure variable while adjusting for measured potential confounding variables. These included the Deyo-adaptation of the Charlson comorbidity index (CCI) score, age, sex, neighborhood (postal code) level income quintile, length of hospitalization, urban versus rural location, and hospital type (academic, large community, small community) [25, 26]. In a secondary analysis, we also constructed a cause-specific Cox proportional hazards model in which deaths were censored. We also conducted a quarterly analysis to examine how the hazard ratios obtained from the Fine and Gray model varied over time during the 1-year follow-up period.

We used a similarly-constructed Fine and Gray competing risk regression model (and including the same measured potential confounding variables) to evaluate the risk of new mental illness diagnosis among ICU survivors after exposure to the following procedures: mechanical ventilation, tracheostomy, other pulmonary procedures (bronchoscopy, chest tube insertion), cardiovascular procedures (pulmonary artery catheterization, transvenous pacemaker insertion, intra-aortic balloon pump), percutaneous feeding tube insertion, and initiation of new dialysis. We also evaluated in this analysis the impact of longer duration of ICU stay, measured in days, on subsequent mental illness diagnosis.

All analyses were completed using SAS Enterprise Guide version 7.1 (Cary, NC). The proportionality assumptions for the Fine and Gray model were tested using graphical Schoenfeld residuals. Model estimates from the Fine and Gray models were presented as subdistribution adjusted hazard ratios (aHR) and 95% confidence intervals.

Results

Participants

Between April 2005 and March 2015, 1,847,462 patients required hospitalization and 121,101 (6.6%) of these had an ICU stay of 48 h or longer. The characteristics of these patients are displayed in Table 1; ICU patients were older [median age 66 (interquartile range-IQR 55–76) vs. 60 (IQR 46–73)], more likely to be men (61 vs. 49%), and had higher levels of chronic illness as estimated by the CCI score (CCI score 1–2, 49 vs. 27%) compared to hospitalized patients who did not require ICU. Online Table E6 summarizes the exposures and interventions received by patients admitted to ICU for $\geq$ 48 h. Mechanical ventilation was provided to 19% (23,645) of ICU patients for an average of 1.1 days (SD 4.5 days).

Mental illness diagnosis after intensive care unit admission

Overall, 17% (20,610) of the patients who were admitted to an ICU during their hospitalization received a new mental illness diagnosis during the year after discharge, compared with 15% (257,034) of the hospitalized cohort, corresponding to a subdistribution adjusted hazard ratio (aHR) of 1.17 (95% CI 1.15–1.19; $P < 0.001$; Fig. 1) for ICU patients compared to hospitalized patients. The adjusted hazard ratio (aHR) after accounting for potential confounders was 1.08 (95% CI

Table 1 Characteristics of patients with hospitalizations with and without ICU admission

	ICU cohort	Hospital cohort	SD
Number of patients	121,101	1,726,361	
Patient characteristics			
Age, median (IQR)	66 (55–76)	60 (46–73)	0.32
Age, n (%)			
18–24	2426 (2.0)	83,881 (4.9)	0.16
25–34	3256 (2.7)	109,614 (6.3)	0.18
35–44	7020 (5.8)	185,295 (10.7)	0.18
45–44	17,002 (14.0)	289,596 (16.8)	0.08
55–44	25,992 (21.5)	334,019 (19.3)	0.05
65–54	29,289 (24.2)	330,324 (19.1)	0.12
75–84	26,870 (22.2)	275,160 (15.9)	0.16
> 85	9246 (7.6)	118,472 (6.9)	0.03
Male, n (%)	73,644 (60.8)	844,823 (48.9)	0.24
Charlson comorbidity index score, n (%)			
0	30,678 (25.3)	1,075,058 (62.3)	0.80
1–2	58,877 (48.6)	470,010 (27.2)	0.45
3+	31,546 (26.0)	181,293 (10.5)	0.41
Rural residence, n (%)	20,671 (17.1)	262,372 (15.2)	0.05
Income quintile, n (%)			
First	25,798 (21.3)	331,773 (19.2)	0.05
Second	25,946 (21.4)	347,894 (20.2)	0.03
Third	24,179 (20.0)	342,877 (19.9)	0.00
Fourth	23,209 (19.2)	350,912 (20.3)	0.03
Fifth	21,423 (17.7)	345,677 (20.0)	0.06
Missing	546 (0.5)	7228 (0.4)	0.01
Hospital LOS, med (IQR)	7 (4–11)	3 (1–5)	0.59
Medical comorbidities, n (%)			
Cardiovascular disease	59,319 (49.0)	165,448 (9.60)	0.96
Chronic obstructive pulmonary disease	12,517 (10.3)	101,182 (5.90)	0.16
Diabetes mellitus	30,579 (25.3)	238,959 (13.8)	0.29
GI disease	4936 (4.10)	44,033 (2.60)	0.09
Renal disease	6886 (5.70)	41,506 (2.40)	0.17
Cancer diagnosis	16,662 (13.8)	236,982 (13.7)	0.00

Characteristics of the patients who were admitted to ICU for 48 h or more compared to patients admitted to hospital without an ICU stay

For description of the ICU cohort and hospital cohort see main text. Difference between the two groups are described using standardized differences of means

SD = standardized differences (greater than 0.1 considered important), *med* median, *IQR* interquartile range, *n* number, *LOS* hospital length of stay, *GI* gastrointestinal

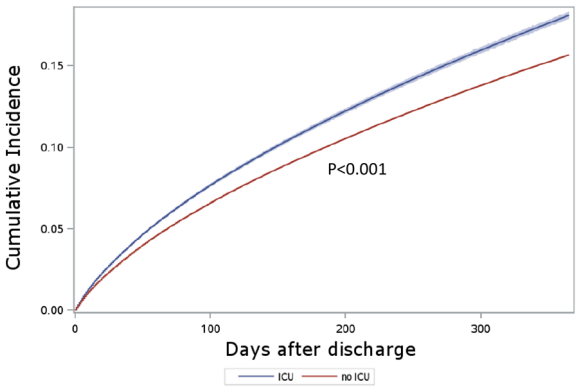

Fig. 1 Cumulative incidence of incident mental illness diagnosis among patients admitted to ICU compared to hospitalized patients who did not require ICU. This graph shows cumulative incidence of mental illness diagnosis obtained from the Fine and Gray model and 95% confidence intervals (shaded areas). The blue line corresponds to patients who survived an ICU admission, and the red line corresponds to hospitalized patients who did not require ICU admission. The aHR was 1.17 (95% CI 1.15–1.19; $P < 0.001$). Y axis is cumulative incidence function; X axis is days after discharge

1.07–1.10) (Fig. 2); similar results were obtained from a cause-specific Cox-proportional hazards model with censoring of deaths (aHR 1.08; 95% CI 1.06–1.09). Each additional day of hospitalization was associated with a marginally increased risk of a subsequent mental illness diagnosis (aHR 1.01 per day; 95% CI 1.01–1.01). Other factors that increased the risk of a mental illness diagnosis after hospital discharge included urban residence (aHR 1.16; 95% CI 1.15–1.17) and larger number of comorbidities (CCI score 1 or 2 vs. 0, aHR 1.17; 95% CI 1.16–1.18). Admission to a smaller hospital (aHR 0.91; 95% CI 0.90–0.92) and male sex (aHR 0.84; 95% CI 0.84–0.85) were associated with a lower subsequent risk of mental illness diagnosis.

In the sensitivity analyses that restricted the cohort to six pre-specified most responsible diagnoses, only patients with pneumonia continued to have a significantly higher risk of subsequent mental illness diagnoses after discharge that included ICU admission compared to hospitalized patients without ICU admission (aHR 1.15; 95% CI 1.03–1.29; $P = 0.01$; Fig. 3 and Online Table E7). In the other groups (COPD exacerbation, congestive heart failure, asthma exacerbation, sepsis, and severe sepsis) an increased risk of mental illness diagnosis after ICU was no longer apparent.

We also evaluated whether the hazard for developing mental illness varied depending on the length of time after discharge (Table 2). The greatest hazard associated with ICU admission for new mental illness diagnosis occurred early after discharge (i.e., during the first 3 months after hospital discharge, aHR 1.17 (95% CI 1.14–1.19) and decreased over time compared to hospitalized patients who did not require ICU admission: 3–6-month follow-up period, aHR 1.05 (95% CI 1.01–1.08); 6–9-month follow-up, aHR 0.97 (95% CI

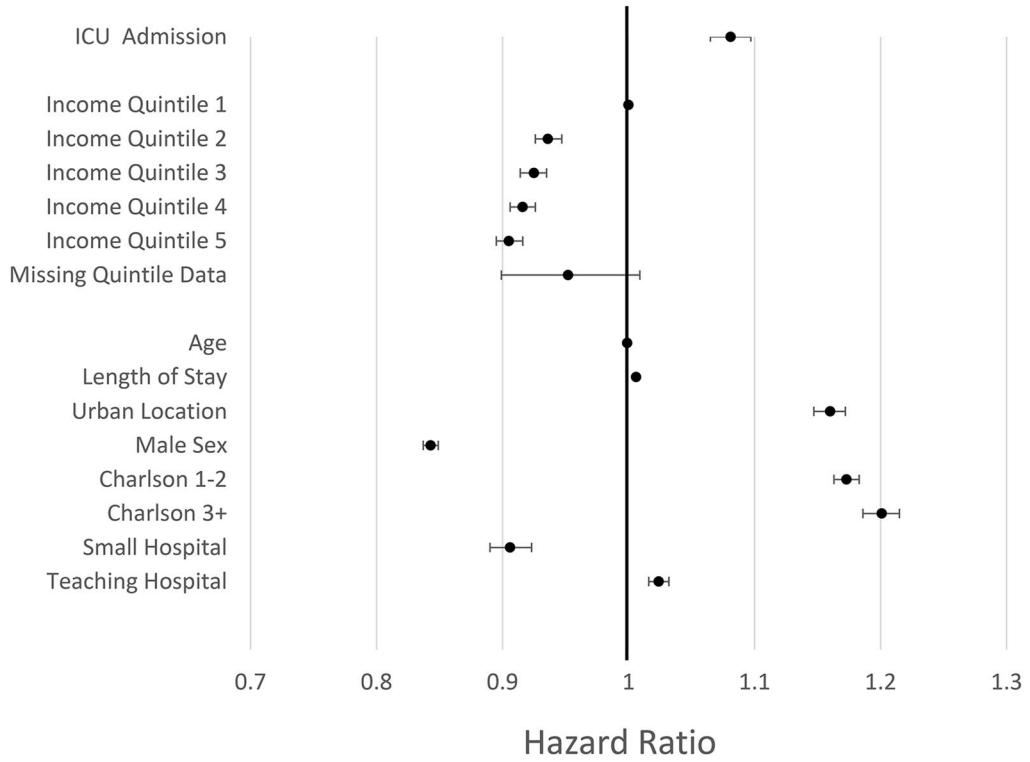

Fig. 2 Adjusted hazard of new mental illness diagnoses after ICU admission. Figure showing hazard ratios for developing new mental illness diagnosis after hospital discharge, obtained from the time to event Fine and Gray multivariable model. X axis shows the Hazard ratios for developing a new mental illness diagnosis for each covariate; Y axis shows various exposures and/or covariates. The main exposure for this analysis was ICU admission during hospitalization. Abbreviations: Length of stay = Hospital Length of stay; Charlson = Charlson Comorbidity Index Score; Small hospital = Small Community Hospital; Missing Quintile data = 5% of the patients had missing quintile data. Hospitals associated with the Ontario Council of Teaching hospitals were considered academic. Small community hospital type was defined as a hospital that had fewer than 20,000 referral population and admitted less than 3500 weighted cases a year. A large hospital was defined as any hospital that did not meet criteria for teaching or small hospital [32], Rural was defined as a community site with less than 1000 people [33]

0.94–1.01), 9–12-month follow-up, aHR 0.93 (95% CI 0.90–0.97).

Mental illness diagnosis after intensive care unit procedures

ICU patients who required mechanical ventilation, tracheostomy, and percutaneous feeding tube insertion all had increased crude rates of mental illness diagnosis after discharge compared to patients who did not receive these interventions while in ICU (Online Table E8).

In adjusted analyses accounting for measured confounders (Figure E1), only mechanical ventilation (aHR 1.08; 95% CI 1.05–1.12) and increased duration of ICU stay (aHR 1.004 per additional day, 95% CI 1.003–1.005) were associated with an increased risk of developing a new mental illness diagnosis after discharge. Conversely, renal dialysis was associated with a lower risk of developing new mental illness diagnosis (aHR 0.88; 95% CI 0.80–0.97).

Discussion

Our study shows that patients admitted to the ICU have a slightly elevated risk of being diagnosed with a mental illness after hospital discharge, compared to hospitalized patients without an ICU admission. Specific ICU exposures and procedures—for example receiving mechanical ventilation, or duration of ICU admission—appear to further increase this risk of subsequent mental illness diagnosis after critical illness. These findings suggest that some ICU survivors may warrant closer follow-up to monitor for mental illness complications after discharge, in particular after certain exposures that increase their risk.

Previous studies have described an increased risk of mental illness after ICU admission [27]. A large systematic review described an increased risk of anxiety symptoms after an ICU admission [9]. A large population-based cohort study of mechanically ventilated patients demonstrated a higher rate of mental illness after ICU compared to hospitalized controls [11].

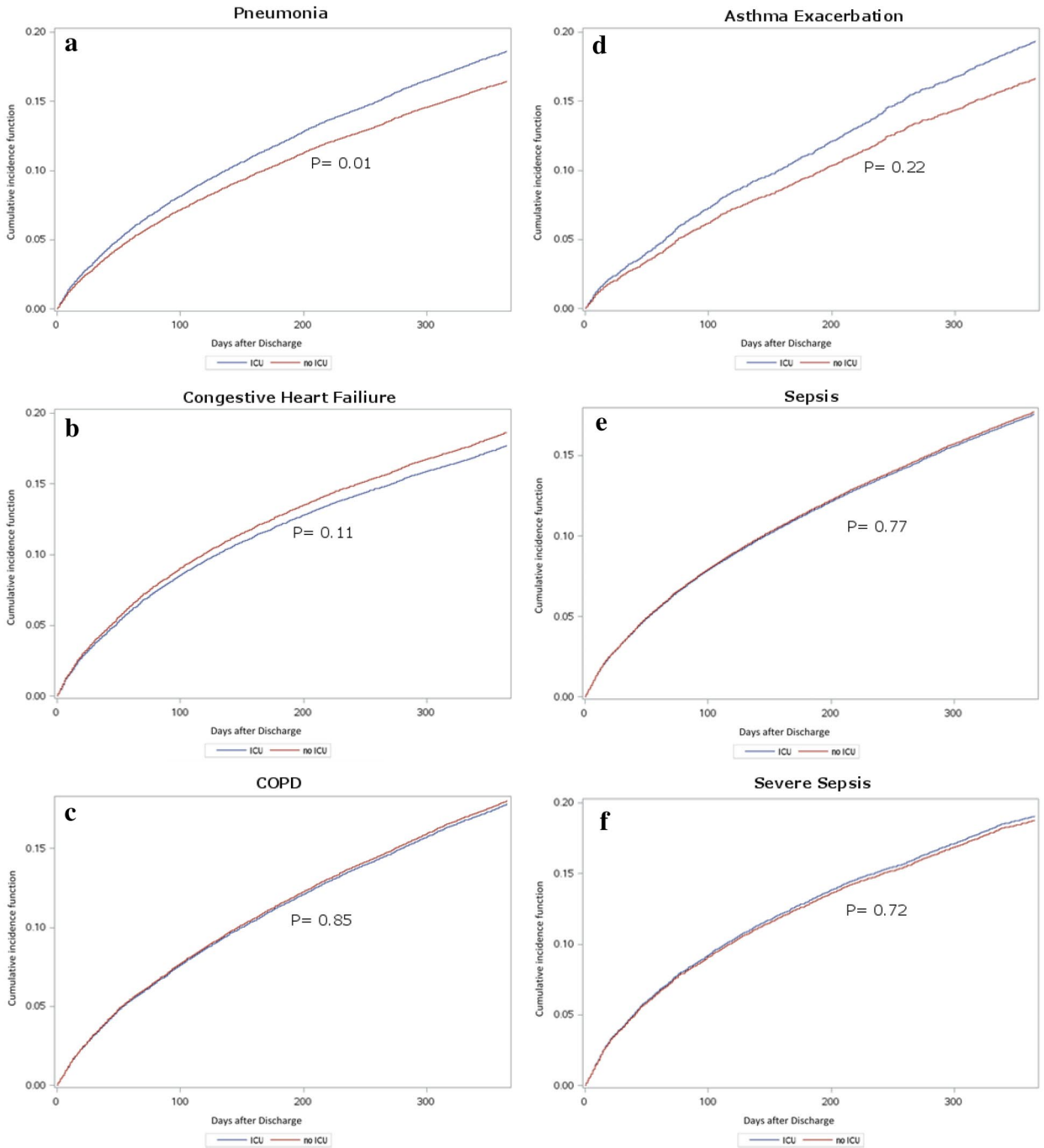

Fig. 3 Restricted cohort analyses examining risk of new mental illness diagnoses after ICU admission. Figure showing results of sensitivity analyses restricted to pre-specified diseases. **a** Pneumonia patients ($n = 31,420$). Higher hazard ratio for ICU patients compared to hospitalized patients (aHR 1.15; 95% CI 1.03–1.29; $P = 0.01$). **b** Congestive heart failure patients ($n = 28,241$) (aHR 0.940; 95% CI 0.872–1.01; $P > 0.05$). **c** Chronic obstructive pulmonary disease (COPD) patients ($n = 34,410$). (aHR 0.991; 95% CI 0.906–1.09; $P > 0.05$). **d** Asthma patients ($n = 6619$). (aHR 1.18; 95% CI 0.906–1.54; $P > 0.05$). **e** Sepsis patients ($n = 66,912$). (aHR 0.991; 95% CI 0.929–1.06; $P > 0.05$). **f** Severe Sepsis patients ($n = 14,031$). (aHR 1.02; 95% CI 0.921–1.13; $P > 0.05$). (X axis shows the days after hospital discharge; Y shows has the cumulative incidence function. See Online Table E7 for detailed results

Table 2 Risk of new mental illness diagnosis over time after hospitalization with ICU admission versus without

Time (months)	Hazard ratio	95% CI	*P* value
0–3	1.17	1.14–1.20	< 0.001
3–6	1.05	1.014–1.08	0.0041
6–9	0.97	0.94–1.01	0.1155
9–12	0.93	0.90–0.97	< 0.001

Changes in aHR for the development of new mental illness over each quarter of the year after discharge

Similar to our findings, this previous study also noted an increased risk early after hospital discharge, supporting a causal relationship between critical illness and subsequent mental illness. Our observed incidence of new mental illness diagnosis after hospitalization was lower than reported in some previous studies; [9, 12] this discrepancy is likely explained by differences in methodology, in particular coding of clinician-based diagnoses of mental illness (instead of self-reports) and exclusion of patients with pre-existing diagnoses of mental illness in our study.

Our secondary analyses may offer additional insights about the relationship between ICU admission and subsequent mental illness diagnoses. The risk of mental illness appears to increase in a dose-dependent fashion, with a higher risk among patients exposed to longer time in the ICU or to more invasive and uncomfortable mechanical ventilation. Interestingly, when we restricted our analyses to patients with 6 specific pre-specified diagnoses that can lead to hospitalization with or without ICU admission, only patients with pneumonia still had a higher risk of mental illness diagnosis after an ICU containing hospitalization. An increased risk of depression after hospitalization for patients with pneumonia has been previously observed; our findings therefore suggest that ICU admission may further increase their risk [28]. Taken together, however, the results of these sensitivity analyses suggest that for many patients the underlying diagnosis is a more important determinant of subsequent mental illness diagnosis than ICU admission per se. An unexpected finding was that patients who were exposed to dialysis during ICU had lower rates of new mental illness diagnoses after discharge compared to ICU patients who did not require dialysis. Previous research has described an overlap of symptoms of uremia and depression, and it may be that new mental illness diagnoses in these survivors were mislabeled as complications of poor renal function [29, 30].

Our study examined 1.8 million hospital survivors of which 121,101 were admitted to ICU, making it the largest population-based cohort to evaluate rates of new mental illness diagnoses among ICU survivors. We excluded patients with evidence of mental illness prior to ICU admission, since previous mental illness diagnosis strongly predicts subsequent mental health problems [31]. We also excluded conditions already known to increase risk for subsequent mental illness. Mental illness in our study was based on physician-assigned clinical diagnoses instead of self-reported surveys, which increases the specificity of diagnosis but may lead to underestimation of rates of mental illness in patients not seeking medical attention. An important strength of our study was inclusion of diagnoses made by a broad range of clinicians including family physicians and not only psychiatrists. Indeed, the majority (83%) of patients with new mental illnesses were diagnosed by family physicians. However, this approach could have decreased the specificity of the diagnosis of mental illness. Finally, we examined the association of new mental illness diagnosis with exposure to several common ICU procedures, allowing us to identify specific groups of ICU survivors who may be at highest risk for subsequent mental illness.

Our study also has several limitations. Notably, there are other risk factors for mental illness diagnosis, including genetic predisposition and availability of psychosocial supports, which are potentially important confounders that were unavailable in our databases. To better assess the impact of ICU admission on the risk of developing a new mental illness after discharge, we excluded patients with conditions already known to increase the risk of subsequent mental illness, or those with pre-existing mental illnesses. However, future research should consider whether critical illness exacerbates mental illness among these patient groups. We may have underestimated true rates of incident mental illness diagnoses, as patients who did not seek healthcare would not be captured by our methodology. Our one-year look-back period to detect previous mental illness diagnoses may also have failed to capture patients with pre-existing but stable mental illness, who did not require attention from their healthcare providers. Another limitation was that our coding algorithms were unable to reliably distinguish between different types of mental illness diagnosis, such as depression, anxiety and post-traumatic stress disorder (Online Table E9). We are therefore unable to determine which specific mental illness diagnoses are more common after ICU admission versus hospitalization without ICU. Patients may have received closer follow-up after a hospitalization that included an ICU admission, leading to earlier diagnosis of a new mental illness. We attempted to mitigate this potential bias by following all patients for at least one year, to increase the case-capture rate in both cohorts. We included patients admitted to both level 2

(capable of providing vasopressors and non-invasive ventilation but not invasive mechanical ventilation) and level 3 (capable of providing invasive mechanical ventilation) to provide a large population of critically ill patients with a spectrum of illness severity; however, this resulted in a comparatively low rate of mechanical ventilation compared to previous similar studies [11]. Our control group comprised hospital survivors who were already unwell due to the need for hospitalization; the choice of this control group (instead of general population controls) may explain why we only detected a marginal increase in the risk of mental illness diagnosis after ICU admission. Our sensitivity analyses restricting to pre-specified diagnoses may have been underpowered to detect small but potentially important differences in risk of mental illness after ICU admission. Testing all possible admission diagnoses was not feasible, and there may exist some admission diagnoses for which ICU admission has a more pronounced impact on subsequent mental illness risk.

Conclusion and relevance

ICU survivors have a marginally increased risk for mental illness diagnosis compared to hospitalized patients without ICU admission. However, the underlying reason for hospitalization may be a more important risk factor for subsequent mental illness than the ICU admission per se. Among patients admitted to ICU, the need for mechanical ventilation and longer duration of ICU stay were independent factors associated with an increased risk of subsequent mental illness diagnosis. These patients could be targeted for closer monitoring for mental illness complications, especially during the 3-month period after discharge when the risk appears to be highest.

Electronic supplementary material
The online version of this article (https://doi.org/10.1007/s00134-019-05752-5) contains supplementary material, which is available to authorized users.

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Author contributions
Conception of Study: LS, HW, SV, DCS. Design of Study: LS, HW, SV, DCS. Analytical Plan/Analyses: LS, HW, SV, AH, RP, DCS. Supervision: HW, SV, DCS. Editing of Manuscript for Intellectual Content: LS, HW, SV, AH, RP, DCS.

Compliance with ethical standards

Conflicts of interest
Dr. Vigod receives royalties from UpToDate Inc. for authorship of materials related to depression and pregnancy. Other authors have no commercial or financial conflicts of interest to declare.

Ethics approval
This study was approved by the Research Ethics Board of Sunnybrook Health Sciences Center and the University of Toronto Office of Research Ethics.

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References

1. Pandharipande PP, Girard TD, Jackson JC et al (2013) Long-term cognitive impairment after critical illness. N Engl J Med 369:1306–1316. https://doi.org/10.1056/NEJMoa1301372
2. Zimmerman JE, Kramer AA, Knaus WA (2013) Changes in hospital mortality for United States intensive care unit admissions from 1988 to 2012. Crit Care 17:R81. https://doi.org/10.1186/cc12695
3. Jackson JC, Pandharipande PP, Girard TD et al (2014) Depression, post-traumatic stress disorder, and functional disability in survivors of critical illness in the BRAIN-ICU study: a longitudinal cohort study. Lancet Respir Med 2:369–379. https://doi.org/10.1016/S2213-2600(14)70051-7
4. Jutte JE, Erb CT, Jackson JC (2015) Physical, cognitive, and psychological disability following critical illness: What is the risk? Semin Respir Crit Care Med 36:943–958. https://doi.org/10.1055/s-0035-1566002
5. Needham DM, Davidson J, Cohen H et al (2012) Improving long-term outcomes after discharge from intensive care unit. Crit Care Med 40:502–509. https://doi.org/10.1097/CCM.0b013e318232da75
6. Rawal G, Yadav S, Kumar R (2017) Post-intensive care syndrome: an overview. J Transl Intern Med 5:90–92. https://doi.org/10.1515/jtim-2016-0016
7. Myers EA, Smith DA, Allen SR, Kaplan LJ (2016) Post-ICU syndrome. J Am Acad Physician Assist 29:34–37. https://doi.org/10.1097/01.JAA.0000481401.21841.32
8. Scragg P, Jones A, Fauvel N (2001) Psychological problems following ICU treatment. Anaesthesia 56:9–14. https://doi.org/10.1046/j.1365-2044.2001.01714.x
9. Nikayin S, Rabiee A, Hashem MD et al (2016) Anxiety symptoms in survivors of critical illness : a systematic review and meta-analysis. Gen Hosp Psychiatry 43:23–29. https://doi.org/10.1016/j.genhosppsych.2016.08.005
10. Wolters AE, Peelen LM, Welling MC et al (2016) Long-Term Mental Health Problems after Delirium in the ICU. Crit Care Med 44:1808–1813. https://doi.org/10.1097/CCM.0000000000001861
11. Wunsch H, Christiansen CF, Johansen MB et al (2014) Psychiatric diagnoses and psychoactive medication use among nonsurgical critically ill patients receiving mechanical ventilation. JAMA 311:1133–1142. https://doi.org/10.1001/jama.2014.2137
12. Hatch R, Young D, Barber V et al (2018) Anxiety, depression and post traumatic stress disorder after critical illness: a UK-wide prospective cohort study. Crit Care 22:1–13
13. Saverino C, Swaine B, Jaglal S et al (2016) Rehospitalization after traumatic brain injury: a population-based study. Arch Phys Med Rehabil 97:S19–S25. https://doi.org/10.1016/j.apmr.2015.04.016
14. Tully PJ, Baker RA (2012) Depression, anxiety, and cardiac morbidity outcomes after coronary artery bypass surgery: a contemporary and practical review. J Geriatr Cardiol 9:197–208. https://doi.org/10.3724/SP.J.1263.2011.12221

15. McCarthy MJ, Sucharew HJ, Alwell K et al (2016) Age, subjective stress, and depression after ischemic stroke. J Behav Med 39:55–64. https://doi.org/10.1007/s10865-015-9663-0
16. Hare DL, Toukhsati SR, Johansson P, Jaarsma T (2014) Depression and cardiovascular disease: a clinical review. Eur Heart J 35:1365–1372. https://doi.org/10.1093/eurheartj/eht462
17. Vigod S, Sultana A, Fung K et al (2016) A population-based study of postpartum mental health service use by immigrant women in Ontario, Canada. Can J Psychiatry 61:705–713. https://doi.org/10.1177/0706743716645285
18. Polachek IS, Fung K, Vigod SN et al (2016) First lifetime psychiatric admission in the postpartum period: a population-based comparison to women with prior psychiatric admission. Gen Hosp Psychiatry 40:25–32. https://doi.org/10.1016/j.genhosppsych.2016.01.007
19. Steele LS, Glazier RH, Lin E, Evans M (2004) Using administrative data to measure ambulatory mental health service provision in primary care. Med Care 42:960–965. https://doi.org/10.1097/00005650-200410000-00004
20. Juurlink D, Preyra C, Croxford R, Chong A, Austin P, Tu JV (2006) Canadian Institute for Health Information Discharge Abstract Database: a validation study ICES investigative report June 2006 Canadian Institute for Health Information Discharge Abstract Database
21. Scales DC, Thiruchelvam D, Kiss A, Redelmeier DA (2008) The effect of tracheostomy timing during critical illness on long-term survival. Crit Care Med 36:2547–2557. https://doi.org/10.1097/CCM.0b013e31818444a5
22. Hill AD, Fowler RA, Pinto R et al (2016) Long-term outcomes and healthcare utilization following critical illness—a population-based study. Crit Care 20:76. https://doi.org/10.1186/s13054-016-1248-y
23. Scales DC, Thiruchelvam D, Kiss A et al (2008) Intensive care outcomes in bone marrow transplant recipients: a population-based cohort analysis. Crit Care 12:R77. https://doi.org/10.1186/cc6923
24. Quan H, Li B, Duncan Saunders L et al (2008) Assessing validity of ICD-9-CM and ICD-10 administrative data in recording clinical conditions in a unique dually coded database. Health Serv Res 43:1424–1441. https://doi.org/10.1111/j.1475-6773.2007.00822.x
25. Needham DM, Scales DC, Laupacis A, Pronovost PJ (2005) A systematic review of the Charlson comorbidity index using Canadian administrative databases: a perspective on risk adjustment in critical care research. J Crit Care 20:12–19. https://doi.org/10.1016/j.jcrc.2004.09.007
26. Deyo RA, Cherkin DC, Ciol MA (1992) Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol 45:613–619. https://doi.org/10.1016/0895-4356(92)90133-8
27. Kowalczyk M, Nestorowicz A, Fijałkowska A, Kwiatosz-Muc M (2013) Emotional sequelae among survivors of critical illness. Eur J Anaesthesiol 30:111–118. https://doi.org/10.1097/EJA.0b013e32835dcc45
28. Davydow DS, Hough CL, Levine DA et al (2013) Functional disability, cognitive impairment, and depression after hospitalization for pneumonia. Am J Med 126:615–624. https://doi.org/10.1016/j.amjmed.2012.12.006
29. Shirazian S, Grant CD, Aina O et al (2017) Depression in chronic kidney disease and end-stage renal disease: similarities and differences in diagnosis, epidemiology, and management. Kidney Int Rep 2:94–107. https://doi.org/10.1016/j.ekir.2016.09.005
30. Smith M, Hong B, Robson A (1985) Diagnosis of depression in patients with end-stage renal disease: comparative analysis. Am J Med 79:160–166
31. Burcusa SL, Iacono WG (2007) Risk for recurrence in depression. Clin Psychol Rev 27:959–985. https://doi.org/10.1016/j.cpr.2007.02.005
32. McKillop I, Daniel I, McGillis L, Hall GP (2005) Hospital report 2005: emergency department care
33. Rotermann M, Sanmartin C, Trudeau R, St-Jean H (2015) Linking 2006 census and hospital data in Canada. Heal Reports 26:10–20