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Characteristics and Outcomes for Low-Risk Hospital Admissions Admitted to the ICU: A Multisite Cohort Study

IMPORTANCE: Prognostication following ICU admission can often be determined based on known risk factors, including demographics and illness severity; however, little is known about outcomes of patients deemed to be “low-risk” at the time of hospital admission who subsequently are admitted to the ICU.

OBJECTIVES: The objectives of this study were to determine the characteristics, outcomes, and costs for patients requiring ICU admission despite having lower predicted mortality when they were admitted to the hospital.

DESIGN, SETTING, AND PARTICIPANTS: In this historical cohort study, we used a prospectively maintained ICU registry that included all ICU admissions to The Ottawa Hospital for patients 18 years or older from January 2011 to December 2016. We classified patients as low-risk using the Hospital-patient 1-year Mortality Risk at admission score, a hospital admission score validated to predict 1-year mortality.

MAIN OUTCOMES AND MEASURES: The primary outcome was inhospital mortality. Secondary outcomes included adverse events, resource utilization, and costs.

RESULTS: Of the 17,173 total ICU patients, 3,445 (20.1%) were classified as low-risk at hospital admission. Low-risk patients were younger (48.7 vs 67.5 yr; $p < 0.001$) and had a lower Multiple Organ Dysfunction Score (2.37 vs 4.14; $p < 0.001$). Mortality for low-risk patients was significantly lower than for non-low-risk patients (4.1% vs 25.4%; $p < 0.001$). For low-risk patients, multivariable logistic regression showed mortality was independently associated with older age (odds ratio, 1.02 per 1 yr; 95% CI, 1.00–1.03 per 1 yr), Multiple Organ Dysfunction Score (odds ratio, 1.42 per 1 point; 95% CI, 1.31–1.54 per 1 point), fluid management adverse events (odds ratio, 2.84; 95% CI, 1.29–6.25), hospital-acquired infections (odds ratio, 1.60; 95% CI, 1.02–2.51), and mechanical ventilation (odds ratio, 1.98; 95% CI, 1.20–3.26).

CONCLUSIONS AND RELEVANCE: Despite their robust premonitory status, low-risk patients admitted to the ICU had significant inhospital mortality. Fluid management adverse events, hospital-associated infections, multiple organ dysfunction, and mechanical ventilation are important prognostic factors for low-risk patients.

KEY WORDS: cost; fluid overload; hospital-acquired infections; intensive care; mortality; prognosis

Mortality for patients admitted to ICUs varies by country, center, case mix, and local resources (1). While important research has focused on outcomes and costs associated with elderly and frail patients admitted to the ICU (2–4), less is known about younger, less comorbid, and low-risk patients requiring ICU admission. Improvements in hospital datasets and predictive modeling have allowed for the classification of certain hospital admissions as low risk. For any number of reasons, low-risk patients may deteriorate

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and require admission to ICU, with some of these patients ultimately dying. These predictive models may help with optimizing resource allocation and benchmarking expected outcomes for admitted patients.

Understanding prognostic factors for ICU patients in particular is important to identify “unexpected” deaths, to inform discussions surrounding end-of-life care, and to understand resource utilization at a systems level. Previous research has shown that most deaths in the ICU occur with multiple organ dysfunction (MOD), as opposed to single-organ dysfunction or sudden cardiac death (5, 6). Unexpected deaths, defined as sudden cardiac death or death despite full-level ICU care, are less frequent than anticipated deaths, occur earlier during an ICU admission, and are associated with less MOD (5). Despite research into unexpected deaths, little is known about outcomes and risk factors for death for low-risk hospital admission admitted to the ICU.

The objective of this study was to determine the characteristics, outcomes, and costs for patients requiring ICU admission despite having lower predicted mortality when they were admitted to the hospital. Determining risk factors for mortality in low-risk patients may identify areas where early and targeted interventions could improve outcomes.

MATERIALS AND METHODS

Ethics Approval

Ethics approval for this study was obtained from The Ottawa Health Science Network Research Ethics Board (Protocol 20160570-01H). This cohort study has been reported as per the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (7). The study data is available from the corresponding author at reasonable request.

Study Design, Setting, and Subjects

Patients were included from two tertiary care hospitals within The Ottawa Hospital network (Ottawa, ON, Canada). Combined, these hospitals have approximately 1,200 hospital beds, 64 ICU beds, with 60,000 total hospital admissions and 2,500 total ICU admissions per year. We retrospectively analyzed prospectively collected data from “The Ottawa Hospital Data Warehouse,” a health administrative database used in previous studies (2, 8–10). Data for each admitted

patient is collected daily and stored in “The Ottawa Hospital Data Warehouse.” Data quality assurance is regularly conducted to ensure completeness and accuracy. Consecutive patients were included for analysis if they were 18 years or older and were admitted to either of the two ICUs between January 1, 2011, and December 31, 2016.

Data Collection

From the “The Ottawa Hospital Data Warehouse,” basic demographic data, comorbidities, Elixhauser comorbidity score (11), and Multiple Organ Dysfunction Score (MODS) (12) were extracted. As part of the database, outcome data were collected from admission until either the point of hospital discharge or in-hospital death.

The Hospital-patient 1-year Mortality Risk at admission (HOMR-now!) score was calculated for each patient based on hospital admission data (13). The HOMR-now! score was developed and validated for use at The Ottawa Hospital to predict 1-year mortality based at admission characteristics (13). Patients with a predicted 1-year mortality of less than 4.8% were defined as low risk, a threshold chosen as this defined the lowest 20% of HOMR-now! scores for our ICU cohort. The HOMR-now! score uses patient demographics, hospitalization specifics, and initial laboratory data to predict 1-year mortality (13). Patient characteristics include sex, comorbidities, previous admissions, living status, previous emergency department (ED) visits, and previous cancer clinic assessments. Hospitalization specifics include whether the admission was elective, the ED presentation was with or without ambulance transfer, and the admitting service (e.g., surgery, medicine). Admission laboratory data uses the Laboratory-based Acute Physiology Score to capture the extent of laboratory perturbation for a patient (14).

Patient costs during hospital admission were determined using the case-costing system of “The Ottawa Hospital Data Warehouse,” as performed previously (2, 8, 9, 15). Total hospital costs included both direct and indirect sources. Direct costs are all expenses to the hospital with fee codes linked to a patient identifier. Indirect costs refer to any overhead operational fees associated with provided services. The Ottawa Hospital uses a standardized case-costing methodology developed by the Ontario Case Costing Initiative, which is based upon the Canadian Institute for Health

Information Management guidelines (16). Costs were indexed to 2018 Canadian Dollars using consumer price indices. The Nine Equivalents of Nursing Manpower use Score, an indicator of nursing requirements, was also calculated daily for ICU patients (17).

Outcomes

The primary outcome was in-hospital mortality. Secondary outcomes included adverse events acquired in hospital (e.g., hospital-acquired infection [HAI]), resource utilization (e.g., invasive mechanical ventilation, dialysis), and hospital costs. Specific *International Classification of Diseases*, 10th Revision (ICD-10) codes included in the adverse event categories are available on the Open Science Framework (<https://osf.io/3xv8n/>).

Statistical Analysis

All statistical analyses were performed with STATA v11.1 (StataCorp LLC) and IBM SPSS (v27.0) (IBM). Data are presented as mean values with SD or median values with interquartile range, where appropriate. Student *t* test (parametric values), Mann-Whitney *U* test (nonparametric values), chi-square (for categorical values), and Fisher exact test (for categorical variables where the expected cell count was < 5) were used to determine differences between groups. A *p* value of

less than or equal to 0.05 was considered statistically significant.

Multivariable logistic regression was used to evaluate predictors of mortality in low-risk patients and was performed based on a priori selection of clinically important variables including age, male sex, Elixhauser comorbidity score, MODS, admission after 5 PM, cardiac complications, surgical complications, delirium, drug-related adverse event, fluid administration adverse event (e.g., fluid overload, dehydration, and infusion reaction), HAI, renal replacement therapy, and invasive mechanical ventilation. Based on current critical care research guidelines, predictors were not selected on the basis of univariate significance testing to avoid possible model overfitting (18).

RESULTS

A total of 17,173 patients were admitted to the ICUs during the study period. From these, 12 patients were excluded due to missing data or data entry errors. A flow diagram is provided in **Figure 1**. Additionally, 3,185 patients (18.6%) were missing data for ICU interventions (i.e., invasive and noninvasive mechanical ventilation, arterial line, and dialysis). Analyses involving these variables were performed for patients with complete data only.

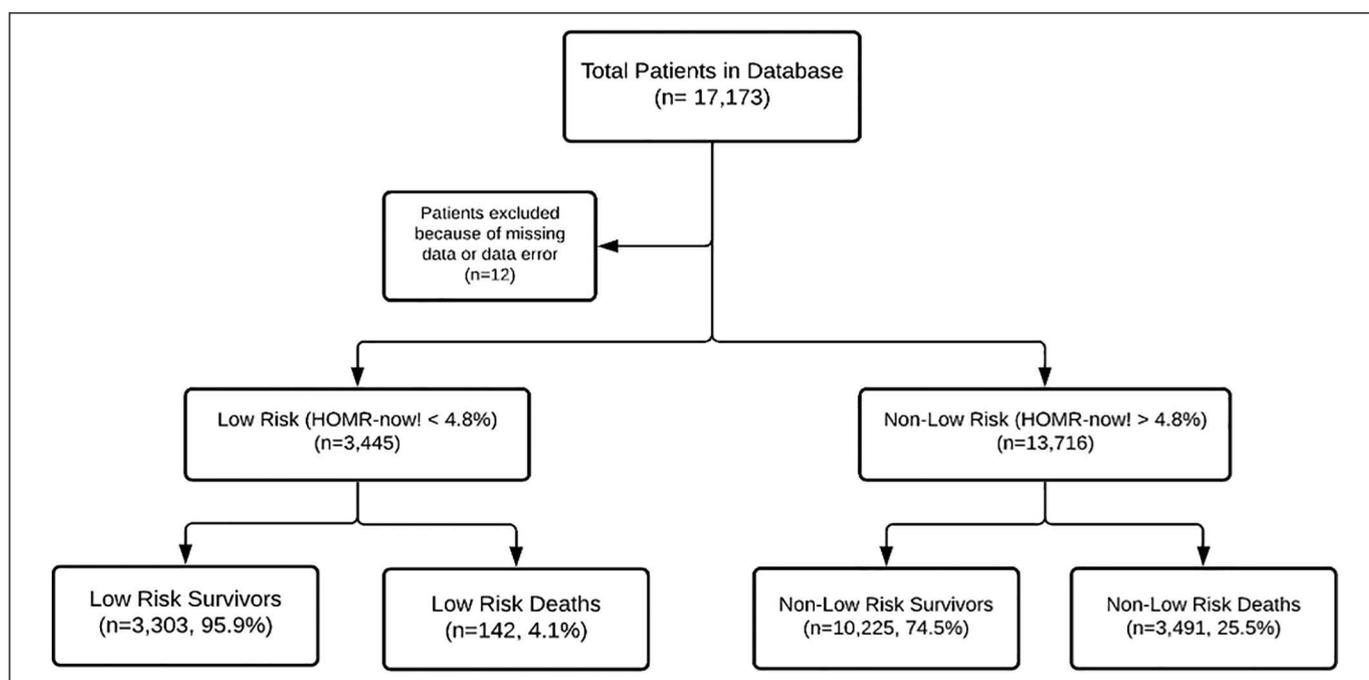


Figure 1. Study flow diagram. HOMR-now! = Hospital-patient 1-year Mortality Risk at admission.

A total of 3,445 (20.1%) had a hospital admission HOMR-now! score indicating a mortality of less than 4.8% and were designated as low-risk patients. Low-risk patients were significantly younger (48.7 vs 67.5 yr; $p < 0.001$), had a lower Elixhauser comorbidity score (1.70 vs 6.10; $p < 0.001$), and had a lower MODS (2.37 vs 4.14; $p < 0.001$). Low-risk patients also had lower median ICU length of stay (3 vs 5 d; $p < 0.001$), as well as several differences in admission diagnoses. In-hospital mortality was lower for low-risk patients (4.1% vs 25.4%; $p < 0.001$). Low-risk patients also had a lower mean total hospital cost compared with non-low-risk admissions (\$28,085 vs \$41,639; $p < 0.001$).

Low-risk patients had fewer adverse events compared with non-low-risk patients (26.8% vs 37.5%; $p < 0.001$) (**Supplemental Table 1**, <http://links.lww.com/CCX/A872>). Demographic information is provided in **Table 1** and a complete list of comorbidities is provided in **Supplemental Table 2** (<http://links.lww.com/CCX/A872>). Individual ICD-10 codes that comprise each major admission category for low-risk and non-low-risk patients are included in **Supplemental Tables 3 and 4** (<http://links.lww.com/CCX/A872>), and the top 10 most likely diagnoses for both groups are included in **Supplemental Figure 1** (<http://links.lww.com/CCX/A872>).

TABLE 1.
Demographics and Inhospital Mortality for Low-Risk and Non-Low-Risk ICU Admissions

Characteristics	All Patients, <i>n</i> = 17,161	Non-Low-Risk, <i>n</i> = 13,716	Low-Risk, <i>n</i> = 3,445	<i>p</i>	Low-Risk Survivors, <i>n</i> = 3,303	Low-Risk Decedents, <i>n</i> = 142	<i>p</i>
Age, yr, mean (sd)	63.7 (17.2)	67.5 (15.1)	48.7 (16.7)	< 0.001	48.7 (16.7)	48.4 (16.2)	0.82
Male, <i>n</i> (%)	9,697 (56.5)	7,739 (56.4)	1,958 (56.8)	0.68	1,892 (57.3)	66 (46.5)	0.01
Most responsible diagnosis, <i>n</i> (%)							
Circulatory system	5,692 (33.2)	4,207 (30.7)	1,485 (43.1)	< 0.001	1,456 (44.1)	29 (20.4)	< 0.001
Respiratory system	1,867 (10.9)	1,661 (12.1)	206 (6.0)	< 0.001	192 (5.8)	14 (9.9)	0.07
Gastrointestinal or genitourinary system	1,760 (10.3)	1,531 (11.2)	229 (6.6)	< 0.001	211 (6.4)	18 (12.7)	< 0.01
Nervous system	495 (2.9)	375 (2.7)	120 (3.5)	0.02	112 (3.4)	8 (5.6)	0.16
Infectious disease	1,696 (9.9)	1,577 (11.5)	119 (3.5)	< 0.001	104 (3.1)	15 (10.6)	< 0.001
Injury, poisoning, and other external causes	2,273 (13.2)	1,661 (12.1)	612 (17.8)	< 0.001	583 (17.7)	29 (20.4)	0.46
Malignancy related	1,131 (6.6)	1,001 (7.3)	130 (3.8)	< 0.001	119 (3.6)	11 (7.7)	0.02
Other ^a	2,247 (13.2)	1,703 (12.4)	544 (15.8)	< 0.001	526 (15.9)	18 (12.7)	0.36
Comorbidities ^b , mean (sd)							
Elixhauser comorbidity score	5.2 (6.2)	6.10 (6.45)	1.70 (3.43)	< 0.001	1.67 (3.43)	2.35 (3.57)	0.03
Multiple Organ Dysfunction Score	3.8 (2.8)	4.14 (2.80)	2.37 (2.35)	< 0.001	2.22 (2.22)	5.26 (2.79)	< 0.001
Primary outcome, <i>n</i> (%)							
Mortality	3,633 (21.2)	3,491 (25.4)	142 (4.1)	< 0.001			

^aIncludes diseases of the blood, diseases of the skin, diseases of the eye, diseases of the ear, diseases of the musculoskeletal system, endocrine diseases, pregnancy, childbirth and puerperium, mental and behavioral disorders, symptoms, signs and abnormal clinical and laboratory findings, factors influencing health status, and congenital malformations.

^bA full table of patient comorbidities is provided in Supplemental Table S1 (<http://links.lww.com/CCX/A872>).

Of the 3,445 low-risk patients, 142 died (4.1%). Compared with low-risk decedents, low-risk survivors were more likely to be male (57.3% vs 46.5%; $p = 0.01$). Additionally, low-risk survivors had lower Elixhauser

comorbidity score (1.67 vs 2.35; $p = 0.03$) and MODS (2.22 vs 5.26; $p < 0.001$). Low-risk survivors had a modest but significantly lower number of median days spent in the ICU (3 vs 4 d; $p < 0.01$) (Table 2). Overall,

TABLE 2.
Admission Characteristics for Low-Risk and Non-Low-Risk ICU Admissions

Admission Characteristics	All Patients, $n = 17,161$	Non-Low-Risk, $n = 13,716$	Low-Risk, $n = 3,445$	p	Low-Risk Survivors, $n = 3,303$	Low-Risk Decedents, $n = 142$	p
Preadmission characteristics							
Direct transfer, n (%)	2,764 (16.1)	2,473 (18.0)	291 (8.4)	< 0.001	283 (8.6)	8 (5.6)	0.28
ED, n (%)	8,200 (47.8)	6,438 (46.9)	1,762 (51.1)	< 0.001	1,723 (52.2)	39 (27.5)	< 0.001
Ward, n (%)	5,075 (29.6)	4,237 (30.9)	838 (24.3)	< 0.001	763 (23.1)	75 (52.8)	< 0.001
Operating room, n (%)	1,122 (6.5)	568 (4.1)	554 (16.1)	< 0.001	534 (16.2)	20 (14.1)	0.59
Institutional transfer, n (%)	5,833 (34.0)	5,283 (38.5)	550 (16.0)	< 0.001	508 (15.4)	42 (29.6)	< 0.001
Previous ED visits within 1 yr, mean (SD)	0.78 (1.6)	0.85 (1.71)	0.47 (1.25)	< 0.001	0.48 (1.26)	0.47 (1.02)	0.98
Previous ICU admissions within 1 yr, mean (SD)	0.16 (0.63)	0.18 (0.67)	0.08 (0.42)	< 0.001	0.08 (0.42)	0.05 (0.30)	0.37
Previous ICU days within 1 yr, mean (SD)	1.12 (6.54)	1.29 (7.01)	0.46 (4.12)	< 0.001	0.41 (3.46)	1.47 (11.52)	0.28
Surgical procedure within 30 d, n (%)	418 (2.4)	356 (2.6)	62 (1.8)	< 0.01	59 (1.8)	3 (2.1)	0.74
Admission characteristics							
Number of ICU admissions, mean (SD)	1.20 (0.52)	1.20 (0.53)	1.17 (0.48)	< 0.001	1.16 (0.44)	1.34 (1.01)	0.04
ICU LOS, total days, median (IQR)	4 (2–9)	5 (2–9)	3 (2–6)	< 0.001	4 (2–8)	3 (1–9)	< 0.01
Acute LOS, total days, median (IQR)	8 (4–18)	9 (4–20)	6 (3–11)	< 0.001	9 (4–19)	6 (2–16)	< 0.01
Total LOS, total days, median (IQR)	8 (4–19)	10 (4–21)	6 (3–11)	< 0.001	9 (4–20)	7 (2–17)	< 0.01
First ICU before 5 PM, n (%)	10,910 (63.6)	8,690 (63.4)	2,220 (64.4)	0.25	2,136 (64.7)	84 (59.2)	0.21

ED = emergency department, IQR = interquartile range, LOS = length of stay.

a greater proportion of low-risk decedents experienced an adverse event compared with low-risk survivors (58.5% vs 25.4%; $p < 0.001$) (Table 3). Additionally, low-risk decedents had significantly higher utilization for every ICU resource and transfusion product compared with low-risk survivors with the exception of those requiring noninvasive mechanical ventilation (13.3% vs 10.4%; $p = 0.38$) (Table 4). Low-risk decedents also had a significantly higher mean total hospital cost than survivors (\$71,078 vs \$26,236; $p < 0.001$) and mean total ICU-specific costs (\$51,430 vs \$18,333; $p < 0.001$) (Table 4). The resource utilization for non-low-risk patients did not show a statistically higher mean hospital cost for decedents (\$42,923 vs \$41,200; $p = 0.197$) (Supplemental Table 5, <http://links.lww.com/CCX/A872>).

The results of the multivariable logistic regression are presented in Supplemental Table 6 (<http://links.lww.com/CCX/A872>). Compared with low-risk survivors, low-risk decedents were more likely to be older (odds ratio [OR], 1.02 per 1 yr; 95% CI, 1.00–1.03 per 1 yr), more likely to have a higher MODS (OR, 1.42 per 1 point; 95% CI, 1.31–1.54 per 1 point), more likely to have a fluid management adverse event that occurred while admitted (e.g., volume overload, dehydration, and infusion complication) (OR, 2.84; 95% CI, 1.29–6.25), more likely to have a HAI (OR, 1.60; 95% CI, 1.02–2.51), and more likely to require invasive

mechanical ventilation (OR, 1.98; 95% CI, 1.20–3.26). A post hoc multivariable logistic regression was performed with the same variables looking at low-risk patients admitted to the ICU from the ward, showing a significant association with MODS and fluid management-related adverse events (Supplemental Table 7, <http://links.lww.com/CCX/A872>).

DISCUSSION

In our multisite historical cohort study, 20.1% of patients admitted to the ICU were classified as low-risk hospital admissions. Low-risk patients were younger, less comorbid, and had lower inhospital mortality (4.1% vs 25.6%). Inhospital mortality was independently associated with increasing age, MOD, mechanical ventilation, fluid-related adverse events occurring after admission (e.g., volume overload or dehydration), and HAIs.

Although the mortality for low-risk patients is much lower than the general ICU population, it is still important given their robust pre-morbid status. It also raises the question of whether some of their deaths were preventable. The major risk factors for death in low-risk patients are similar to other ICU populations, with MOD and mechanical ventilation highly associated with death (2, 6, 19). These are unlikely to be modifiable and are more reflective of illness severity.

TABLE 3.
Adverse Events in Low-Risk Patients

Adverse Events, <i>n</i> (%)	All Low-Risk Patients, <i>n</i> = 3,445	Low-Risk Survivors, <i>n</i> = 3,303	Low-Risk Decedents, <i>n</i> = 142	<i>p</i>
Any adverse event	922 (26.8)	839 (25.4)	83 (58.5)	< 0.001
Endocrine metabolic complication	1 (0.0)	1 (0.0)	0 (0.0)	1.00
Cardiac complication	161 (4.7)	141 (4.3)	20 (14.1)	< 0.001
Drug-related adverse event	36 (1.0)	35 (1.1)	1 (0.7)	1.00
Fluid management adverse event	59 (1.7)	47 (1.4)	12 (8.5)	< 0.001
Traumatic injury arising in hospital	2 (0.1)	2 (0.1)	0 (0)	1.00
Gastrointestinal complication	192 (5.6)	173 (5.2)	19 (13.4)	< 0.001
Hospital-acquired infection	352 (10.2)	308 (9.3)	44 (31.0)	< 0.001
Surgical complication	221 (6.4)	198 (6.0)	23 (16.2)	< 0.001
Delirium	89 (2.6)	79 (2.4)	10 (7.0)	< 0.01
Obstetrical complication	23 (0.7)	23 (0.7)	0 (0)	1.00

Specific *International Classification of Diseases*, 10th Revision codes contained within each adverse event grouping are available at (<https://osf.io/3xv8n/>).

TABLE 4.
Costs and Resource Utilization for Low-Risk Patients

Resource	All Low-Risk Patients, <i>n</i> = 3,445	Low-Risk Survivors, <i>n</i> = 3,303	Low-Risk Decedents, <i>n</i> = 142	<i>p</i>
Hospital costs, \$, mean (sd)				
Total costs	28,085 (59,940)	26,236 (54,777)	71,078 (124,683)	< 0.001
Total direct costs	21,221 (45,510)	19,790 (41,647)	54,518 (94,897)	< 0.001
Total indirect costs	6,863 (14,391)	6,464 (13,175)	16,560 (29,914)	< 0.001
ICU-specific costs, \$, mean (sd)				
Total costs	19,657 (37,571)	18,333 (34,861)	51,430 (70,873)	< 0.001
Direct costs	14,957 (28,817)	13,929 (26,712)	38,862 (54,528)	< 0.001
Indirect costs	4,610 (8,802)	4,404 (8,188)	11,567 (16,517)	< 0.001
ICU resource utilization ^a				
Invasive mechanical ventilation, <i>n</i> (%)	1,117 (42.2)	1,010 (40.3)	107 (79.3)	< 0.001
Invasive mechanical ventilation days, median (IQR)	0 (0–2)	0 (0–2)	3 (1–8)	< 0.001
Noninvasive mechanical ventilation, <i>n</i> (%)	283 (10.7)	271 (10.4)	18 (13.3)	0.38
Noninvasive mechanical ventilation days, median (IQR)	0 (0–0)	0 (0–0)	0 (0–0)	0.28
Arterial line, <i>n</i> (%)	1,216 (46.0)	1,113 (44.4)	103 (76.3)	< 0.001
Arterial line days, median (IQR)	0 (0–3)	0 (0–3)	3 (1–8)	< 0.001
Dialysis, <i>n</i> (%)	93 (3.5)	76 (3.0)	17 (12.6)	< 0.001
Dialysis days, median (IQR)	0 (0–0)	0 (0–0)	0 (0–0)	< 0.001
Nine Equivalents of Nursing Manpower use Score/d, mean (sd)	19.56 (6.81)	19.02 (6.24)	29.6 (8.96)	< 0.001
Transfusion products, <i>n</i> (%)				
Packed RBC	679 (19.7)	609 (18.5)	70 (49.3)	< 0.001
Platelet	172 (5.0)	139 (4.2)	33 (23.2)	< 0.001
Thawed plasma	256 (7.4)	211 (6.4)	45 (31.7)	< 0.001

IQR = interquartile range.

^aResource utilization data only available for 2,509/3,303 and 135/142 for low-risk survivors and deceased, respectively. There was no missing data for transfusion products.

Fluid-related adverse events and HAIs are also associated with illness severity; however, may also be partially preventable or modifiable.

The importance of rationale fluid management is increasingly being recognized among critically ill patients (20–23). Fluid overload is independently associated with increased mortality, length of ICU stay, and end-organ dysfunction for various ICU populations (20–23). Fluid overload has several putative mechanisms of injury including endothelial glycocalyx dysfunction leading to increased capillary permeability and multisystem organ congestion (24–26). Recently,

noninvasive techniques for detecting venous congestion using point-of-care ultrasound have been developed, with sonographic features of organ congestion associated with delirium and worsening acute kidney injury (26–29). In our cohort, fluid management-related adverse events were the strongest independent predictor of mortality, although this association is vulnerable to residual confounding (30). This association remained when looking at the subgroup of low-risk patients initially admitted to the ward but who subsequently deteriorated and required ICU admission (Supplemental Table S7, <http://links.lww.com/CCX/A872>).

As this is an administrative dataset, we cannot determine whether these adverse events were coded as fluid overload, as opposed to dehydration; however, as fluid positivity is consistently associated with mortality (20–23), we hypothesize these might be attributable to fluid overload. Regardless, judicious use of crystalloids, close attention to volume status to avoid hyper or hypovolemia, and early deresuscitation strategies could conceivably improve outcomes for low-risk patients; however, these strategies need to be investigated with prospective clinical trials.

HAIs are another important risk factor for death for low-risk patients and have previously been associated with an increased hospital and ICU mortality (31–33). Indeed, the results of this study indicate that HAIs conferred an increased risk of mortality amongst low-risk patients (OR = 1.60), although this finding is likely not specific to low-risk patients. Preventing HAIs requires a multidisciplinary approach to promote and adhere to infection control and prevention policies (33–36). Additionally, antimicrobial stewardship efforts are important to reduce the burden of resistant HAIs, particularly as rates of methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant *Enterococcus* have increased in Canadian healthcare systems in recent years (37).

In addition to patient outcomes, resource utilization and cost are important considerations for ICUs and health systems. The total hospital cost for low-risk patients was lower than for non-low-risk patients, likely due to shorter ICU and hospital admissions. Among low-risk patients who died, however, we observed longer ICU admissions, higher resource utilization, and increased costs. This was not seen for non-low-risk patients, where hospital costs between survivors and decedents were similar. In medical-surgical ICUs, approximately half of deaths occur from the withdrawal of life support through shared decision-making with families (38). When a patient with robust pre-morbid status becomes critically ill, discussions surrounding prognosis can be challenging as their chance for recovery may be greater than for frail patients (39). Even in low-risk patients, however, severe multiple organ failure and the need for mechanical ventilation are potential prognostic factors to inform discussions with families.

There are a number of important limitations to this study. Twelve patients were excluded due to missing outcome data and 18.6% of patients had incomplete

data for resource utilization variables (Table 4). As well, using HOMR-now! score to identify low-risk patients has several limitations. The laboratory component of the score is designed to capture the degree of physiologic perturbation for a patient; however, some patients with isolated system injuries (e.g., catastrophic neurologic injury) may have poor prognoses despite a low HOMR-now! score. As well, although the HOMR-now! score may be useful at hospital admission, it may have less value as an ICU prediction model given the heterogeneity of ICU admissions. Instead, disease-specific ICU prediction models such as those used for cardiac arrest, cirrhosis, or subarachnoid hemorrhage are more useful for critical care practitioners (40–42). Finally, as an administrative database was used, details about mechanisms of death and hospital-associated infections, the exact ICD-10 diagnoses that comprise each adverse event (e.g., how many fluid management adverse events were dehydration related vs volume overload), and laboratory data are not available.

CONCLUSIONS

This study has several important implications for low-risk hospital admissions. It highlights that although prediction models can identify higher risk hospital admissions, it does not preclude clinical deterioration in low-risk patients. Additionally, fluid-related adverse events, HAIs, MOD, and mechanical ventilation are independently associated with death. Finally, the inhospital mortality, costs, and resource utilization for low-risk patients are significant and represent an area for future research.

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Dr. Thompson, Dr. McNeill, and Ms. Milani also contributed to the formal analysis of the data. Dr. Kyeremanteng also provided supervision for the project. All authors contributed to conceptualization, methodology, investigation, writing, and editing of the article.

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