# Hospital-Based Acute Care Use in Survivors of Septic Shock

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**Objectives:** Septic shock is associated with increased long-term morbidity and mortality. However, little is known about the use of hospital-based acute care in survivors after hospital discharge. The objectives of the study were to examine the frequency, timing, causes, and risk factors associated with emergency department visits and hospital readmissions within 30 days of discharge.

**Design:** Retrospective cohort study.

**Setting:** Tertiary, academic hospital in the United States.

**Patients:** Patients admitted with septic shock (serum lactate ≥ 4 mmol/L or refractory hypotension) and discharged alive to a non-hospice setting between 2007 and 2010.

**Interventions:** None.

**Measurements and Main Results:** The coprimary outcomes were all-cause hospital readmission and emergency department visits (treat-and-release encounters) within 30 days to any of the three health system hospitals. Of 269 at-risk survivors, 63 (23.4%; 95% CI, 18.2–28.5) were readmitted within 30 days of discharge and another 12 (4.5%; 95% CI, 2.3–7.7) returned to the emergency department for a treat-and-release visit. Readmissions occurred within 15 days of discharge in 75% of cases and were more likely in oncology patients ($p = 0.001$) and patients with a longer hospital length of stay ($p = 0.04$). Readmissions were frequently due to another life-threatening condition and resulted in death or discharge to hospice in 16% of cases. The reasons for readmission were deemed potentially related to the index septic shock hospitalization in 78% (49 of 63) of cases. The most common cause was infection related, accounting for 46% of all 30-day readmissions, followed by cardiovascular or thromboembolic events (18%).

**Conclusions:** The use of hospital-based acute care appeared to be common in septic shock survivors. Encounters often led to readmission within 15 days of discharge, were frequently due to another acute condition, and appeared to result in substantial morbidity and mortality. Given the potential public health implications of these findings, validation studies are needed. (*Crit Care Med* 2014; XX:00–00)

**Key Words:** emergency department use; hospital readmission; infection; septic shock

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Sepsis has a tremendous impact on our healthcare system. The prevalence of sepsis in the United States has been rising (1) and the associated cost has been estimated at $24.3 billion (2). Although the prevalence has increased, substantially more patients are surviving their hospitalization (1, 3–8).

Sepsis survivorship is associated with cognitive and physical impairments, decreased quality of life, and increased long-term mortality (9–13). Although evidence has highlighted the importance of understanding the trajectories of care after critical illness (14), little is known about the healthcare needs of septic shock survivors. Hospital-based, acute care use after a hospitalization is common and costly (15–17). Emergency department (ED) visits and hospital readmissions may reflect the quality and coordination of care provided during the index

hospitalization (15–20). To patients and family members, these are important and stressful events that can disrupt the recovery process (21). Recent studies using administrative data have shown that sepsis survivors may be particularly vulnerable (22–24). Therefore, urgent investigation is justified to determine how often these events occur and, importantly, why.

We evaluated septic shock survivors, defined by several recent clinical trials as a serum lactate level of 4 mmol/L or higher or refractory hypotension (5–7), to determine the frequency, timing, and causes of ED visits and hospital readmissions. We hypothesized that hospital-based acute care use in the 30 days following a hospitalization for septic shock would be common, occurring in one in five cases or more based on other high-risk conditions (15–17), and the reasons for and outcomes related to these encounters may explain the increased mortality that survivors experience.

## MATERIALS AND METHODS

### Study Design

This was a retrospective cohort study of adult survivors of septic shock discharged between December, 2007, and January, 2010. The institutional review board of the University of Pennsylvania approved the study (#819400) with an informed consent exemption.

### Study Setting and Population

We conducted the study at the Hospital of the University of Pennsylvania (HUP), a tertiary care university hospital within the three hospital University of Pennsylvania Health System (UPHS). We studied patients admitted from the ED with septic shock, defined as a serum lactate level greater than or equal to 4 mmol/L or systolic blood pressure less than 90 mm Hg after volume resuscitation or use of a vasoactive agent (5–7). The details of our validated strategy to identify cases of severe sepsis and quality assurance have been described previously (25–28). To examine hospital-based, acute care use in survivors and maintain the assumption of independent observations, we limited the study to patients discharged to a nonhospice setting after an index septic shock admission. We excluded patients who did not fulfill criteria for septic shock (29, 30) and those who left against medical advice (AMA) or were transferred to another institution.

### Data Collection

As part of the HUP Severe Sepsis database, trained investigators collected ED and hospitalization data from the electronic medical record (EMR) using a predrafted case abstraction form (25–28), permitting calculation of the Charlson comorbidity index (31). Consistent with prior work (25), missing data (> 5% per variable) were rare and limited to laboratory measurements (e.g., coagulation measures). The Acute Physiology and Chronic Health Evaluation (APACHE) II score was calculated at hospital admission (25, 32).

We abstracted the following from the EMR using a separate abstraction form to examine hospital-based, acute care use within UPHS: disposition and follow-up at discharge from the index hospitalization, prior hospitalization within 30 days of the index hospitalization, and dates, timing, cause, and outcome of an ED encounter and/or hospital readmission within 30 days (33). We identified readmissions occurring after 30 days to calculate 60- and 90-day readmission rates. We did not collect data on ED visits or readmissions outside UPHS, nor did we abstract data on subsequent ED visit(s) or readmission(s), with the exception of ED encounters that led to readmission. Consistent with the parent registry (25), postdischarge data were verified by a separate investigator for accuracy.

Our coprimary outcomes were ED visits (treat-and-release) and all-cause hospital readmission to any UPHS hospital within 30 days of discharge after the index hospitalization for septic shock (15–17). We included patients readmitted via interhospital transfer to minimize the risk of underestimating the hospital readmission rate. As a reference, using 2010 administrative data, we calculated the 30-day readmission rate for 10,985 index medical and surgical admissions at HUP to be 13.4% (95% CI, 12.8–14.1). Secondary outcomes included 60- and 90-day hospital readmission rate and a composite outcome of ED visit and hospital readmission within 30 days of discharge.

A focus of the study was to understand why survivors returned to the hospital. Consistent with the readmission literature (34, 35), we considered a 30-day readmission to be potentially related to the index septic shock admission when the readmission was due to an unresolved, recurrent, or new infection or was due to a clinical deterioration or complication potentially related to care provided or a consequence of sepsis. We a priori categorized readmissions as related to acute kidney injury, cognitive impairment (e.g., medication error), complications of tubes and catheters, cardiovascular and thromboembolic events, infection, physical impairment (e.g., falls), and when the readmission was potentially related to the index septic shock admission but not captured in the above categories, as other (9–13, 36–44). When the readmission was attributed exclusively to the underlying disease and/or was elective, it was deemed unavoidable.

Two independent investigators reviewed the discharge summary, including primary and secondary diagnoses, and EMR to determine the readmission cause. Due to the infrequent number of readmissions attributed to cognitive and physical impairment, these were collapsed into the other category, resulting in six final response options. The interrater reliability for diagnoses was good, with a $\kappa$ statistic of 0.79 (95% CI, 0.67–0.92). Adjudication, necessary for nine readmissions, was performed by a third investigator blinded to prior assessments. The cause of an ED treat-and-release visit was determined by its *International Classification of Diseases, 9th Edition* code.

Last, we examined the relationship between clinical risk factors and 30-day hospital readmission. Using the general readmission (33–35) and sepsis literature, we examined sociodemographics, comorbid conditions, illness severity at presentation and during the hospitalization, source of sepsis, hospital length of stay, and discharge disposition. To assess whether hospital readmission was associated with quality

of care provided at presentation, we tested time to antibiotics (27), volume of resuscitation (5–7), and initiation of early goal-directed therapy (5–7, 26). We considered year of admission and prior hospitalization within 30 days of the index hospitalization as potential confounders (28, 34).

### Statistical Analyses

We compared continuous variables across groups using Student *t* test or Wilcoxon rank-sum test and compared categorical variables across groups using the chi-square test or Fisher exact test, as appropriate. We used Stata 13.0 IC (Stata Datacorp, College Station, TX) to perform analyses and considered *p* values less than or equal to 0.05 as significant.

We used multivariable logistic regression to adjust for potential confounding in the associations between risk factors and 30-day hospital readmission. In primary analyses, factors associated with the dependent variable at a significance level of *p* less than 0.05 in bivariate analyses were included to create parsimonious multivariable models. Potential confounding variables associated at a significance level of *p* less than 0.20 were added one at a time to the base model and maintained if there was an alteration by greater than 10% in the point estimate for the odds ratio (OR) of any risk factor (45). Multicollinearity was assessed using variance inflation factors. In primary analyses, we excluded variables with less than or equal to 10 observations per cell to avoid overfitting. In secondary analyses, we included these variables one at a time. In separate secondary analyses, we included factors associated with the dependent variable at a significance level of *p* less than 0.20 in bivariate analyses into the multivariable models.

## RESULTS

### Baseline Characteristics

Of 997 unique severe sepsis patients over the study interval, we examined 414 patients admitted from the ED with septic shock. Of these 414 patients, 23.2% expired in-hospital and 8.7% were discharged to hospice (**Fig. 1**). After excluding 13 survivors who left AMA or were transferred, there were 269 survivors at risk for hospital readmission (**Table 1**).

### Rate, Timing, and Cause of 30-Day ED Visits and 30-Day Readmission

Of 269 at-risk survivors, 63 (23.4%; 95% CI, 18.2–28.5) were readmitted within 30 days and another 12 (4.5%; 95% CI, 2.3–7.7) returned to the ED for a treat-and-release visit (readmission rates presented in **Table 2**). The median time to an ED encounter was 8 days, with interquartile range (IQR) from 4 to 15 days. Of the 56 ED encounters within 30 days, the conversion rate to hospital admission was 75% (42 of 56). The reasons for a treat-and-release ED visit varied, with the most common reasons being infection ($n$ = 6), device complications ($n$ = 3), and fall injuries ($n$ = 2) (Table 2).

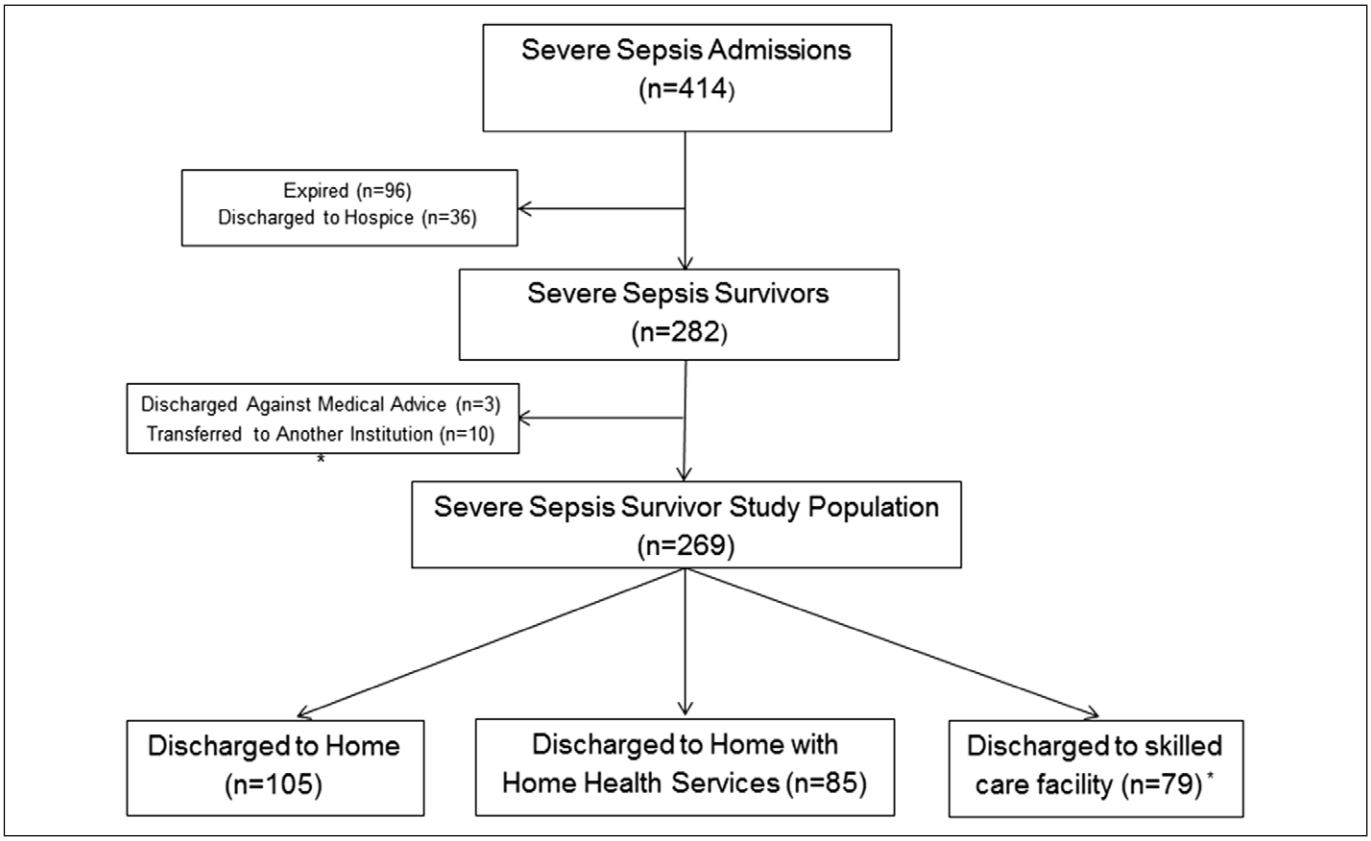


**Figure 1.** Flow diagram of use of postacute care in survivors of sepsis. *Of 79 survivors discharged to a skilled care facility, 25 were discharged to acute rehabilitation, 47 to a skilled nursing facility, and seven to a long-term acute care hospital.

**TABLE 1. Baseline Characteristics of Septic Shock Survivor Cohort**

| Clinical Factors at Presentation | At-Risk Survivors (*n* = 269) |
|---|---|
| Age, yr | 59 ± 18 |
| Female sex (*n*, %) | 135 (50.2) |
| Race (*n*, %) | |
| White | 112 (42.6) |
| Black | 144 (54.8) |
| Other | 7 (2.7) |
| Charlson comorbidity index | 2 (1–3) |
| Illness severity at presentation | |
| Initial serum lactate (mmol/L) | 4.6 (3.7–6.1) |
| Hypotension (*n*, %)[a] | 184 (68.4) |
| Refractory hypotension (*n*, %) | 95 (35.3) |
| Admission to ICU (*n*, %) | 207 (77.0) |
| Acute Physiology and Chronic Health Evaluation II score | 19 ± 7 |
| Admission to ICU (*n*, %) | 207 (77.0) |
| Mechanical ventilation use (*n*, %) | 54 (20.1) |
| Source of sepsis (*n*, %) | |
| Bacteremia | 27 (10.0) |
| Pneumonia | 50 (18.6) |
| Genitourinary | 57 (21.2) |
| Gastrointestinal | 53 (19.7) |
| Skin or soft tissue | 21 (7.8) |

[a]Hypotension defined as systolic blood pressure ≤ 90 mm Hg. Refractory hypotension defined as systolic blood pressure ≤ 90 mm Hg after fluid resuscitation or use of vasoactive agents.

Categorical variables are presented as counts and percentages. Continuous variables are presented as means and SDs or median and interquartile ranges, as determined by their distribution.

The majority of 30-day readmissions presented to UPHS through the ED (68%), with the remainder presenting as a direct admission (24%) or outside hospital transfer (8%). The median time to 30-day hospital readmission was 7 days (IQR, 3–15) (**Fig. 2**), and the median length of stay for readmissions was 5 days (IQR, 2–14). Of 30-day readmissions, 21 (33%) survivors required ICU care and 10 (16%) expired or were transitioned to hospice during the readmission. Follow-up appointments were not arranged for 26 readmitted patients, and 17 were readmitted prior to their scheduled follow-up.

The reasons for readmission were potentially related to the index septic shock hospitalization in 78% (49 of 63) of cases (**Table 3**). The most common cause was infection, accounting for 46% of 30-day readmissions, followed by cardiovascular or thromboembolic at 18%. The infectious causes for readmission varied, with cellulitis and soft-tissue infections being the most common (28%), followed by pneumonia (24%), gastrointestinal infections (17%), and bacteremia (17%).

**TABLE 2. Hospital-Based Acute Care Use in 269 Survivors of Septic Shock**

| Outcomes | *n* (%) |
|---|---|
| Hospital readmissions | |
| 30-day hospital readmission | 63 (23.4) |
| 60-day hospital readmission | 89 (33.1) |
| 90-day hospital readmission | 100 (37.2) |
| ED visits (treat-and-release encounters) | |
| 30-day ED visit[a] | 14 (5.2) |
| Hospital-based acute care postdischarge | |
| 30-day ED visit or readmission | 75 (27.9)[b] |

ED = emergency department.

[a]Of 56 emergency department (ED) encounters within 30 days, 42 (75%) led to an admission. The reasons for the 14 ED encounters not resulting in an admission were cellulitis or surgical site infection (*n* = 4), complication of a device (*n* = 3), head injury after a fall (*n* = 2), altered mental status (*n* = 1), postoperative pain (*n* = 1), dyspnea (*n* = 1), gastroenteritis (*n* = 1), and pneumonia (*n* = 1).

[b]One patient returned for a treat-and-release ED visit for altered mental status and subsequently was readmitted, both within 30 days of discharge; one patient was readmitted and subsequently returned for a treat-and-release ED visit for a head injury after a fall, both within 30 days. These two instances explain why the sum of the ED visits and 30-day hospital readmissions do not total 75.

Categorical variables are reported as a count and percentage.

### Characteristics of Patients Readmitted Within 30 Days

Compared with those not readmitted, readmitted patients were more likely to have been hospitalized within the prior 30 days of the index septic shock hospitalization ($p < 0.001$), have cirrhosis ($p = 0.05$), an oncology diagnosis ($p < 0.001$), lower initial serum lactate levels ($p = 0.02$), higher APACHE II scores ($p = 0.05$), longer hospital lengths of stay ($p = 0.01$), and were more likely to be discharged with a peripherally inserted central catheter ($p = 0.02$) (**Table 4**). Although readmitted

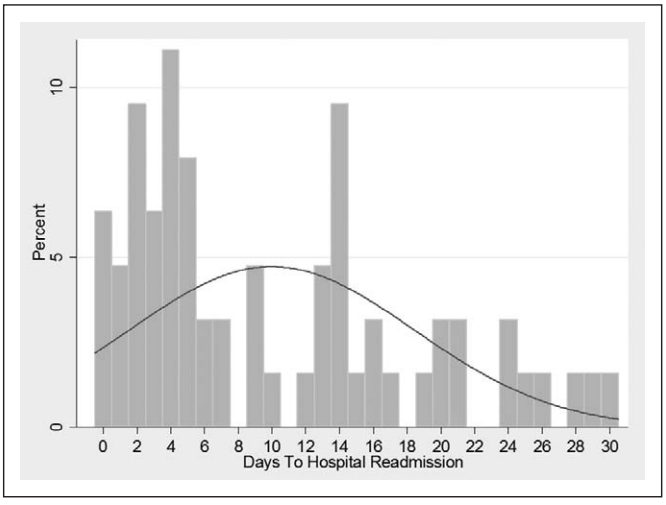


**Figure 2.** Timing of 30-day hospital readmission in severe sepsis survivors.

**TABLE 3. Readmission Diagnoses Following Hospitalization for Septic Shock**

| | |
|---|---|
| Readmission diagnoses potentially related to prior sepsis hospitalization, *n* (%) | |
| Infection[a] | 29 (46.0) |
| Cardiovascular and thromboembolic[b] | 11 (17.5) |
| Acute kidney injury[c] | 4 (6.4) |
| Complications of devices | 2 (3.2) |
| Other[d] | 3 (4.8) |
| Readmission unrelated to prior hospitalization | |
| Related to comorbid condition[e] | 14 (22.2) |
| | Total: *n* = 63 |

[a]Infectious cases included eight skin or soft-tissue infections (three cellulitis cases and five abscess cases), seven respiratory infections (six pneumonia cases and one empyema case), five gastrointestinal infections (two new *Clostridium difficile* cases, two recurrent cases, and one spontaneous bacterial peritonitis case), five bacteremia infections (including three catheter-related cases), two urinary tract infections, and two systemic infections (one culture-negative sepsis case and one disseminated candidiasis case).

[b]Cardiovascular and thromboembolic cases included four cases of venous thromboembolism, three cases of congestive heart failure, one cerebrovascular accident, one case of venous sinus thrombosis, one acute coronary syndrome, and one cardiac arrest.

[c]Acute kidney injury includes one case of acute interstitial nephritis due to treatment for endocarditis diagnosed during prior hospitalization and one case of concomitant hypotension at time of readmission.

[d]Other diagnoses include subarachnoid haemorrhage status post fall, altered mental status due to medication error, and anemia requiring transfusion.

[e]Categorization includes five oncology cases readmitted for failure to thrive or chemotherapy, two cases of progressive liver disease, two cases of chronic pain, one case of malignant pericardial effusion, one case of gout, one case of nephrolithiasis, one case of recurrent small bowel obstruction after *Clostridium difficile* enterocolitis, and one case of hydrocephalus requiring the placement of a shunt.

patients had more comorbidities as measured by the Charlson ($p = 0.001$), the association was nonsignificant when the oncology subscore was removed ($p = 0.67$). There were no significant differences between the two groups in ED quality measures, other metrics of illness severity, or admission year ($p = 0.46$).

In multivariable models, independent risk factors associated with 30-day hospital readmission included an oncology diagnosis ($p = 0.001$), hospitalization within 30 days of the index septic shock hospitalization ($p = 0.01$), and length of stay ($p = 0.04$) (**Table 5**). Initial serum lactate levels were collinear with APACHE II scores. Neither initial lactate levels ($p = 0.07$) nor APACHE II when substituted for lactate levels in multivariable models ($p = 0.58$) were associated with 30-day readmission. In secondary analyses including variables with less than or equal to 10 observations per cell, cirrhosis was independently associated with 30-day readmission ($p = 0.04$). In separate secondary analyses, including discharge disposition, use of mechanical ventilation, and coagulation failure as variables associated with the dependent variable at a less conservative significance level, an oncology diagnosis ($p = 0.001$) and a hospitalization within 30 days of the index septic shock hospitalization ($p = 0.02$) were the lone factors associated with 30-day readmission.

## DISCUSSION

In this observational study of survivors of septic shock, our principal finding was that there was a high rate of hospital-based acute care use among patients discharged after an admission for septic shock. Three quarters of hospital-based, acute care occurred within 15 days of discharge, and these encounters often led to readmission. In sum, we found that 23% of at-risk survivors were readmitted within 30 days, substantially higher than the general 30-day readmission rate at HUP, and nearly one out of six readmissions resulted in death or a transition to hospice. Furthermore, an additional 5% returned to the ED for a treat-and-release visit.

These findings support and complement the recent findings of Liu et al (23) and Prescott et al (24). Using a claims-based approach to identify cases of sepsis at an integrated community-based healthcare system, Liu et al (23) observed that 18% of sepsis survivors were rehospitalized within 30 days, with a median time to readmission of 11 days. The rate of readmission was observed to be as high as 22% in survivors in the highest predicted mortality quartile. In a separate claims-based investigation, Prescott et al (24) examined the postdischarge healthcare use of elderly survivors of severe sepsis within a longitudinal cohort (1998–2005) study. Using a design that would result in a slightly higher rate of readmission (i.e., repeat severe sepsis hospitalizations were included), Prescott et al (24) reported a rate of 30- and 90-day readmission rate of 26% and 41%, respectively, after a severe sepsis hospitalization. Survivors, in comparison to their presepsis state and matched nonsepsis hospitalizations, experienced a substantial increase in healthcare use and greater postdischarge mortality in the year postdischarge (24).

Collectively, these findings suggest that sepsis survivors are a high-risk group that frequently requires hospital-based acute care after discharge. Importantly, whether these apparent risks are concentrated in the most severely ill survivors remains unclear. Nevertheless, the rate and pattern observed in these studies mirrors those seen in readmissions after heart failure, acute myocardial infarction, and pneumonia (33). Although it is possible that high-quality discharge planning and short-term follow-up after discharge could play a substantial role in lowering the rate of readmissions after sepsis (46), two critical questions require examination to focus efforts: who is at risk to be readmitted and why?

Consistent with Liu et al (23), we found that a higher burden of comorbid conditions and a lengthy hospitalization, as a measure of illness severity, were associated with readmission. Specifically, and in line with hospital readmissions in general (33–35), we found that an oncologic diagnosis was both prevalent among septic shock survivors and independently associated with an increased risk of hospital readmission. Further, many septic shock survivors had been hospitalized prior to the index septic shock admission, and this exposure was a risk factor for subsequent hospital readmission. Given evidence

**TABLE 4. Patient-Level Factors Associated With 30-Day Hospital Readmission in Survivors of Septic Shock**

| Clinical Factors | No Readmission (*n* = 206) | Readmissions (*n* = 63) | *p* |
|---|---|---|---|
| Age, yr | 59 ± 18 | 60 ± 16 | 0.75 |
| Female sex (*n*, %) | 100 (48.5) | 35 (55.6) | 0.33 |
| Race (*n*, %) | | | 0.74 |
| White | 84 (41.4) | 28 (46.7) | |
| Black | 113 (55.7) | 31 (51.7) | |
| Other | 6 (3.0) | 1 (1.7) | |
| Comorbidities (*n*, %) | | | |
| Coronary artery disease | 25 (12.1) | 8 (12.7) | 0.90 |
| Congestive heart failure | 26 (12.6) | 9 (14.3) | 0.73 |
| Cirrhosis | 7 (3.4) | 6 (9.5) | 0.05 |
| Chronic renal disease | 23 (11.2) | 8 (12.7) | 0.74 |
| Chronic obstructive pulmonary disease | 16 (7.8) | 5 (7.9) | 0.96 |
| Diabetes mellitus | 68 (33.0) | 17 (27.0) | 0.37 |
| Early goal-directed therapy | 16 (7.8) | 4 (6.4) | 0.71 |
| Human immunodeficiency virus | 9 (4.4) | 2 (3.2) | 1.00 |
| Hypertension | 95 (46.8) | 31 (49.2) | 0.74 |
| Oncology | 43 (20.9) | 29 (46.0) | < 0.001 |
| Transplant | 29 (14.1) | 8 (12.7) | 0.78 |
| Charlson comorbidity index | 1 (1–3) | 2 (1–3) | 0.001 |
| Prior hospitalization within 30 d | 43 (20.9) | 28 (44.4) | < 0.001 |
| Illness severity at presentation | | | |
| Organ dysfunction | | | |
| Acute kidney injury (*n*, %)[a] | 87 (42.2) | 23 (36.5) | 0.42 |
| Change in mental status | 57 (27.7) | 17 (27.0) | 0.92 |
| Coagulation failure[a] | 34 (16.5) | 15 (23.8) | 0.19 |
| Hematologic failure[a] | 18 (8.7) | 7 (11.1) | 0.57 |
| Hepatic failure[a] | 8 (3.9) | 4 (6.4) | 0.48 |
| Hypoperfusion, lactate (mmol/L) | 4.8 (4.0–6.3) | 4.2 (2.5–5.3) | 0.02 |
| Refractory hypotension | 70 (34.0) | 25 (39.7) | 0.41 |
| Admission to ICU | 157 (76.2) | 50 (79.4) | 0.60 |
| Acute Physiology and Chronic Health Evaluation II score | 18 ± 7 | 20 ± 6 | 0.05 |
| Emergency department processes of care | | | |
| Time to antibiotics, min | 114 (62–198) | 142 (81–224) | 0.29 |
| Volume resuscitation, cc | 3,150 (2,050–4,350) | 3,100 (2,050–4,150) | 0.44 |
| Transfusion (*n*, %) | 10 (4.8) | 2 (3.2) | 0.57 |
| Early goal-directed therapy initiated | 58 (28.2) | 22 (34.9) | 0.30 |

(*Continued*)

**TABLE 4. (*Continued*). Patient-Level Factors Associated With 30-Day Hospital Readmission in Survivors of Septic Shock**

| Clinical Factors | No Readmission (*n* = 206) | Readmissions (*n* = 63) | *p* |
|---|---|---|---|
| Source of sepsis (*n*, %) | | | |
| Bacteremia | 20 (9.7) | 7 (11.1) | 0.75 |
| Pneumonia | 37 (18.0) | 13 (20.6) | 0.63 |
| Genitourinary | 47 (22.8) | 10 (15.9) | 0.24 |
| Gastrointestinal | 40 (19.4) | 13 (20.6) | 0.83 |
| Skin or soft tissue | 13 (6.3) | 8 (12.7) | 0.10 |
| Hospitalization | | | |
| Hospital length of stay | 6 (4–13) | 10 (5–15) | 0.01 |
| ICU length of stay[b] | 3 (1–5) | 2 (2–4) | 0.32 |
| Mechanical ventilation use (*n*, %) | 46 (22.3) | 8 (12.7) | 0.10 |
| Peripherally inserted central catheter present at discharge | 15 (7.3) | 11 (17.5) | 0.02 |
| Discharge disposition | | | |
| Home | 87 (42.2) | 18 (28.6) | |
| Home with home services | 61 (29.6) | 24 (38.1) | 0.15 |
| Skilled care facility | 58 (28.2) | 21 (33.3) | |

Categorical variables are presented as counts and percentages. Continuous variables are presented as means and SDs or median and interquartile ranges, as determined by their distribution.

[a]Acute kidney injury defined as serum creatinine ≥ 0.5 mg/dL from baseline. Coagulation failure defined as international normalized ratio > 1.5 or activated partial thromboplastin time > 60 and hematologic failure as platelets < 100, and hepatic failure as total bilirubin > 4.0 mg/dL (25, 30). Coagulation measures and hepatic function measures were obtained in 78% and 90% of the cohort, respectively; when not assessed, they were presumed to be normal in accord with Acute Physiology and Chronic Health Evaluation II score calculations (32). Refractory hypotension defined as systolic blood pressure ≤ 90 mm Hg after fluid resuscitation or use of vasoactive agents (5–7, 30).

[b]ICU length of stay in subgroup of patients requiring ICU admission.

of a bidirectional relationship between cognitive and physical decline and an acute infectious insult (9, 47), further investigation is required to elucidate the role that hospital-based, acute care plays in the path to decline or recovery in survivors (48).

As to why survivors are readmitted, the initial suggestion that infection played a pivotal role emanated from a recent Healthcare Cost and Utilization Project (49). Therein, Sutton et al (49) reported that among hospital admissions with a primary or secondary diagnosis of septicemia, 16% of survivors were rehospitalized with the same condition, and this scenario appeared to be increasing. More recently, while data were limited to 79% of readmissions, Liu et al (23) found that infection was the cause in 28–43% of cases. We found that septic shock survivors were frequently readmitted within 30 days with life-threatening conditions. Infections caused, or at least contributed to, readmission in 46% of cases. The source of infection varied, with a skin or soft-tissue infection or pneumonia accounting for approximately 50% of the infectious cases, and an additional 34% due to gastrointestinal infections or bacteremia. These observations complement the report by Liu et al (23) and are consistent with a small, recent study that suggested that infectious risk is increased in sepsis survivors (50). Additional common causes included cardiovascular and thromboembolic events and acute kidney injury. These findings, in concert with the available evidence (23, 24), suggest that readmissions are the result of a synergistic process between presepsis health conditions and sepsis-related sequelae. The latter influence, which requires direct examination, may be related to provisions of

**TABLE 5. Clinical Risk Factors Associated With 30-Day Hospital Readmission in Survivors of Septic Shock**

| Independent Variable[a] | Adjusted OR (95% CI) | *p* |
|---|---|---|
| Oncology | 3.02 (1.60–5.68) | 0.001 |
| Recent hospitalization | 2.26 (1.19–4.29) | 0.01 |
| Length of stay, > 4 d | 2.18 (1.02–4.64) | 0.04 |
| Initial lactate levels (mmol/L) | 0.89 (0.78–1.01) | 0.07 |
| Peripherally inserted central catheter at discharge | 1.68 (0.66–4.25) | 0.27 |

OR = odds ratio.

[a]An adjusted odds ratio of > 1 represents an increased risk of 30-day hospital readmission. The potential confounder, year of admission, was neither associated with the dependent variable nor did its inclusion alter the odds ratios of any of the candidate risk factors significantly. Conversely, a recent hospitalization attenuated the association between length of stay and 30-day readmission significantly.

sepsis care or to residual organ dysfunction, new or progressive functional impairments, and/or the enduring immunosuppressive, inflammatory, and procoagulant response of sepsis (36–44).

Innovative interventions will be required to accelerate recovery and mitigate the apparent readmission risk among survivors. The optimal strategy will likely require a coordinated, comprehensive approach from diagnosis to discharge planning and follow-up. Components with the potential to reduce readmissions include an antibiotic stewardship program during the hospitalization and postdischarge (51, 52), a longitudinal rehabilitation program to mitigate against functional impairments (53), early and frequent follow-up, and timely access to providers to effectively manage new conditions and complications (54). Comparative studies, designed to test the various potential strategies, will be essential.

There are several limitations to discuss. First, our study focused on septic shock patients admitted through the ED. Further studies, designed to examine the full spectrum of sepsis and those who develop sepsis during the hospitalization, are required to determine whether postacute care needs are concentrated in the most severely ill. Second, although we designed our study to identify ED visits and hospital readmissions to any UPHS hospital and captured patients readmitted through interhospital transfer, we were unable to capture care provided outside UPHS and therefore may have underestimated the rate of postdischarge resource utilization and ED visits specifically. Third, we did not fully account for the burden experienced by septic shock survivors. Future studies, designed to complement the recent work of Liu et al (23) and Prescott et al (24), will be necessary to more completely describe the survivor's experience, utilization of services, and associated costs. Fourth, among the readmissions categorized as unavoidable, septic shock may have accelerated the decline. Therefore, our classification schema may have underestimated the deleterious effects of septic shock. Fifth, the risk factor analyses were limited by power and therefore the potential for a type II error exists. Although we examined a multitude of factors at presentation and during the hospitalization, we acknowledge the threat of residual confounding and the potential for a type I error. Additional study is warranted to examine factors (e.g., infectious source, provisions of care, duration of antibiotics, and transfusions) associated with postacute care use at discharge and readmission and how discharge disposition may modify this relationship.

In conclusion, the use of hospital-based acute care appears to be common in septic shock survivors. Encounters often occurred within 15 days of discharge, frequently led to readmission with a life-threatening condition, and appeared to result in substantial morbidity and mortality. Further studies are necessary to validate these findings and to identify effective strategies to address the postacute care needs of survivors.

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