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Hospital readmission and healthcare utilization following sepsis in community settings

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Abstract

Background—Sepsis, the most expensive cause of hospitalization in the US, is associated with high morbidity and mortality. However, healthcare utilization patterns following sepsis are poorly understood.

Objective—To identify patient-level factors which contribute to post-sepsis mortality and healthcare utilization.

Design, Setting, Patients—A retrospective study of sepsis patients drawn from 21 community-based hospitals in Kaiser Permanente Northern California in 2010.

Measurements—We determined one-year survival and use of outpatient and facility-based healthcare before and after sepsis and used logistic regression to identify the factors that contributed to early readmission (within 30 days) and high utilization (15% of living days spent in facility-based care).

Results—Among 6,344 sepsis patients, 5,479 (86.4%) survived to hospital discharge. Mean age was 72 years with 28.9% of patients aged <65 years. Post-sepsis survival was strongly modified by age; one-year survival was 94.1% for <45 year olds and 54.4% for ≥85 year olds. A total of 978 (17.9%) patients were readmitted within 30 days; only a minority of all rehospitalizations were for infection. After sepsis, adjusted healthcare utilization increased nearly threefold compared with pre-sepsis levels and was strongly modified by age. Patient factors including acute severity of illness, hospital length of stay, and the need for intensive care were associated with early readmission and high healthcare utilization, however, the dominant factors explaining variability—comorbid disease burden and high pre-sepsis utilization—were present prior to sepsis admission.

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Conclusion—Post-sepsis survival and healthcare utilization were most strongly influenced by patient factors already present prior to sepsis hospitalization.

INTRODUCTION

Sepsis, the systemic inflammatory response to infection, is a major public health concern.[1] Worldwide, sepsis affects millions of hospitalized patients each year.[2] In the United States (US), it is the single most expensive cause of hospitalization.[3–6] Multiple studies suggest that sepsis hospitalizations are also increasing in frequency.[3, 6–10]

Improved sepsis care has dramatically reduced in-hospital mortality.[11–13] However, the result is a growing number of sepsis survivors discharged with new disability.[1, 9, 14–16] Despite being a common cause of hospitalization, little is known about how to improve post-sepsis care.[15, 17–19] This contrasts with other, often less common, hospital conditions for which many studies evaluating readmission and post-discharge care are available.[20–23] Identifying the factors contributing to high utilization could lend critical insight to designing interventions that improve long-term sepsis outcomes.[24]

We conducted a retrospective study of sepsis patients discharged in 2010 at Kaiser Permanente Northern California (KPNC) to describe their post-hospital trajectories. In this diverse community-hospital based population, we sought to identify the patient-level factors that impact the post-hospital healthcare utilization of sepsis survivors.

METHODS

This study was approved by the KPNC Institutional Review Board.

Setting

We conducted a retrospective study of sepsis patients aged ≥18 years admitted to KPNC hospitals in 2010 whose hospitalizations included an overnight stay, began in a KPNC hospital, and was not for peripartum care. We identified sepsis based on *International Classification of Disease, 9th Edition* principal diagnosis codes used at KPNC which capture a similar population to that from the Angus definition (Appendix Table 1).[7, 25, 26] We denoted each patients' first sepsis hospitalization as the 'index' event.

We linked hospital episodes with existing KPNC inpatient databases to describe patient characteristics.[27–30] We categorized patients by age (<45, 45–64, 65–84, and ≥85 years) and used Charlson comorbidity scores and Comorbidity Point Scores 2 (COPS2) to quantify comorbid illness burden.[28, 30–32] We quantified acute severity of illness using the Laboratory Acute Physiology Scores 2 (LAPS2) which incorporates 15 laboratory values, 5 vital signs, and mental status prior to hospital admission (including emergency department data).[30] Both the COPS2 and LAPS2 are independently associated with hospital mortality.[30, 31] We also generated a summary predicted risk of hospital mortality based on a validated risk model and stratified patients by quartiles.[30] We determined whether patients were admitted to the intensive care unit (ICU).[29]

Outcomes

We used patients' health insurance administrative data to quantify post-sepsis utilization. Within the KPNC integrated healthcare delivery system, uniform information systems capture all healthcare utilization of insured members including services received at non-KPNC facilities.[28, 30] We collected utilization data from the year preceding index hospitalization (pre-sepsis) and for the year after discharge date or until death (post-sepsis). We ascertained mortality after discharge from KPNC medical records as well as state and national death record files.

We grouped services into facility-based or outpatient categories. Facility-based services included inpatient admission, subacute nursing facility or long-term acute care, and emergency department visits. We grouped outpatient services as hospice, home health, outpatient surgery, clinic, or other (e.g., laboratory). We excluded patients whose utilization records were not available over the full pre-sepsis interval. Among these 1,211 patients (12.5% of total), the median length of records prior to index hospitalization was 67 days with a mean value of 117 days.

Statistical analysis

Our primary outcomes of interest were hospital readmission and utilization in the year after sepsis. We defined a hospital readmission as any inpatient stay after the index hospitalization grouped within one, three, six, and twelve months intervals. We designated those within thirty days as an 'early' readmission. We grouped readmission principal diagnoses, where available, by the 17 HCUP Clinical Classifications Software multi-level categories with sepsis in the infectious category.[33, 34] In secondary analysis we also designated other infectious diagnoses not included in the standard HCUP infection category (e.g., pneumonia, meningitis, cellulitis) as infection (Appendix).

We quantified outpatient utilization based on the number of episodes recorded. For facility-based utilization, we calculated patient length of stay intervals. Because patients surviving their index hospitalization might not survive the entire year after discharge, we also calculated utilization adjusted for patients' living days by dividing the total facility length of stay by the number of living days after discharge.

Continuous data are represented as mean (standard deviation) and categorical data as number (%). We compared groups with analysis of variance or chi-squared testing. We estimated survival with Kaplan-Meier analysis (95% confidence interval [CI]) and compared groups with log-rank testing. We compared pre- and post-sepsis healthcare utilization with paired t-tests.

To identify factors associated with early readmission after sepsis we used a competing risks regression model.[35] The dependent variable was time to readmission and the competing hazard was death within 30 days without early readmission; patients without early readmission or death were censored at 30 days. The independent variables included age, gender, comorbid disease burden (COPS2), acute severity of illness (LAPS2), any use of intensive care, total index length of stay, and percentage of living days prior to sepsis hospitalization spent utilizing facility-based care. We also used logistic regression to

quantify the association between these variables and high post-sepsis utilization; we defined high utilization as 15% of living days post-sepsis spent in facility-based care. For each model, we quantified the relative contribution of each predictor variable to model performance based on differences in log likelihoods.^{35,36} We conducted analyses using STATA/SE version 11.2 (StataCorp; College Station, TX) and considered a p-value of <0.05 to be significant.

RESULTS

Cohort characteristics

Our study cohort included 6,344 patients with index sepsis hospitalizations in 2010 (Table 1). Mean age was 72 (s.d. 16) years including 1,835 (28.9%) patients aged <65 years. During index hospitalizations, higher predicted mortality was associated with increased age, comorbid disease burden, and severity of illness ($p<0.01$ for each). ICU utilization increased across predicted mortality strata; for example, 10.7% of patients in the lowest quartile were admitted directly to the ICU compared with 48.6% in the highest quartile. In the highest quartile, observed mortality was 35.1%.

One-year survival

A total of 5,479 (86.4%) patients survived their index sepsis hospitalization. Overall survival after living discharge was 90.5% (89.6%–91.2%) at 30 days and 71.3% (70.1%–72.5%) at one year. However, post-sepsis survival was strongly modified by age (Figure 1). For example, one-year survival was 94.1% (91.2%–96.0%) for <45 year olds and 54.4% (51.5%–57.2%) for ≥85 year olds ($p<0.01$). Survival was also modified by predicted mortality, however, not by ICU admission during index hospitalization (Appendix Figure 1; $p=0.18$).

Hospital readmission

Overall, 978 (17.9%) patients had early readmission after index discharge (Table 2); nearly half were readmitted at least once in the year following discharge. Rehospitalization frequency was slightly lower when including patients with incomplete pre-sepsis data (Appendix Table 2). The frequency of hospital readmission varied based on patient age and severity of illness. For example, 22.3% of patients in the highest predicted mortality quartile had early readmission compared with 11.6% in the lowest. The median time from discharge to early readmission was 11 days. Principal diagnoses were available for 78.6% of all readmissions (Appendix Table 3). Between 28.3% and 42.7% of those readmissions were for infectious diagnoses (including sepsis).

Healthcare utilization

The unadjusted difference between pre- and post-sepsis healthcare utilization among survivors was statistically significant for most categories but of modest clinical significance (Appendix Table 4). For example, the mean number of pre-sepsis hospitalizations was 0.9 (1.4) compared to 1.0 (1.5) post-sepsis ($p<0.01$). After adjusting for post-sepsis living days, the difference in utilization was more pronounced (Figure 2). Overall, there was roughly a threefold increase in the mean percentage of living days spent in facility-based care between

patients' pre- and post-sepsis phases (5.3% versus 15.0%, $p<0.01$). Again, the difference was strongly modified by age. For patients aged <45 years, the difference was not statistically significant (2.4% versus 2.9%, $p=0.32$) while for those aged ≥ 65 years, it was highly significant (6.2% versus 18.5%, $p<0.01$).

Factors associated with early readmission included severity of illness, comorbid disease burden, index hospital length of stay, and intensive care (Table 3). However, the dominant factor explaining variation in the risk of early readmission was patients' prior comorbid disease burden (73.9%), followed by acute severity of illness (12.4%), total hospital length of stay (6.6%), and the need for intensive care (5.2%). Severity of illness and age were also significantly associated with higher odds of high post-sepsis utilization, however, the dominant factor contributing to this risk was a history of high pre-sepsis utilization (64.2%).

DISCUSSION

In this population-based study in a community healthcare system, the impact of sepsis extended well beyond the initial hospitalization. One in six sepsis survivors was readmitted within 30 days and roughly half were readmitted within one year. Fewer than half of rehospitalizations were for sepsis. Patients had a threefold increase in the percentage of living days spent in hospitals or care facilities after sepsis hospitalization. While age and acute severity of illness strongly modified healthcare utilization and mortality after sepsis, the dominant factors contributing to early readmission and high utilization rates—comorbid disease burden and pre-sepsis healthcare utilization—were present prior to hospitalization.

Sepsis is the single most expensive cause of US hospitalizations.[3–5] Despite its prevalence, there is little contemporary data identifying factors that impact healthcare utilization among sepsis survivors.[9, 16, 17, 19, 24, 36, 37] Recently, Prescott and others found that, in Medicare beneficiaries, post-severe sepsis healthcare utilization was markedly increased.[17] More than one-quarter of survivors were readmitted within 30 days and 63.8% were readmitted within a year. Severe sepsis survivors also spent an average of 26% of their living days in a healthcare facility—a nearly fourfold increase compared to their pre-sepsis phase. The current study included a population with a broader age and severity range, however, in a similar subgroup of patients—those aged ≥ 65 years within the highest predicted mortality quartile—the frequency of readmission was similar. These findings are concordant with those from prior studies.[17, 19, 36, 37]

Among sepsis survivors, most readmissions were not for sepsis or infectious diagnoses—a novel finding with implications for designing approaches to reduce rehospitalization. The pattern in sepsis is similar to that seen in other common and costly hospital conditions.[17, 20, 23, 38–40] For example, between 18 and 25 percent of Medicare beneficiaries hospitalized for heart failure, acute myocardial infarction, or pneumonia were readmitted within 30 days; fewer than one-third had the same diagnosis.[20] The timing of readmission in our sepsis cohort was also similar to that seen in other conditions.[20] For example, the median time of early readmission in this study was 11 days; it was between 10 and 12 days for patients with heart failure, pneumonia, and myocardial infarction.[20]

Krumholz and others suggest that the pattern of early rehospitalization after common acute conditions reflects a post-hospital syndrome—‘an acquired, transient period of vulnerability’—that could be the byproduct of common hospital factors.[20, 41] Such universal impairments might result from new physical and neurocognitive disability, nutritional deficiency, and sleep deprivation or delirium, among others.[41] If this construct were also true in sepsis, it could have important implications on the design of post-sepsis care. However, prior studies suggest that sepsis patients may be particularly vulnerable to the sequelae of hospitalization.[2, 42–45]

Among Medicare beneficiaries, Iwashyna and others reported that hospitalizations for severe sepsis resulted in significant increases in physical limitations and moderate to severe cognitive impairment.[1, 14, 46] Encephalopathy, sleep deprivation, and delirium are also frequently seen in sepsis patients.[47, 48] Furthermore, sepsis patients frequently need intensive care which is also associated with increased patient disability and injury.[16, 46, 49, 50] Indeed, we found that severity of illness and the need for intensive care were both predictive of the need for early readmission following sepsis. We also confirmed the results of prior studies suggesting that sepsis outcomes are strongly modified by age.[16, 19, 43, 51]

However, we found that the dominant factors contributing to patients’ health trajectories were conditions present prior to admission. This finding is in accord with prior suggestions that acute severity of illness only partially predicts patients facing adverse post-hospital sequelae.[23, 41, 52] Among sepsis patients, prior work demonstrates that inadequate consideration for pre-sepsis level of function and utilization can result in an overestimation of the impact of sepsis on post-discharge health.[52, 53] Further, we found that the need for intensive care was not independently associated with an increased risk of high post-sepsis utilization after adjusting for illness severity; a finding also seen in prior studies.[17, 23, 38, 51]

Taken together, our findings might suggest that an optimal approach to post-hospital care in sepsis should focus on treatment approaches that address disease-specific problems within the much larger context of common hospital risks. However, further study is necessary to clearly define the mechanisms by which age, severity of illness, and intensive care affect subsequent healthcare utilization. Furthermore, sepsis patients are a heterogeneous population in terms of severity of illness, site and pathogen of infection, and underlying comorbidity whose post-hospital course remains incompletely characterized limiting our ability to draw strong inferences.

These results should be interpreted in light of the study’s limitations. First, our cohort included patients with healthcare insurance within a community-based healthcare system. Care within the KPNC system, which bears similarities with accountable care organizations, is enhanced through service integration and a comprehensive health information system. While prior studies suggest that these characteristics result in improved population-based care it is unclear whether there is a similar impact in hospital-based conditions like sepsis. [54, 55] Furthermore, care within an integrated system may impact post-hospital utilization patterns and could limit generalizability. However, prior studies demonstrate the similarity

of KPNC members to other patients in the same region in terms of age, socioeconomic, overall health behaviors, and racial/ethnic diversity.[56]

Second, our study did not characterize organ dysfunction based on diagnosis coding, a common feature of sepsis studies which lack detailed physiologic severity data.[4–6, 8, 26] Instead, we focused on using granular laboratory and vital signs data to ensure accurate risk adjustment using a validated system developed in >400,000 hospitalizations.[30] While this method may hamper comparisons with existing studies, traditional methods of grading severity by diagnosis codes can be vulnerable to biases resulting in wide variability.[10, 23, 26, 57, 58] Nonetheless, it is likely that characterizing pre-existing and acute organ dysfunction will improve risk stratification in the heterogeneous sepsis population. Third, this study did not include data regarding patients' functional status which has been shown to strongly predict patient outcomes following hospitalization. Fourth, this study did not address the cost of care following sepsis hospitalizations.[19, 59] Finally, our study excluded patients with incomplete utilization records, a choice designed to avoid the spurious inferences that can result from such comparisons.[53]

In summary, we found that sepsis exacted a considerable toll on patients in the hospital and in the year following discharge. Sepsis patients were frequently rehospitalized within a month of discharge and, on average, had a threefold increase in their subsequent time spent in healthcare facilities. While age, severity of illness, and the need for ICU care impacted post-sepsis utilization, the dominant contributing factors—comorbid disease burden or pre-sepsis utilization—were present prior to sepsis hospitalization. Early readmission patterns in sepsis appeared similar to those seen in other important hospital conditions suggesting a role for shared post-hospital, rather than just post-sepsis, care approaches.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Kaplan-Meier survival curves following living discharge after sepsis hospitalization, stratified by age categories.

Figure 2. Percentage of living days spent in facility-based care, including inpatient hospitalization, subacute nursing facility, and long-term acute care before and after index sepsis hospitalization.

Table 1

Baseline patient and hospital characteristics of patients with sepsis hospitalizations, stratified by predicted hospital mortality quartiles.

Baseline	Predicted hospital mortality quartiles (n = 1,586 for each group)				
	Overall	1	2	3	4
Age, years					
Mean	71.9 ± 15.7	62.3 ± 17.8	71.2 ± 14.2	75.6 ± 12.7	78.6 ± 12.2
By age category					
< 45	410 (6.5)	290 (18.3)	71 (4.5)	25 (1.6)	24 (1.5)
45 – 64	1,425 (22.5)	539 (34.0)	407 (25.7)	292 (18.4)	187 (11.8)
65 – 84	3,036 (47.9)	601 (37.9)	814 (51.3)	832 (52.5)	789 (49.8)
85	1,473 (23.2)	156 (9.8)	294 (18.5)	437 (27.6)	586 (37.0)
Male	2,973 (46.9)	686 (43.3)	792 (49.9)	750 (47.3)	745 (47.0)
Comorbidity					
COPS2 score	51 ± 43	26 ± 27	54 ± 41	64 ± 45	62 ± 45
Charlson score	2.0 ± 1.5	1.3 ± 1.2	2.1 ± 1.4	2.4 ± 1.5	2.4 ± 1.5
Hospitalization					
LAPS2 severity score	107 ± 42	66 ± 21	90 ± 20	114 ± 23	159 ± 28
Admitted via emergency department	6,176 (97.4)	1,522 (96.0)	1,537 (96.9)	1,539 (97.0)	1,578 (99.5)
Direct ICU admission	1,730 (27.3)	169 (10.7)	309 (19.5)	482 (30.4)	770 (48.6)
ICU transfer, at any time	2,206 (34.8)	279 (17.6)	474 (29.9)	603 (38.0)	850 (53.6)
Hospital mortality					
Predicted, %	10.5 ± 13.8	1.0 ± 0.1	3.4 ± 0.1	8.3 ± 2.3	29.4 ± 15.8
Observed	865 (13.6)	26 (1.6)	86 (5.4)	197 (12.4)	556 (35.1)
Hospital length of stay, days	5.8 ± 6.4	4.4 ± 3.8	5.4 ± 5.7	6.6 ± 8.0	6.6 ± 6.9

Data are presented as mean (standard deviation) or number (frequency).

COPS 2: Comorbidity Point Score, version 2

LAPS 2: Laboratory Acute Physiology Score, version 2

ICU: Intensive care unit

Table 2
Frequency of readmissions after surviving index sepsis hospitalization, stratified by predicted mortality quartiles.

Readmission	Overall	Predicted mortality quartile			
		1	2	3	4
Within 30 days	978 (17.9)	158 (11.6)	242 (17.7)	274 (20.0)	304 (22.3)
Within 90 days	1,643 (30.1)	276 (20.2)	421 (30.8)	463 (33.9)	483 (35.4)
Within 180 days	2,061 (37.7)	368 (26.9)	540 (39.5)	584 (42.7)	569 (41.7)
Within 365 days	2,618 (47.9)	498 (36.4)	712 (52.1)	723 (52.9)	685 (50.2)

Table 3
Factors associated with early readmission (left) and high post-sepsis facility-based utilization (right)

High post-sepsis utilization defined as 15% of living days spent in hospital, subacute nursing facility, or long-term acute care. Hazard ratios are based on competing risk regression and odds ratios are based on logistic regression including all listed variables. Relative contribution to model performance was quantified by evaluating the differences in log likelihoods based on serial inclusion or exclusion of each variable.

Variable	Hazard ratio for early readmission		Odds ratio for high utilization	
	HR (95% CI)	Relative contribution	OR (95% CI)	Relative contribution
Age category, years		1.2%		11.1%
< 45	1.00 [reference]		1.00 [reference]	
45 – 64	0.86 (0.64 – 1.16)		2.22 (1.30 – 3.83) ⁺	
65 – 84	0.92 (0.69 – 1.21)		3.66 (2.17 – 6.18) ⁺	
85	0.95 (0.70 – 1.28)		4.98 (2.92 – 8.50) ⁺	
Male	0.99 (0.88 – 1.13)	0.0%	0.86 (0.74 – 1.00)	0.1%
Severity of illness (LAPS2)	1.08 (1.04 – 1.12) ⁺	12.4%	1.22 (1.17 – 1.27) ⁺	11.3%
Comorbid illness (COPS2)	1.16 (1.12 – 1.19) ⁺	73.9%	1.13 (1.09 – 1.17) ⁺	5.9%
Intensive care	1.21 (1.05 – 1.40) ⁺	5.2%	1.02 (0.85 – 1.21)	0.0%
Hospital length of stay, day	1.01 (1.00 – 1.02) [*]	6.6%	1.04 (1.03 – 1.06) ⁺	6.9%
Prior utilization, per 10%	0.98 (0.95 – 1.02)	0.7%	1.74 (1.61 – 1.88) ⁺	64.2%

⁺ p<0.01;

^{*} p<0.05