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ORIGINAL RESEARCH

Hospital Readmission and Healthcare Utilization Following Sepsis in Community Settings

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BACKGROUND: Sepsis, the most expensive cause of hospitalization in the United States, is associated with high morbidity and mortality. However, healthcare utilization patterns following sepsis are poorly understood.

OBJECTIVE: To identify patient-level factors that contribute to postsepsis 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 1-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 ($\geq$15% of living days spent in facility-based care).

RESULTS: Among 6344 sepsis patients, 5479 (86.4%) survived to hospital discharge. Mean age was 72 years with 28.9% of patients aged $<$65 years. Postsepsis survival was strongly modified by age; 1-year survival was 94.1% for $<$45 year olds and 54.4% for $\geq$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 3-fold compared with presepsis 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 presepsis utilization—were present prior to sepsis admission.

CONCLUSION: Postsepsis survival and healthcare utilization were most strongly influenced by patient factors already present prior to sepsis hospitalization. *Journal of Hospital Medicine* 2014;9:502–507. © 2014 Society of Hospital Medicine

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, 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 postsepsis care.[15,17–19] This contrasts with other, often less common, hospital conditions for which many studies evaluating readmission and postdischarge 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]

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We conducted a retrospective study of sepsis patients discharged in 2010 at Kaiser Permanente Northern California (KPNC) to describe their posthospital trajectories. In this diverse community-hospital–based population, we sought to identify the patient-level factors that impact the posthospital 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 $\geq$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 (see Supporting Appendix, Table 1, in the online version of this article).[7,25,26] We denoted each patient's 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 ($\leq$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 postsepsis 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 (presepsis) and for the year after discharge date or until death (postsepsis). 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 (eg, laboratory). We excluded patients whose utilization records were not available over the full presepsis interval. Among these 1211 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 1-, 3-, 6-, and 12-month intervals. We designated those within 30 days as an "early" readmission. We grouped readmission principal diagnoses, where available, by the 17 Healthcare Cost and Utilization Project (HCUP) Clinical Classifications Software multilevel 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 (eg, pneumonia, meningitis, cellulitis) as infection (see Supporting Appendix in the online version of this article).

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 [SD]) and categorical data as number (%). We compared groups with analysis of variance or χ^2 testing. We estimated survival with Kaplan-Meier analysis (95% confidence interval) and compared groups with log-rank testing. We compared pre- and postsepsis 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 postsepsis utilization; we defined high utilization as ≥15% of living days postsepsis 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 6344 patients with index sepsis hospitalizations in 2010 (Table 1). Mean age was 72 (SD 16) years including 1835 (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 5479 (86.4%) patients survived their index sepsis hospitalization. Overall survival after living discharge was 90.5% (range, 89.6%–91.2%) at 30 days and 71.3% (range, 70.1%–72.5%) at 1 year. However, postsepsis survival was strongly modified by age (Figure 1). For example, 1-year survival was 94.1% (range, 91.2%–96.0%) for <45 year olds and 54.4% (range, 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 ($P = 0.18$) (see Supporting Appendix, Figure 1, in the online version of this article).

TABLE 1. Baseline Patient and Hospital Characteristics of Patients With Sepsis Hospitalizations, Stratified by Predicted Hospital Mortality Quartiles

	Predicted Hospital Mortality Quartiles (n = 1,586 for Each Group)				
	Overall	1	2	3	4
Baseline					
Age, y, 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 years	410 (6.5)	290 (18.3)	71 (4.5)	25 (1.6)	24 (1.5)
45–64 years	1,425 (22.5)	539 (34.0)	407 (25.7)	292 (18.4)	187 (11.8)
65–84 years	3,036 (47.9)	601 (37.9)	814 (51.3)	832 (52.5)	789 (49.8)
≥85 years	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, d	5.8 ± 6.4	4.4 ± 3.8	5.4 ± 5.7	6.6 ± 8.0	6.6 ± 6.9

NOTE: Data are presented as mean (standard deviation) or number (frequency). **Abbreviations:** COPS2: Comorbidity Point Score, version 2; ICU: intensive care unit; LAPS2: Laboratory Acute Physiology Score, version 2.

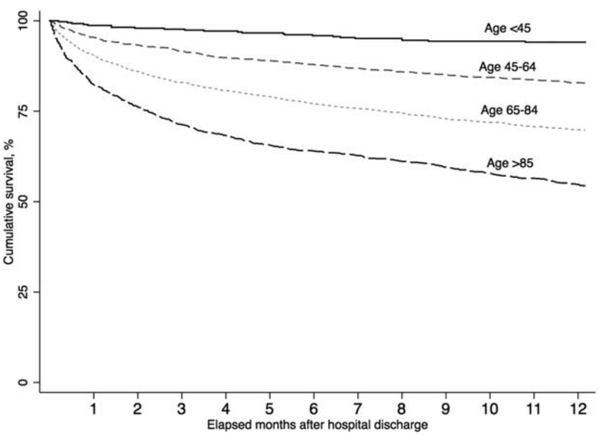

FIG. 1. Kaplan-Meier survival curves following living discharge after sepsis hospitalization, stratified by age categories.

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 presepsis data (see Supporting Appendix, Table 2, in the online version of this article). 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 (see Supporting Appendix, Table 3, in the online version of this article). Between 28.3% and 42.7% of those readmissions were for infectious diagnoses (including sepsis).

Healthcare Utilization

The unadjusted difference between pre- and postsepsis healthcare utilization among survivors was statistically significant for most categories but of modest clinical significance (see Supporting Appendix, Table 4, in the online version of this article). For example, the mean number of presepsis hospitalizations was 0.9 (1.4) compared to 1.0 (1.5) postsepsis ($P < 0.01$). After adjusting for postsepsis living days, the difference in utilization was more pronounced (Figure 2). Overall, there was roughly a 3-fold increase in the mean percentage of living days spent in facility-based care between patients' pre- and postsepsis phases (5.3% vs 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% vs 2.9%, $P = 0.32$), whereas for those aged ≥65 years, it was highly significant (6.2% vs 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 postsepsis utilization; however, the dominant factor contributing to this risk was a history of high presepsis 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 6 sepsis survivors was readmitted within 30 days, and roughly half were readmitted within 1 year. Fewer than half of rehospitalizations were for sepsis. Patients had a 3-fold increase in the percentage of living days spent in hospitals or care facilities after sepsis hospitalization. Although 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 presepsis healthcare utilization—were present prior to hospitalization.

Sepsis is the single most expensive cause of US hospitalizations.[3–5] Despite its prevalence, there are 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, following 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 4-fold increase compared to their presepsis phase. The current study included a population with a broader age and severity range; however, in a similar subgroup of patients, for 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, which is 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% 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 posthospital 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 postsepsis 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

TABLE 2. Frequency of Readmissions After Surviving Index Sepsis Hospitalization, Stratified by Predicted Mortality Quartiles

		Predicted Mortality Quartile			
Readmission	Overall	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 and High Postsepsis Facility-Based Utilization

	Hazard Ratio for Early Readmission		Odds Ratio for High Utilization	
Variable	HR (95% CI)	Relative Contribution	OR (95% CI)	Relative Contribution
Age category		1.2%		11.1%
<45 years	1.00 [reference]		1.00 [reference]	
45–64 years	0.86 (0.64-1.16)		2.22 (1.30-3.83)*	
65–84 years	0.92 (0.69-1.21)		3.66 (2.17-6.18)*	
≥85 years	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%

NOTE: High postsepsis utilization defined as ≥15% of living days spent in the 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. **Abbreviations:** CI, confidence interval; COPS2: Comorbidity Point Score, version 2; HR, hazard ratio; LAPS2: Laboratory Acute Physiology Score, version 2; OR, odds ratio. *$P < 0.01$. †$P < 0.05$.

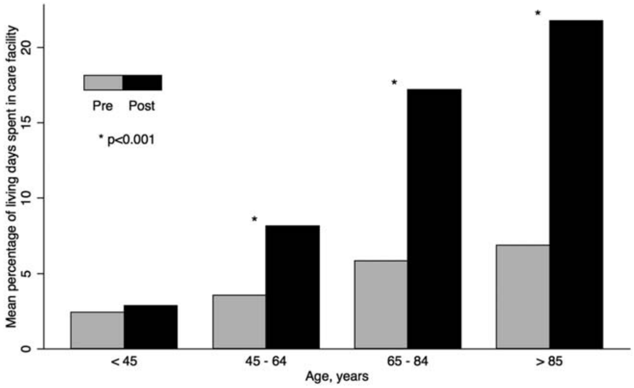

FIG. 2. Percentage of living days spent in facility-based care, including inpatient hospitalization, subacute nursing facility, and long-term acute care before and after index sepsis hospitalization.

also associated with increased patient disability and injury.[16,46,49,50] 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 posthospital sequelae.[23,41,52] Among sepsis patients, prior work demonstrates that inadequate consideration for presepsis level of function and utilization can result in an overestimation of the impact of sepsis on postdischarge health.[52,53] Further, we found that the need for intensive care was not independently associated with an increased risk of high postsepsis 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 posthospital 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 posthospital 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. Although 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 such as sepsis.[54,55] Furthermore, care within an integrated system may impact posthospital 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, socioeconomics, 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 that 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] Although 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 preexisting 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 3-fold increase in their subsequent time spent in healthcare facilities. Although age, severity of illness, and the need for ICU care impacted postsepsis utilization, the dominant contributing factors—comorbid disease burden or presepsis 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 posthospital, rather than just postsepsis, care approaches.

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