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## Increased Healthcare Facility Use in Veterans Surviving Sepsis Hospitalization

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### Abstract

**Purpose**—We sought to measure inpatient healthcare utilization among U.S. Veteran Affairs beneficiaries surviving sepsis hospitalization, and to examine how post-sepsis utilization varies by select patient characteristics.

**Materials and Methods**—Retrospective cohort study of 26,561 Veterans who survived sepsis hospitalization in 2009. Using difference-in-differences analysis, we compared changes in healthcare utilization in one year before and one year after sepsis hospitalization by Veteran age, illness severity, and recent nursing facility use.

**Results**—Median days in a healthcare facility increased from 5 to 10. Veterans with recent nursing facility use spent a median 65 days (or 86% of days alive) in a healthcare facility in the year after sepsis. Older age, greater illness severity, and recent nursing home use were each associated with spending more days, and a greater proportion of days alive, in a healthcare facility during the year after sepsis. However, none of these characteristics was associated with a greater rise in utilization after sepsis.

**Conclusions**—Veterans surviving sepsis experience high rates of post-sepsis mortality and significant increases in healthcare facility use. Recent nursing facility use is strongly predictive of greater post-sepsis healthcare utilization.

### INTRODUCTION

Over the past decade, there has been a steady rise in number of hospitalizations with a recognized diagnosis of sepsis, and a concurrent decline in the rate of in-hospital sepsis

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mortality<sup>1-4</sup>. As a result, there is an emerging population of sepsis survivors<sup>4</sup>, the majority of whom experience new functional disability and/or cognitive impairment<sup>4,5</sup>. In the U.S.-nationwide Veterans Affairs (VA) health system, over 35,000 Veterans are hospitalized with sepsis each year, and approximately 80% survive to hospital discharge<sup>2,6</sup>. Similar to Medicare beneficiaries, Veterans have a high rate of hospital readmission following sepsis<sup>6</sup>. However, little is known about the overall burden of healthcare utilization in Veterans surviving sepsis, and how this utilization differs by patient subtypes. Thus, we sought to measure all days spent in a hospital or nursing facility among Veterans surviving a sepsis hospitalization, to compare post-sepsis utilization to Veterans' own pre-sepsis resource use, and examine how post-sepsis utilization varies by patient characteristics, such as age, illness severity, and recent nursing home use.

## METHODS

### Cohort of Sepsis Hospitalizations

We identified all sepsis hospitalizations at any of 114 VA hospitals in 2009. We used the method of Angus *et al.*<sup>7</sup>, which requires either concurrent International Classification of Diseases, 9<sup>th</sup> Edition, Clinical Modification (ICD-9-CM) codes for infection and acute organ dysfunction or explicit coding for severe sepsis or septic shock. This method has similar specificity, but greater sensitivity than other claims-based identification methods<sup>8</sup>, and performs comparably within the VA to non-federal hospitals<sup>6</sup>. We excluded hospitalizations with inpatient mortality and hospitalizations in which the patient transferred from a non-VA hospital to the VA. For patients with multiple sepsis hospitalizations during 2009, we included just the first hospitalization.

### Healthcare Use

Our outcome of interest was days spent in a healthcare facility—the composite of short-term acute care hospitalizations, long-term acute care hospitalizations, skilled nursing facility (SNF), and custodial nursing care. To measure healthcare facility use before and after sepsis hospitalization, we used four data sources: (1) VA Inpatient Evaluation Center files on VA hospitalizations, (2) VA Inpatient Evaluation Center files on VA nursing homes, (3) “fee-based” care files for VA-funded care provided outside of the VA, and (4) MedPAR files for dual VA and Medicare beneficiaries. Collectively, these files capture all inpatient healthcare provided or paid for by the VA, as well as all non-VA care paid for by Medicare.

Inspired by the methods of Intrator, *et al.*<sup>9</sup>, we determined each patient's daily location based on dates of service in the four data sources, and assumed that patients were at home for any day that they were known to be alive and not admitted to a healthcare facility based on the above files. By determining each patient's daily location for the one year before and one year after sepsis hospitalization, we ensured that healthcare use was never “double-counted”. For example, if a skilled nursing facility bed were “held” while a patient was briefly hospitalized, the days with over-lapping SNF and hospitals stays would be counted just once in the tally of healthcare facility days. For the instances where patients use multiple types of healthcare facilities, we classified the patient's location using the following hierarchy: dead, hospital, nursing facility, home, similar to Intrator, *et al.*

After determining the daily location of each patient during the one year before and one year after sepsis hospitalization, we calculated the total number of days spent separately at home, in a hospital, and in nursing facilities. We also calculated the total number of days spent in any healthcare facility (hospital or nursing facility), and also the proportion of days alive spent in a healthcare facility.

### Illness Severity

We calculated illness severity (predicted 30-day mortality) using a composite score similar to APACHE IV<sup>2,10</sup>. We constructed the score using variables that make up the VA ICU severity score, a validated risk-adjustment measure<sup>10</sup> that includes age, admission diagnosis category, 29 comorbid conditions<sup>11,12</sup>, and 11 laboratory values drawn in the first 24 hours of hospitalization: sodium, blood urea nitrogen, glomerular filtration rate, glucose, albumin, bilirubin, WBC count, hematocrit, pH, PaCO<sub>2</sub>, and PaO<sub>2</sub>. To allow for a flexible nonlinear structure in the severity of illness score, we used a logistic multivariate adaptive regression spline (MARS)<sup>13</sup>, a nonparametric spline-and-knot-based form of regression that models the functional forms of covariates, as well as the nonlinearities and higher-level interactions thereof, for an outcome of 30-day mortality<sup>2</sup>.

### Statistical Analysis

We present patient and hospitalization characteristics as numbers (percentages), means (SDs), or medians (interquartile ranges [IQR]) as appropriate. To compare Veterans' own healthcare use before and after sepsis, we used the Wilcoxon signed-rank test. This non-parametric test accounts for the skewed distribution of the outcomes and the paired nature of the data. To compare healthcare utilization in the year after sepsis among non-patients subgroups, we used the non-parametric Wilcoxon rank sum test.

We performed three difference-in-difference analyses<sup>14</sup> to compare changes in healthcare use between patients of differing: (1) age: older (≥ 65 years) versus younger (< 64 years); (2) illness severity: predicted mortality above versus below median predicted 30-day mortality (as described below); and (3) pre-sepsis nursing facility use: none versus any in the 30 days preceding hospitalization.

We then built a multivariable model predicting the percentage of days alive in the year after sepsis hospitalization that are spent in a healthcare facility. Because the dependent variable (percentage of days in a healthcare facility) falls between 0 and 1, we used a generalized linear model with a logit link and the binomial family<sup>15</sup>. Model calibration was assessed by comparing the predicted versus actual percentage of days alive spent in a healthcare facility, by decile of predicted percentage. Using this model, we present post-sepsis utilization for select patient scenarios. Specifically, we calculated the predicted percentages of days alive spent in a nursing facility for patients with median illness severity and median hospital length of stay, but varying ages (50, 65, and 80 years) and varying nursing home use (none, the week prior, and the 6 months prior to sepsis hospitalization).

This research was approved by the Ann Arbor VA Institutional Review Board. We conducted all analyses using Stata MP Software, version 14.1 (StataCorp, College Station, TC) and SAS 9.4.

## RESULTS

### Patient and Hospital Characteristics

We identified 26,561 Veterans who survived a first sepsis hospitalization at any of 114 VA hospitals in 2009 (Table 1). Patients were older (median 69 years), predominantly male (96.8%), with a moderate burden of co-morbid disease (median Elixhauser Comorbidity Index 6). Hospital length of stay was a median of 7 days (IQR 4–13 days). 36.2% of patients were admitted to an ICU, and 12.7% were mechanically ventilated. Median predicted risk of 30-day mortality was 10.6%. Patient and hospitalization characteristics by subgroup are presented in Supplemental Table 1.

### Healthcare Use and Mortality in the Year after Sepsis

Of the 26,561 Veterans surviving sepsis, 2,373 (8.9%) had been admitted to a nursing facility in the prior 30 days, and 5,144 (19.4%) were discharged to a nursing facility. In the year after sepsis hospitalization, the median patient spent 0 days (IQR 0, 12) in a nursing facility and 10 days (IQR 0, 37) in any healthcare facility, or 3.8% of days alive (IQR 0.0%, 20.9%) (Table 2, Figure 1). 2,329 (8.8%) died within 30 days, and 8,289 (31.2%) died within 1 year of discharge from sepsis hospitalization.

Inpatient facility use was markedly higher in the patients with recent nursing facility use. These patients spent a median 65 days (IQR 17, 215) admitted to an inpatient healthcare facility in the year after sepsis—which represented 86.5% (IQR 16.4%, 100.0%) of all days alive. Patients with 3 weeks of nursing facility use in the prior 30 days (N=1,343) spent a median 111 days (100% of all days alive) in a healthcare facility in the year after sepsis (Supplemental Table 2).

Patients with older age and greater illness severity spent more days and a greater percent of days alive in inpatient facilities in the year after sepsis (Table 2), compared to younger and less severely ill Veterans, respectively,  $p<0.001$  for each comparison. Meanwhile, patients with prior nursing facility use spent substantially more days in healthcare facilities after sepsis: median 65 days (IQR 17, 215) versus 8 (0, 31) in patients without recent nursing facility use;  $p<0.001$ ; and median 86.5% of days alive (IQR 16.4%, 100%) versus 3.0% (0.0%, 15.3%) in patients without recent nursing facility use.

### Changes in Healthcare Use Before and After Sepsis

Overall, patients used more inpatient healthcare resources in the year after sepsis compared to the year prior (Supplemental Table 3, Figure 1). Median hospital days increased from 4 to 6 days ( $p<0.001$ ), while median healthcare facility days increased from 5 to 10 days ( $p<0.001$ ), and median percent of days alive in a healthcare facility increased from 1.4% to 3.8% ( $p<0.001$ ).

### Changes in Healthcare Use by Age, Illness Severity, and Recent Nursing Facility Use

Changes in healthcare utilization before and after sepsis hospitalization by sub-group are presented in Supplemental Tables 4–6. The rise in inpatient facility days after sepsis hospitalization was similar between older (age  $\geq 65$  years) and younger (age  $<65$  years)

patients (difference-in-differences for days in a healthcare facility 0.9 days [95% CI: -1.4, 3.2],  $p=0.43$ ); and also similar between patients with higher versus lower severity of acute illness (difference-in-differences for days in a healthcare facility -1.5 [95% CI: -3.8, 0.7],  $p=0.18$ ) (Table 3). However, because older sepsis survivors experienced greater mortality in the year after sepsis (37.8% versus 22.2%,  $p<0.001$ ), they had a greater rise in the proportion of days alive admitted to a healthcare facility (difference-in-differences 5.7% [95% CI: 4.8%, 6.6%],  $p<0.001$ ) and steeper decline in days spent at home (difference-in-differences -40.3 days [95% CI: -44.0, -36.5],  $p<0.001$ ). Likewise, because Veterans who survived a more severe sepsis hospitalization had greater mortality in the year after sepsis (44.4% versus 18.0%,  $p<0.001$ ), they also experienced a greater rise in the proportion of days alive admitted to a healthcare facility (difference-in-differences 5.1% [95% CI: 4.2%, 5.9%],  $p<0.001$ ) and a steeper decline in days spent at home in the year after sepsis (difference-in-differences -37.8 days [95% CI: -41.5, -34.1],  $p<0.001$ ).

Veterans who resided in a nursing facility prior to sepsis experienced a much higher rate of 1-year mortality: 48.0% versus 29.6% ( $p<0.001$ ) in patients without recent nursing facility use (Figure 2). Due to this high rate of mortality post-hospitalization and high healthcare use prior to sepsis, these Veterans spent fewer days in healthcare facilities in the year after sepsis, compared to the year prior: median 92 days (IQR 42, 287) in the year prior versus 65 (IQR 17,215) in the year after sepsis hospitalization.

### Percentage of Days Alive Spent in a Healthcare Facility

In a multivariable model, age, illness severity, length of hospitalization, and prior nursing facility use were each significantly associated with the percentage of days alive spent in a healthcare facility in the year after sepsis (Supplemental Table 7, Supplemental Figure 1). We present the predicted percentages of days alive spent in a healthcare facility for a variety of clinical scenarios in Table 4. These can vary dramatically. For example, for a 50-year-old Veteran surviving sepsis hospitalization, with median illness severity, median hospital length of stay, and no recent nursing facility use, the predicted percentage of days spent in a healthcare facility in the year after sepsis was 8%. This jumps dramatically to 25% for a 50-year-old Veteran who spent the prior week in a nursing facility, and to 58% for a 50-year-old Veteran who spent the prior 6 months in a nursing facility. By contrast, the predicted percentage increases just slightly with age (to 9% for a 65-year-old Veteran, with no recent nursing facility use, and 11% for an otherwise similar 80-year-old Veteran), and only trivially with greater severity of illness.

## DISCUSSION

In this study of a national cohort of Veterans, we found that sepsis survivors use substantial inpatient healthcare resources in the year after sepsis. The median patient spent 10 days (3.8% of all days alive) admitted to a healthcare facility. Older age, greater illness severity, and quite powerfully, recent nursing facility use were each associated with spending more days, and a greater proportion of days alive, in a healthcare facility during the year after sepsis. Patients with any recent nursing facility use spent a median 65 days (and over 80% of all days alive) in a healthcare facility in the year after sepsis, while those with at least 3

weeks of recent nursing facility use spent a median of 111 days (100% of all days alive) in a healthcare facility.

For the overall cohort, the median number of days in a healthcare facility doubled from 5 in the year prior to sepsis, to 10 in the year after sepsis—suggesting that the healthcare utilization in the year after sepsis is not merely a reflection of sepsis survivors' age, co-morbidity burden, or propensity to use healthcare, but is also a reflection of new disability<sup>5</sup> and heightened risk for medical deterioration after sepsis, such as recurrent infections<sup>16–18</sup>, acute renal failure<sup>17</sup>, aspiration<sup>17,19</sup>, and cardiovascular events<sup>20,21</sup>.

The number of healthcare facility days increased after sepsis for all sub-groups, except for patients with recent nursing facility use (who spent a median 92 days in a healthcare facility in the year prior to sepsis). However, the proportion of days alive spent in a healthcare facility increased two- to three-fold in all subgroups.

Our findings are consistent with prior studies showing similar median increases in health care utilization after sepsis hospitalization in Medicare<sup>22</sup> and Kaiser Permanente beneficiaries<sup>23</sup>, as well as with prior studies showing high risk for death in the year after surviving sepsis hospitalization<sup>24,25</sup>. This study extends prior work, however, by understanding how post-sepsis healthcare utilization differs by patient characteristics, and by providing post-sepsis healthcare utilization estimates for common patient scenarios. These scenarios highlight the importance of prior nursing home use in patients' post-sepsis experience. Prior nursing facility use is associated with several-fold increases in the predicted percentage of days alive spent in a healthcare facility, compared to a three percentage point increase per 15 years of age and trivial increases across the range of illness severity.

While it is not surprising that nursing home patients surviving sepsis hospitalization have high rates of subsequent healthcare utilization and mortality, we believe that these estimates may be helpful to counseling patients and families who are interested not just in the likelihood of long-term survival, but also in quality of their remaining days. While the median Veteran surviving sepsis hospitalization spent just under 4% of their days alive in the subsequent year admitted to a healthcare facility, the median Veteran with recent nursing facility use spent over 2 months and over 80% of their days alive in the subsequent year admitted to a healthcare facility. Patients with recent nursing home use have already made the decision that residing in nursing facility provides acceptable quality of life (at least for the short term). However, sepsis hospitalization—which frequently results in additional functional limitations<sup>5</sup>—signifies that care-taking needs are unlikely to be temporary, and thus may be an ideal time to reassess goals of care.

Our study should be interpreted in the context of several limitations. First, sepsis was ascertained by ICD-9-CM coding for infection and acute organ dysfunction. This method has greater sensitivity and similar specificity to other claims-based methods for identifying sepsis<sup>8</sup>, and performs similarly in the VA<sup>6</sup>. However, there is the possibility for misclassification in both directions. Second, days spent at home were defined by an absence of claims data indicating that the Veteran was admitted to a healthcare facility. While we



examined claims for all care provided by the VA, paid for by the VA, or paid for by Medicare for the duration of the study, we did not have information on private insurance claims, Medicaid claims, or self-paid healthcare use. However, we believe that our data sources captured the vast majority of healthcare use for the study population. Third, our study examined sepsis survivors alone. It is possible that these findings are not unique to patients surviving sepsis hospitalization, but rather, are common to survivors of all types of acute medical illness requiring hospitalization.

## CONCLUSION

In this national cohort of Veterans surviving sepsis hospitalization, we found that post-sepsis healthcare use was markedly elevated relative to patients own utilization in the year prior to sepsis. The median percentage number of day in a healthcare facility 5 in the year prior to sepsis, to 10 in the year after sepsis. Older age, greater illness severity, and in particular, recent nursing facility use were each associated with spending more days and a greater proportion of days alive in a healthcare facility after sepsis. Veterans with recent nursing facility use spent a median 65 days and >80% of days alive in a healthcare facility during the year after sepsis.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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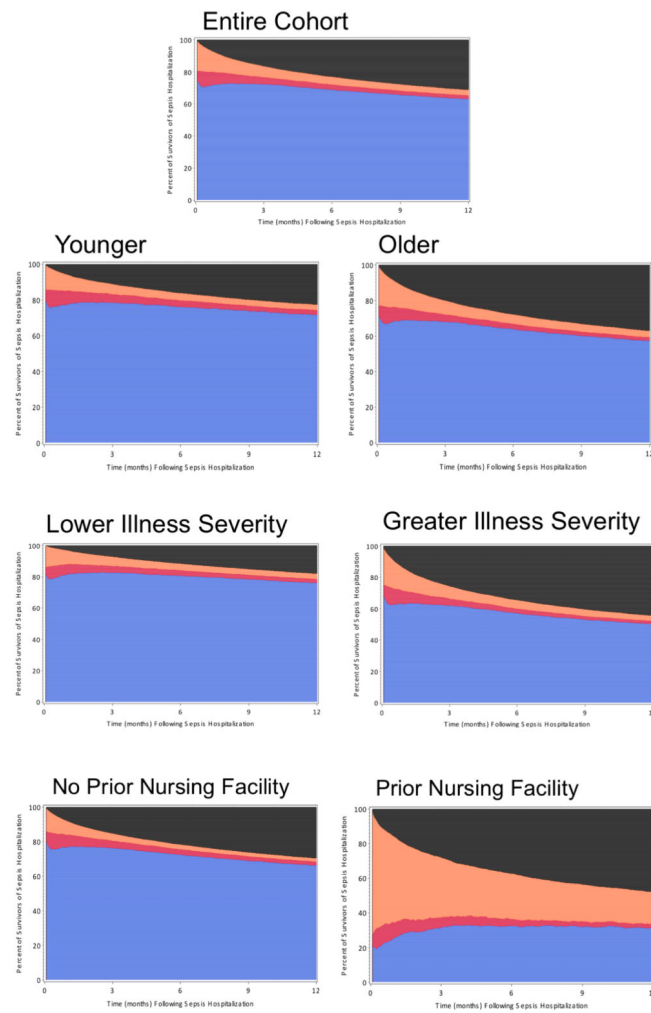
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### Highlights

- The median patient spent 3.8% of their post-sepsis year in a healthcare facility
- Recent nursing facility use was strongly predictive of post-sepsis healthcare use
- Those with recent nursing facility use spent little time at home post-sepsis



**Figure 1.** Healthcare Facility Use and Mortality in the Year Before and After Sepsis Hospitalization, Overall and by Subgroups  
 This figure shows the daily location of 26,591 sepsis survivors in the year after sepsis hospitalization. The index sepsis hospitalization is not included; the year after begins the day after hospital discharge. Patients are depicted as being at home (*blue*), admitted to a hospital (*red*), admitted to an LTAC or nursing facility (*orange*), or dead (*black*).

**Table 1**

Characteristics and Outcomes of Sepsis Hospitalizations with Live Discharge

Patient and Hospitalization Characteristics	Sepsis Hospitalizations (N=26,561)
Age, median (IQR)	69 (61, 80)
Race, N (%)	
<i>African American</i>	4,900 (18.5%)
<i>Caucasian</i>	19,135 (72.0%)
<i>Other</i>	366 (1.4%)
<i>Unknown</i>	2,160 (8.1%)
Male, N (%)	25,710 (96.8%)
Elixhauser Comorbidity Index, median (IQR)	6 (3, 11)
Length of Stay, median (IQR)	7 (4, 13)
Admitted to an Intensive Care Unit, N (%)	9,626 (36.2%)
Used mechanical ventilation, N (%)	3,372 (12.7%)
Outcomes	
30-Day Readmission, N (%)	7,251 (27.3%)
90-Day Readmission, N (%)	11,504 (43.3%)
30-Day Mortality, N (%)	2,329 (8.8%)
90-Day Mortality, N (%)	4,368 (16.5%)
1-Year Mortality, N (%)	8,289 (31.2%)

**Table 2**

One-year outcomes in survivors of sepsis

<b>Cohort</b>	<b>Days at Home, Median (IQR)</b>	<b>Days in Healthcare Facility, Median (IQR)</b>	<b>% of days alive in Healthcare Facility, Median (IQR)</b>	<b>1-Year Mortality N (%)</b>
All Patients, N=26,561	336 (115, 362)	10 (0, 37)	3.8% (0.0%, 20.9%)	8,289 (31.2%)
Age ≥ 65 years, N=15,924	320 (64, 320)	11 (0, 39)	4.6% (0.0%, 26.1%)	5,893 (37.0%)
Age < 65 years, N=10,637	349 (228, 365)	9 (0, 34)	3.0% (0.0%, 15.3%)	2,396 (22.5%)
Higher Illness Severity, N=13,280	268 (30, 357)	12 (0, 42)	6.6% (0.0, 33.7%)	5,901 (44.4%)
Lower Illness Severity, N=13,281	353 (278, 365)	8 (0, 32)	2.5% (0.0%, 12.6%)	2,388 (18.0%)
Recent Nursing Facility Use, N=2,373	9 (0, 262)	65 (17, 215)	86.5% (16.4%, 100%)	1,138 (48.0%)
No Recent Nursing Facility Use, N=24,188	343 (168, 363)	8 (0, 31)	3.0% (0.0%, 15.3%)	7,151 (29.6%)

Recent nursing facility use = any nursing facility use in the 30 days prior to sepsis hospitalization; Community dwelling = no nursing facility use in the 30 days prior to sepsis hospitalization.

Abbreviations: IQR=interquartile range; MV=mechanically ventilated; NF=nursing facility

Difference-in-Differences Analyses Comparing Changes in Healthcare Use in Older vs Younger Patients, Higher versus Lower Illness Severity, and Nursing Home Use versus Not

**Table 3**

	Older Age		Illness Severity		Nursing Home Use	
	DID Estimate (95% CI)	P	DID Estimate (95% CI)	P	DID Estimate (95% CI)	P
Days at Home	-40.3 (-43.9, -36.5)	<0.001	-37.8 (-41.5, -34.1)	<0.001	-12.9 (-18.8, -6.9)	<0.001
Days in Healthcare Facility	0.9 (-1.4, 3.2)	0.43	-1.5 (-3.8, 0.7)	0.18	-40.8 (-44.1, -37.5)	<0.001
Days in a Hospital	-0.5 (-1.3, 0.2)	0.16	-2.8 (-3.5, -2.1)	<0.001	-12.6 (-13.9, -11.3)	<0.001
Days in a Nursing Facility	1.4 (-0.6, 3.5)	0.17	1.3 (-0.7, 3.3)	0.21	-28.2 (-31.2, -25.2)	<0.001
Proportion of days alive in a healthcare facility	0.06 (0.05, 0.07)	<0.001	0.05 (0.04, 0.06)	<0.001	0.09 (0.08, 0.1)	<0.001

**Table 4**  
 Predicted Proportion of Days Alive after Sepsis Hospitalization Spent in a Healthcare Facility

Scenario*	Age	Nursing Facility Use	Predicted Risk of 30-Day Mortality	Predicted Percentage of Days After Sepsis in a Healthcare Facility, 95% CI
1	50	None	Median (10.7%)	7.6% (7.2%, 7.9%)
2	50	Prior Week	Median (10.7%)	24.8% (22.9%, 26.7%)
3	50	Prior 6 months	Median (10.7%)	58.1% (55.5%, 60.7%)
4	65	None	Median (10.7%)	9.1% (8.8%, 9.4%)
5	65	Prior Week	Median (10.7%)	28.8% (26.8%, 30.7%)
6	65	Prior 6 months	Median (10.7%)	63.0% (60.6%, 65.3%)
7	65	None	5 <sup>th</sup> percentile (3.1%)	9.1% (8.8%, 9.4%)
8	65	Prior Week	5 <sup>th</sup> percentile (3.1%)	28.7% (26.8%, 30.7%)
9	65	Prior 6 months	5 <sup>th</sup> percentile (3.1%)	62.9% (60.6%, 65.3%)
10	65	None	95 <sup>th</sup> percentile (41.4%)	9.2% (8.9%, 9.5%)
11	65	Prior Week	95 <sup>th</sup> percentile (41.4%)	28.9% (27.0%, 30.9%)
12	65	Prior 6 months	95 <sup>th</sup> percentile (41.4%)	63.1% (60.8%, 65.4%)
13	80	None	Median (10.7%)	10.9% (10.5%, 11.4%)
14	80	Prior Week	Median (10.7%)	33.1% (31.0%, 35.3%)
15	80	Prior 6 months	Median (10.7%)	67.6% (65.3%, 69.9%)

\* For each scenario patients had a median hospital length of stay (7 days).