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The Impact of Surgical Site Infection on Older Operative Patients

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Abstract

Objectives—To determine the impact of surgical site infection (SSI) on mortality, duration of hospitalization and hospital cost among older operative patients.

Design—Retrospective matched outcomes study

Setting—Eight hospitals including Duke University Medical Center and 7 community hospitals.

Participants—Patients ≥ 65 years old undergoing surgery from 1991–2003. Cases were defined as patients who developed deep incisional or organ/space SSI and controls were operative patients who did not develop SSI. Controls were frequency matched to cases by type and year of operative procedure and by hospital in a 1:1 ratio.

Measurements—Mortality, duration of hospitalization (including re-admissions) and hospital charges for the 90 days following surgery.

Results—1,337 patients were enrolled in the study: 561 cases with SSI and 576 control patients without SSI. Among cases, the most common SSI pathogen was *Staphylococcus aureus* (n=275, 51.6%). Among *S. aureus* isolates, 58.2% were methicillin-resistant. One-hundred and sixteen subjects died within 90 days of surgery (8.6%). In multivariable analysis, SSI was associated with an increased mortality risk (odds ratio [OR] 3.51, 95% CI 2.20, 5.59). SSI was also associated with a 2.86 fold increase in the duration of postoperative hospitalization (95% CI 2.61, 3.13) and a 1.93 fold increase in hospital charges (95% CI 1.78, 2.10) in multivariable analysis.

Conclusion—Among elderly operative patients, SSI was associated with an almost 4-fold increase in mortality, a mean attributable duration of hospitalization after surgery of 15.7 days (95% CI 13.9, 17.6) and mean attributable hospital charges of \$43,970 (95% CI \$31,881, \$56,060).

Keywords

Surgical site infection; mortality; duration of hospitalization; hospital charges

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Mr. Sloane was involved in data analysis and interpretation and manuscript preparation Ms. Choi and Ms. Link were involved in study design, acquisition of study subjects and data and analysis of data.

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INTRODUCTION

The population in the US is progressively aging. The proportion of the population aged >65 years is projected to increase from 12.4% to 19.6% by 2030.¹⁻³ and the absolute number of elderly persons is projected to increase from approximately 35 million to 71 million. Moreover, the number of persons in the US > 80 years of age is projected to double from 9.5 million in 2000 to 19 million in 2030.^{1,2}

As the population ages, older adults will have surgery more frequently. For example, the proportion of adults older than 65 who underwent non-obstetric surgeries increased from 19% in 1980 to 43% in 1998.⁴ More than a million American patients >65 years of age had five common operations (coronary bypass, total joint replacement, open reduction and internal fixation, cholecystectomy and large bowel resection) in 1998, and surgeons operated on more than 1 million patients greater than 65 years old in 1998 in the US.⁴

Surgical site infection (SSI) is a serious complication of any surgical procedure. The impact of SSI on mortality, duration of hospitalization and hospital costs have been well described in the general population, but these data are limited in older operative patients. Once the enormous costs of these SSI older patients are quantified and understood the financial benefit of prevention programs can finally be put in perspective. Thus, the objective of this study was to determine the impact of SSI on mortality, hospitalization and cost in older operative patients.

METHODS

Study Design and Hospital Settings

This matched-outcomes study was conducted at 8 hospitals including Duke University Medical Center (DUMC), a 750-bed tertiary care hospital in Durham, NC; and 7 community hospitals (ranging in size from 102 to 391 beds [mean: 202 beds]) in North Carolina. All 7 community hospitals are part of the Duke Infection Control Hospital Network (DICON). The structure and function of DICON has been reported elsewhere.^{5,6}

Prospective surveillance for SSI was conducted at all institutions using similar methods.⁷ Surveillance for SSI was conducted at DUMC for cardiothoracic, neurosurgical and orthopedic procedures. Surveillance at the seven DICON hospitals was performed for all surgeries with National Nosocomial Infections Surveillance System (NNIS) codes.⁷

Informed consent was waived by the IRB of participating hospitals as no human experimentation was performed. Data were de-identified and managed according to the standards required by the IRBs of participating hospitals.

Case and Control Definitions—Patients were identified from existing DUMC and DICON databases. These databases included detailed demographic and clinical information for patients who underwent surgical procedures from 1994-2003 at DUMC; from 1991 to 2003 at one DICON hospital; and from 1998 to 2003 at the 6 other DICON hospitals.

Cases were defined as elderly patients (≥65 years old) who had surgery and developed a SSI during the study period. All SSIs were prospectively identified by infection control practitioners using standard CDC definitions.⁸ SSIs were classified as deep incisional or organ space; superficial incisional infections were excluded. Cases were identified as having SSI through a combination of review of microbiology culture reports, screening operative patients for re-admission to the hospital and/or operating room after surgery and clinical rounds.

Selected controls were operative patients ≥ 65 years of age who did not develop SSI. Controls were frequency matched to cases by type and year of operative procedure and by hospital in a 1:1 ratio. If multiple patients met criteria as potential controls for a specific case, then a single control was randomly selected. A study nurse reviewed medical records of all study patients. If the study nurse had questions or concerns regarding the accuracy of SSI diagnosis, pertinent data were reviewed with the primary study investigator.

Variables

The following data were collected prospectively and stored in electronic infection control databases: patient age, surgical procedure type, NNIS risk index score, 9, American Society of Anesthesiologists (ASA) score, duration of surgery and wound class category. For patients with SSI, additional data collected included the type of infecting pathogen, anatomical site of isolation and date of culture.

Additional data collected retrospectively from the patient chart by a study nurse on all study patients included the following: race, presence of co-morbid illnesses, pre-operative McCabe score,¹⁰ duration of hospitalization before surgery, body mass index (BMI) at the time of surgery, preoperative independence with Activities of Daily Living (ADLs),¹¹ admission source, type of insurance, peak serum glucose during the 24 hour post-operative period and whether or not appropriate antimicrobial prophylaxis was administered pre-operatively. Preoperative independence with ADLs was determined according to the categories proposed by Katz.¹¹ A binary variable for functional status was created: low functional status was defined as assistance required with 3 or more ADLs, and high functional status was defined as assistance required with less than 3 basic ADLs.¹² Antimicrobial prophylaxis was considered appropriate if an approved agent was used and if the dose and timing of the delivery of the agent were appropriate.¹³ Specifically, if an appropriate antibiotic was delivered within 2 hours of incision then antimicrobial prophylaxis was considered to be appropriate. A Charlson score was calculated for each study subject using ICD-9 codes.¹⁴ Obesity was defined as BMI >30 .

Outcome variables were mortality during the 90-day post-operative period (in-hospital and outpatient), total hospital days during the 90-day post-operative period (including readmissions), and hospital charges accrued during the 90-day post-operative period (including readmissions). For hospital charges, the reference year was 2003 and prior charges were discounted at a 3% annual rate. Actual costs were not available at some study hospitals, so charges were used as a surrogate for cost. Outcomes data were obtained from the patient chart, hospital financial databases and the United States Social Security Death Index (<http://www.ancestry.com>). Prior to 1998, charges data were missing for most subjects. Thus, for all charges analyses, only subjects enrolled after 12/31/1997 were included.

The reliability of key study variables was determined by comparing the values obtained by the study nurse to the data obtained by a second, blinded study nurse. Thirty charts were reviewed and 10 variables were abstracted. The Kappa statistic for all variables was greater than 0.4, indicating good to excellent reproducibility of the data.⁶

Statistical Analysis

Statistical analysis was performed using SAS software (SAS Institute Inc, Cary, NC; version 8.2). Analysis was performed separately for each of the three outcomes studied: mortality, duration of hospitalization and hospital charges. Continuous variables were compared in bivariable analysis using either the Wilcoxon rank sum test or Student's t-test. Dichotomous and ordinal variables were compared using the Fisher's exact or Chi-square tests.

For the subjects with missing data, the missing variable was imputed using the mean for continuous variables or the mode for discrete values. Bias due to missing values was assessed by creating dummy variables and adding them to the model to account for missing data. 15.

The independent impact of SSI on each outcome variable was analyzed by multivariable analysis. Specifically, 90-day mortality was analyzed using logistic regression. Duration of hospitalization after surgery and hospital charges were analyzed using linear regression (after log transformation of the outcome variable). The inverse log value was calculated for β coefficients of variables included in the predictor models. These effect measures were described as the (OR) for mortality and multiplicative effects (ME) on length of stay and cost and odds ratio. Linear regression with the least squares means method was used to determine adjusted mean values attributable to SSI for post-operative total hospital days. Hospital variables with a p-value <0.2 in bivariable analysis were included as candidate variables for the multivariable models. Models were derived using a backwards selection procedure and only variables with an adjusted p value < 0.05 were included in the final models. Variables not selected for inclusion in the final models were checked for confounding and collinearity. If the removal of a confounding variable affected the β -coefficient for the effect measure of SSI by more than 10%, the confounding variable was left in the model. All tests were 2-tailed, with p <0.05 considered statistically significant.

RESULTS

Initially, 1,352 patients were enrolled in the study. Subsequently, 16 patients with SSI were excluded after it was determined that they did not meet study criteria for SSI. Thus, 1,337 patients were included in the study cohort used for this analysis: 561 cases with SSI and 576 control patients without SSI. The mean age of the study cohort was 73.9 (standard deviation [SD] 6.3). The study cohort included 500 males (44.0%) and 876 (77.0%) individuals classified as white. The following variables were present more frequently in cases than in controls (p≤0.05): Medicare insurance, a higher Charlson Score, a higher body mass index, underlying congestive heart failure, chronic obstructive pulmonary disease, renal disease, hospitalization prior to surgery, surgical procedures lasting longer than the 75th percentile of the national cut-point. Arthritis occurred less frequently in cases than in controls (Table 1).

Among cases, the most common SSI pathogen was *Staphylococcus aureus* (n=275, 51.6%). Among *S. aureus* isolates, 58.2% were methicillin-resistant. Other common pathogens included gram-positive organisms (coagulase-negative staphylococci, n=44 [8.3%]; *Enterococcus spp.*, n=34 [6.4%]; and *Streptococcus spp.*, n=10 [1.9%]) and gram-negative organisms (*Escherichia coli*, n=30 [5.6%]; *Pseudomonas aeruginosa*, n=16 [3.0%]; and *Proteus spp.*, n=12 [2.3%]).

Mortality

One-hundred and sixteen subjects died within 90 days of surgery (Table 2). SSI was associated with an increased risk for mortality (odds ratio [OR] 3.30, 95% confidence interval [2.14, 5.08]). Variables associated with mortality other than SSI (p≤0.05) are shown in Table 3.

In multivariable logistic regression, SSI remained associated with 90-day mortality (OR 3.51, 95% CI 2.20, 5.59) (Table 2). Other variables associated with mortality included age≥80 years, Charlson score ≥ 3, low functional status, admission to the surgical service, orthopedic surgery and ASA score ≥ 3. This model was controlled for the confounding effect of admission to the hospital from another institutional setting.

Duration of Hospitalization After Surgery

After being discharged from the hospital following surgery, re-admission to the hospital was more common among patients with SSI than in patients without SSI (68.3% and 13.5%, $p < 0.001$). SSI was associated with an increased duration of hospitalization during the 90 days following surgery (median 19 days, inter-quartile range [IQR] 11, 32 for patients with SSI; median 5, IQR 4, 9 for patients without SSI) (Table 2). Other variables associated with an increased duration of hospitalization ($p \leq 0.05$) are shown in Table 4.

SSI was associated with a 2.86 fold increase in the duration of postoperative hospitalization (95% CI 2.61, 3.13) (Table 2). The adjusted mean attributable duration of hospitalization after surgery was 15.7 days (95% CI 13.9, 17.6). Other predictors of increased duration of hospitalization included: McCabe score of 1; BMI > 30, lack of independence with activities of daily living; admission to the hospital before surgery; operative duration > 75th percentile NNIS cut point; wound class of dirty or contaminated; ASA score > 2; and post-operative glucose > 200 mg/dl.

Hospital Charges

Analyses for hospital charges included only subjects enrolled after 12/31/1997 ($n = 531$, 272 cases and 259 controls). The hospital charges during the 90 days following surgery (including readmissions to the hospital) were significantly higher for patients with SSI than for control patients (\$94,564 [IQR 84,942, 104,186] and \$44,080 [IQR 34,219, 53,940] respectively, $p < 0.001$) (Table 2). Other variables associated with increased charges ($p \leq 0.05$) are shown in Table 5.

Having a SSI was associated with a 1.93 fold increase in hospital charges (95% CI 1.78, 2.10) (Table 2). The mean charges attributable to SSI was \$43,970 (95% CI \$31,881, \$56,060). Other independent predictors of hospital charges included age > 80 years, Charlson score > 2; McCabe score of 1; BMI > 30, treatment at a tertiary care hospital; admission to the hospital prior to surgery; undergoing CABG surgery; duration of surgery > 75th percentile NNIS cutpoint and post-operative serum glucose > 200 mg/dl.

DISCUSSION

This study demonstrated that SSI has a significant adverse impact on elderly patients, resulting in increased risk for mortality, prolonged duration of hospitalization and notable significant attributable costs to the hospital. Given the fact that the surgical population is aging, improvements in SSI prevention and management among older adults are warranted.

The costs of SSIs are not apparent to caregivers, administrators and to health policy professionals. Thus, the cost-effectiveness of prevention measures is unknown. In addition, the cost figures in this study do not address health insurance reimbursement of payment in patients with SSI---but there is evidence that the expected reimbursement is far less than the true cost of these infections.¹⁶

In adults of all ages, SSI is associated with approximately a 2-fold increase in mortality 17, 18 and 7-10 days of additional hospitalization. 17, 19, 20. In this study, SSI was associated with a greater than 3-fold increase in mortality and greater than 2 weeks of additional hospitalization. Thus, compared to the general surgical population, SSI has a more severe, adverse impact on clinical outcomes among elderly operative patients. In the general operative population, the additional costs of SSI range from \$3,000 to \$29,000. 16, 17, 21-26. In this study, the impact of SSI on hospital charges (~ \$40,000/SSI) was similar if not greater in elderly patients in this study compared to the general population.

Previous studies from our group have reported similar findings to the current study. Prior studies reported that, among operative patients aged ≥ 65 years, patients who developed an SSI had mortality rates 3 - 5 times higher than uninfected controls, had an increased mean duration of hospitalization of 9-12 days and an approximate 2-fold increase in hospital costs. 27, 28. However, these prior studies only included patients who underwent specific types of operative procedures 27,28, and the study cohorts were considerably smaller than the current study.

Although this investigation was primarily an outcomes study, some findings regarding SSI risk are noteworthy. Among patients with SSI, poor functional status was associated with mortality and longer length of stay. Thus, the interaction between SSI and functional status is marked and results in poor outcome. It was also interesting to note that, of all the co-morbidities evaluated only chronic obstructive lung disease and congestive heart failure, were associated with SSI. This raises the issue of whether oxygen saturation during surgery might be a particularly important variable in older adults. Future studies should evaluate the association between perioperative oxygenation and SSI. Risk factors for SSI in older adults are extensively analyzed and discussed in another publication from our research group⁶.

This study has limitations. Preservation of functional status is an important health outcome and is a particularly important health outcome among elderly patients but due to the retrospective nature of this study, we were unable to assess the impact of SSI on functional status. Future, prospective studies should study the relationship between SSI and functional status. This study included only deep incisional and organ/space infections and superficial SSI were excluded. Thus, the findings from this study cannot be generalized to superficial SSI. However, deep and organ/space SSI are more severe and clinically important than superficial SSI. Financial data was only available from after 1997, which limited the number of subjects in the charges analysis. However, the study still had sufficient power to describe the association between SSI and hospital charges.

This study has multiple strengths. The large study population enrolled at 8 study sites (which included both community and tertiary care hospitals) afforded significant power and generalizability to the study findings. Reference patients were matched to cases patients by hospital, type of procedure and calendar time, eliminating several potential sources of bias and confounding. Rather than quantifying the impact of SSI on a single outcome, 3 outcomes were analyzed.

SSI occurs commonly in the US. As the population ages, the frequency of surgeries performed on elderly individuals and the frequency of SSI in elderly patients will increase. Because outcomes attributable to SSI are severe, prevention and optimal management of SSI are particularly important in older adults. Although many SSIs are preventable²⁹, current prevention efforts at present are based on vague national goals and guidelines but not on basic economic principles. These data are important because they can be used to measure the impact of prevention programs. The results of this study are important because they can be used to measure the impact of prevention programs.

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Dr. Kaye also serves on advisory boards for Ortho-Mcneil and Schering Plough

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Table 1

Characteristics of 561 Elderly (Aged ≥ 65) Cases with Surgical Site Infection (SSI) and 576 Elderly Controls without SSI

	SSI Cases N=561 n(%) [*]	Uninfected Controls N=576 n(%) [*]	P-value
Demographics			
Age - median (IQR)	73.0 (69.0-77.0)	73.3 (69.0-78.0)	0.22
Gender (male)	257 (45.8)	243 (42.2)	0.22
Race (Caucasian)	426 (76.9)	450 (79.8)	0.24
Insurance Status (Medicare)	528 (94.1)	516 (89.6)	0.0007
Comorbid conditions			
Charlson Score - median (IQR)	2 (1-3)	1 (0-3)	0.001
Charlson ≥ 3	120 (21.4)	79 (13.7)	0.0007
McCabe at admission - median (IQR)	2 (2-3)	3 (2-3)	0.08
McCabe score on admission of 1	35 (6.6)	23 (4.3)	0.10
BMI (mean, STD)	28.2 $\pm$ 6.1	26.8 $\pm$ 6.2	0.0002
BMI > 30	174 (35.6)	117 (23.9)	<0.0001
Diabetes	139 (24.8)	132 (22.9)	0.46
End organ damage	19 (3.4)	13 (2.3)	0.25
Myocardial infarction	122 (21.8)	123 (21.4)	0.87
Congestive heart failure	131 (23.4)	90 (15.6)	0.001
Peripheral vascular disease	108 (19.3)	94 (16.3)	0.20
Cerebrovascular disease	46 (8.2)	50 (8.7)	0.77
Dementia	16 (2.9)	23 (4.0)	0.29
Chronic obstructive pulmonary disease	99 (17.7)	60 (10.4)	0.0004
Connective tissue disease	14 (2.5)	15 (2.6)	0.91
Arthritis	132 (23.5)	165 (28.7)	0.05
Peptic ulcer disease	79 (14.1)	68 (11.8)	0.25
Hemiplegia	2 (0.4)	2 (0.4)	1.0
Liver disease	7 (1.3)	2 (0.4)	0.10
Renal disease	48 (8.6)	23 (4.0)	0.002
Hemodialysis	9 (1.6)	18 (3.1)	0.09
History of malignancy	102 (18.2)	90 (15.6)	0.25
Metastatic cancer	16 (2.9)	9 (1.6)	0.14
Use of immunosuppressive medications	34 (6.6)	28 (5.4)	0.41
Preoperative functional status			
Need assistance with ≥ 3 Activities of Daily Living (ADLs)	128 (22.8)	106 (18.4)	0.07
Need assistance with any ADLs	190 (33.9)	169 (29.3)	0.10
Ambulation not independent	173 (33.3)	158 (30.2)	0.28
Bathing not independent	132 (25.4)	108 (20.6)	0.06

	SSI Cases N=561 n(% [*])	Uninfected Controls N=576 n(% [*])	P-value
Dressing not independent	130 (25.1)	107 (20.4)	0.07
Bowel incontinence	13 (2.5)	21 (4.0)	0.18
Urine incontinence	22 (4.3)	31 (6.0)	0.23
Feeding not independent	38 (7.4)	44 (8.4)	0.54
<i>Hospital and admission characteristics</i>			
Hospital (tertiary-care)	238 (42.4)	239 (41.2)	0.75
Admitted from:			0.58
Home	404 (79.2)	407 (77.8)	
Nursing home	25 (4.9)	27 (5.2)	
Rehabilitation center	5 (1.0)	2 (0.4)	
Other	76 (14.9)	87 (16.6)	
Admitting service			0.14
Medicine	33 (5.9)	37 (6.4)	
Surgery	518 (92.3)	519 (90.1)	
Obstetrics-gynecology	6 (1.1)	1 (1.0)	
Other	4 (0.7)	14 (2.4)	
<i>Surgery data</i>			
Preoperative length of hospitalization-days, median (IQR)	1 (0-3)	1 (0-2)	0.0005
Procedures			
Coronary artery bypass graft	170 (30.3)	171 (29.7)	0.82
Orthopedic	168 (30.0)	169 (29.3)	0.82
Insertion of hip prosthesis	35 (6.2)	39 (6.8)	
Insertion of knee prosthesis	20 (3.6)	19 (3.3)	
Repeat procedure at same operative site	53 (10.0)	39 (7.1)	0.09
Operative procedure > 75 th percentile	160 (28.9)	133 (23.3)	0.03
Wound class > 2	39 (7.0)	27 (4.7)	0.10
ASA score ≥ 3	446 (80.1)	409 (71.3)	0.0006
Serum glucose > 200 mg/dL	177 (43.1)	166 (42.4)	0.84
Antimicrobial prophylaxis administered appropriately	329 (68.3)	350 (70.4)	0.46
Surgery on day of admission	221 (39.5)	276 (48.4)	0.002

* All percentages were calculated using denominators that excluded missing data. Data were missing for the following variables: Caucasian (7 cases, 12 controls), insurance (24 cases, 30 controls), McCabe score on admission of 1 (33 cases, 43 controls), BMI (72 cases, 86 controls), use of immunosuppressive medications (43 cases, 54 controls), ambulation, bathing and dressing (42 cases, 51 controls), feeding (47 cases, 53 controls), bowel incontinence (50 cases, 56 controls), and urinary incontinence (49 cases, 56 controls).

Unadjusted and adjusted outcomes data for 561 Elderly (Aged ≥ 65) Cases with Surgical Site Infection (SSI) and 576 Elderly Controls without SSI

Table 2

	Unadjusted outcomes			Adjusted outcomes	
	Cases N=561 n (%)	Controls N=576 n (%)	OR* (95% CI)	p-value	OR* (95% CI) Attributable to SSI (95% CI)
Dead within 90 days of procedure	86 (15.3)	30 (5.2)	3.30 (2.14-5.08)	<0.0001	3.51 (2.20, 5.59)
Total post-procedure length of hospitalization (days) - median (IQR) for unadjusted days and OR* for adjusted days**	19 (11-32)	5 (4-9)		<0.0001	Mean of 15.7 days (13.9, 17.6)
Hospital charges ⁺ , median (IQR)	N=272 69,768 (28,561-127,280)	N=259 28,644 (13,254-60,612)	-	<0.0001	
Hospital charges ⁺ , mean SD for unadjusted charges and OR* for adjusted charges ⁺⁺	94,564 $\pm$ 101,819	44,080 $\pm$ 49,904	-	<0.0001	Mean of \$43,970 (31,881, 56,060)

* OR represents multiplicative effect for length of stay and hospital charges

** Adjusted for age, Charlson score, McCabe score, BMI, admission to a tertiary care hospital, admission from home, undergoing coronary artery bypass graft procedure, operative time, and post-operative serum glucose

⁺ Hospital charge data only includes patients who underwent surgical procedures on or after January 1, 1998. Charge data include the index admission and readmissions within 90 days of the surgical procedure. Charges were normalized to year 2003 by adjusting for inflation at a rate of 0.03% per year. Charge data were unavailable for 10 cases and 27 controls.

⁺⁺ Adjusted for McCabe score, BMI, independence with activities of daily living, surgical procedure on day of admission, operative time, wound class, ASA score, and post-operative serum glucose.

Table 3Bivariate predictors of mortality ($p \leq 0.05$) among operative patients ≥ 65 years old

	Dead at 90 days N=116 n(%)*	Alive at 90 days N=1021 n(%)*	P-value
<i>Surgical Site Infection</i>	86 (74.1)	475 (46.5)	P<0.001
<i>Demographics</i>			
Age (mean, STD)	75.9 $\pm$ 7.4	74.2 $\pm$ 6.5	0.001
Insurance Status			
Medicare	110 (100)	934 (96.0)	0.03
<i>Comorbid conditions</i>			
Charlson Score - median (IQR)	2 (1-4)	1 (0-3)	<0.001
Charlson ≥ 3	40 (34.5)	159 (15.6)	<0.001
McCabe at admission - median (IQR)	2 (2-3)	3 (2-3)	<0.001
McCabe score on admission of 1	12 (10.3)	46 (4.5)	0.007
Diabetes	36 (31.0)	235 (23.0)	0.05
Congestive heart failure	45 (38.8)	176 (17.2)	<0.001
Cerebrovascular disease	18 (15.5)	78 (7.6)	0.004
Chronic obstructive pulmonary disease	32 (27.6)	127 (12.4)	<0.001
Renal disease	20 (17.2)	51 (5.0)	<0.001
Metastatic cancer	6 (5.2)	19 (1.9)	0.02
<i>Preoperative functional status</i>			
Ambulation not independent	52 (48.2)	279 (29.8)	<0.001
Bathing not independent	49 (45.4)	191 (20.4)	<0.001
Dressing not independent	50 (46.3)	187 (20.0)	<0.001
Bowel incontinence	7 (6.7)	27 (2.9)	0.04
Urine incontinence	11 (10.4)	42 (4.5)	0.01
Feeding not independent	21 (19.8)	61 (6.6)	<0.001
<i>Hospital and admission characteristics</i>			
Admitted from:			<0.001
Home	65 (65.0)	746 (80.0)	
Nursing home	14 (14.0)	38 (4.1)	
Rehabilitation center	2 (2.0)	5 (0.5)	
Other	19 (19.0)	144 (15.4)	
<i>Surgery data</i>			
Preoperative length of hospitalization-days, median (IQR)	2 (0-5)	1 (0-2)	<0.0001
Procedures			
Orthopedic	20 (17.2)	317 (31.1)	0.002
Wound class > 2	12 (10.3)	54 (5.3)	0.03
ASA score ≥ 3	111 (95.7)	744 (73.3)	<0.001
Surgery on day of admission	30 (26.1.4)	467 (46.0)	<0.001

* All percentages were calculated using denominators that excluded missing data. Data were missing for the following variables (patients who were dead by day 90, patients who were alive by day 90): Caucasian (1, 18), insurance (6, 48), McCabe score on admission of 1 (8, 68), BMI (23, 135), use of immunosuppressive medications (8, 89), ambulation, bathing and dressing (8, 85), feeding (10, 95), bowel incontinence (11, 95), and urinary incontinence (10, 95).

Table 4

Bivariate predictors of duration of postoperative length of hospital stay ($p \leq 0.05$) among operative patients ≥ 65 years old

	<i>Median * postoperative length of stay for patients with variable (Interquartile range[IQR])</i>	<i>Median * postoperative length of stay for patients without variable (Interquartile range[IQR])</i>	<i>P-value</i>
<i>Surgical Site Infection</i>	19 (11-32)	5.0 (4-9)	<0.001
<i>Demographics</i>			
Insurance Status			
Medicare	10 (5-22)	5 (4-11)	0.008
<i>Comorbid conditions</i>			
Charlson ≥ 3	15 (7-27)	9 (5-20)	<0.001
McCabe score of 1 on admission	18 (11-31)	10 (5-21)	<0.001
BMI > 30	12 (6-23)	9 (5-21)	0.004
Diabetes	12 (5-26)	9 (5-20)	0.007
Myocardial infarction	12 (6-24)	9 (5-21)	0.005
Congestive heart failure	16(7-29)	9 (5-19)	<0.001
Peripheral vascular disease	13(6-25)	9 (5-21)	0.002
Chronic obstructive pulmonary disease	15(6-31)	9 (5-20)	<0.001
Arthritis	8(5-19)	11 (5-23)	0.02
Peptic ulcer disease	11(6-23)	10 (5-21)	0.04
Renal disease	21(8-38)	10 (5-20)	<0.001
Metastatic cancer	18(9-27)	10 (5-21)	0.02
<i>Preoperative functional status</i>			
Ambulation not independent	12(6-24)	9 (5-19)	0.006
Bathing not independent	13(6-25)	9 (5-19)	<0.001
Dressing not independent	13(6-25)	9 (5-19)	<0.001
Feeding not independent	14(7-24)	10 (5-21)	0.02
<i>Hospital and admission characteristics</i>			
Hospital (Tertiary-care)	10(5-25)	10 (5-19)	0.02
Admitted from home	9(5-19)	12 (6-26)	<0.0001
<i>Admission to the hospital on the same day of admission Surgery data</i>	15(7-28)	8 (4-16)	<0.001
<i>Procedures</i>			
Coronary artery bypass graft	12(6-27.5)	9 (4-19)	<0.001
Orthopedic	7(4-15)	11 (5-24)	<0.001
Operative procedure $> 75^{\text{th}}$ percentile	13(7-28)	9 (5-19)	<0.001
Wound Class >2	20(10.5-27.5)	9.5 (5-21)	<0.001
ASA score ≥ 3	12(5-24)	7 (3-12)	<0.001

	<i>Median* postoperative length of stay for patients with variable (Interquartile range[IQR])</i>	<i>Median* postoperative length of stay for patients without variable (Interquartile range[IQR])</i>	<i>P-value</i>
Serum glucose > 200 mg/dL	13(7-27)	11 (5-23)	0.001
Surgery on day of admission	7(3-13)	13 (7-27)	<0.001

* All medians were calculated after excluding missing data. Data were missing for the following variables: medicare status (9), Charlson score >3 (15), McCabe score on admission of 1 (10), BMI (6), comorbidities (15), use of immunosuppressive medications (7), ambulation, bathing, dressing and feeding (7), source of admission (15), admission to the hospital on the same day of admission (15), type of surgery (15), wound class >2 (15), ASA class ≥ 3 (15), operative procedure > 75th percentile (15), post-operative serum glucose > 200 mg/dL (2).

Table 5Bivariate predictors of hospital charges ($p \leq 0.05$) among operative patients ≥ 65 years old ($n = 531$)

	Median * total charges for patients with variable (Interquartile range [IQR])	Median * total charges for patients without variable (IQR)	P-value
Demographics			
Gender (male)	55,622 (24,000-98,775)	38,563 (16,357-79,001)	0.004
Insurance Status			
Medicare	47,477 (19,082-90,614)	24,102 (12,924-45,114)	0.02
Comorbid conditions			
Charlson ≥ 3	68,546 (24,204-103,677)	44,056 (17,374-81,781)	0.003
McCabe score on admission of 1	131,583 (83,012-150,087)	44,444 (17,756-84,971)	<0.001
BMI > 30	54,449 (22,384-102,154)	46,018 (17,101-82,014)	0.03
Diabetes	54,017 (19,982-105,148)	44,865 (18,232-83,012)	0.03
Myocardial infarction	71,702 (38,058-111,984)	41,210 (17,060-81,408)	<0.001
Congestive heart failure	87,788 (44,034-146,072)	39,003 (15,851-75,590)	<0.001
Dementia	14,338 (7,741-42,956)	48,230 (19,660-91,787)	0.003
Chronic obstructive pulmonary disease	70,145 (25,737-128,181)	44,268 (17,262-82,696)	0.003
Arthritis	36,559 (17,988-68,546)	53,023 (19,413-98,775)	0.005
Renal disease	83,401 (44,517-144,596)	45,251 (17,886-84,971)	0.005
Hospital and admission characteristics			
Hospital (Tertiary-care)	78,294 (50,706-128,716)	20,577 (10,543-46,530)	<0.001
Admitted from home	36,227 (15,754-77,100)	78,356 (47,376-121,141)	<0.001
Preoperative length of stay <1	83,401 (51,964-120,404)	31,258 (14,338-65,523)	<0.001
Surgery data			
Procedures			
Coronary artery bypass graft	92,135 (60,103-136,512)	25,737 (13,254-61,358)	<0.001
Orthopedic	28,681 (17,020-59,086)	59,058 (21,078-104,212)	<0.001
Operative procedure $> 75^{\text{th}}$ percentile	79,183 (50,471-128,716)	33,222 (13,798-70,145)	<0.001
ASA score ≥ 3	57,807 (24,615-100,162)	20,148 (8,379-39,354)	<0.001
Serum glucose > 200 mg/dL	81,788 (48,236-128,715)	50,708 (25,202-89,751)	<0.001
Antimicrobial prophylaxis administered appropriately	53,614 (24,615-95,033)	32,304 (12,530-84,701)	0.004
Surgery on day of admission	25,737 (12,614-57,344)	77,647 (41,736-117,049)	<0.001

* All medians were calculated after excluding missing data. Data were missing for the following variables: male (37), medicare (35), Charlson score ≥ 3 (37), immunosuppressant use (34), McCabe score on admission of 1 (35), BMI > 30 (33), comorbidities (37), ambulation, bathing, dressing and feeding (34), source of admission (37), admission to the hospital on the same day of surgery (37), type of surgery (37), wound class > 2 (37), ASA class ≥ 3 (34), operative procedure $> 75^{\text{th}}$ percentile (37), post-operative serum glucose > 200 mg/dL (12), preoperative antibiotics (33) and same day surgery (36).