SURGICAL-SITE INFECTION DUE TO *STAPHYLOCOCCUS AUREUS* AMONG ELDERLY PATIENTS: MORTALITY, DURATION OF HOSPITALIZATION, AND COST

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ABSTRACT

OBJECTIVES: To examine the impact of surgical-site infection (SSI) due to *Staphylococcus aureus* on mortality, duration of hospitalization, and hospital charges among elderly surgical patients and the impact of older age on these outcomes by comparing older and younger patients with *S. aureus* SSI.

DESIGN: A nested cohort study.

SETTING: A 750-bed, tertiary-care hospital and a 350-bed community hospital.

PATIENTS: Ninety-six elderly patients (70 years and older) with *S. aureus* SSI were compared with 2 reference groups: 59 uninfected elderly patients and 131 younger patients with *S. aureus* SSI.

RESULTS: Compared with uninfected elderly patients, elderly patients with *S. aureus* SSI were at risk for increased mortality (odds ratio [OR], 5.4; 95% confidence interval [CI_{95}], 1.5–20.1), postoperative hospital-days (2.5-fold increase; CI_{95}, 2.0–3.1), and hospital charges (2.0-fold increase; CI_{95}, 1.7–2.4; $41,117 mean attributable charges per SSI). Compared with younger patients with *S. aureus* SSI, elderly patients had increased mortality (adjusted OR, 2.9; CI_{95}, 1.1–7.6), hospital-days (9 vs 13 days; $P = .001$), and median hospital charges ($45,767 vs $85,648; $P < .001$).

CONCLUSIONS: Among elderly surgical patients, *S. aureus* SSI was independently associated with increased mortality, hospital-days, and cost. In addition, being at least 70 years old was a predictor of death in patients with *S. aureus* SSI (*Infect Control Hosp Epidemiol* 2004;25:461-467).

Elderly individuals are at risk for nosocomial infections due to immunosenescence, poor nutrition, multiple comorbidities, and impaired wound healing.[1] Of all nosocomial infections among patients 65 years and older, 11% are surgical-site infections (SSIs).[2] The most common cause of SSI is *Staphylococcus aureus*.[3,4] Although common and potentially serious, there is little information available on the impact of SSI due to *S. aureus* on clinical and fiscal outcomes such as mortality, duration of hospitalization, and healthcare costs in elderly adults.

SSI due to *S. aureus* may negatively impact these outcomes in elderly patients, and the impact may be worse in elderly patients compared with younger patients. An estimated 9,700 SSI-related deaths occur annually, with 3,250 being directly attributable to SSI,[5] and an average SSI can account for up to an additional 10 hospital-days and $3,150 in hospital costs.[5,6] Recent studies reported strong associations between methicillin-resistant *S. aureus* (MRSA) SSI and adverse clinical outcomes.[7,8] Compared with surgical patients without SSI, patients with SSI due to MRSA had an 11-fold increased risk for mortality, more than 13 additional hospital-days, and $41,000 in additional hospital charges.[7,8] Elderly individuals may be at risk for worse outcomes attributable to SSI because they are particularly susceptible to infection, have more comorbidities, and have more cognitive and functional disabilities than younger individuals. The objectives of this study were to examine (1) the impact of SSI due to *S. aureus* on mortality, duration of hospitalization, and hospital charges in elderly surgical patients by comparing elderly patients with and without SSI due to *S. aureus* and (2) the impact of older age on these outcomes by comparing older and younger patients with *S. aureus* SSI.

METHODS

Patients and Hospital Settings

This was a nested cohort study. The study population was derived from a previously described patient

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Supported by a fellowship from the Agency for Healthcare Research and Quality to Dr. Engemann; a Mid-Career Award in Patient-Oriented Research from the National Institute of Allergy and Infectious Diseases (K24-AI-51324-01) and the Durham VAMC GRECC to Dr. Schmader; and a Young Investigator Award from the Infectious Diseases Society of America, the Association of Subspecialty Professors, the John A. Hartford Foundation, and Elan Pharmaceuticals to Dr. Kaye.

The authors thank the following infection control practitioners at Duke University Medical Center and Durham Regional Hospital for their surveillance work: Mary Oden, Melissa Bronstein, Jennifer Macfarquar, Jane Briggs, and Sharon Trivette. They also thank Amy Mitchell for her assistance in the preparation of the manuscript.

cohort and included patients with confirmed SSI due to *S. aureus* and uninfected reference patients or control-patients.[8] Patients were prospectively identified from a database containing data on patients undergoing surgery from January 1, 1994, through November 30, 2000. All SSIs were identified by infection control practitioners, using Centers for Disease Control and Prevention definitions.[9] Information regarding the identification of organisms and antimicrobial susceptibility results was provided by the clinical microbiology laboratory at each hospital. *S. aureus* isolates were determined by the identification of coagulase-positive and catalase-positive, gram-positive cocci. The presence of methicillin resistance was confirmed by lack of inhibition of growth by an oxacillin disk on mannitol salt agar.[10] SSIs classified as superficial following cardiothoracic procedures were excluded.

Three patient groups were studied: (1) elderly patients (70 years or older) with SSI due to *S. aureus*, (2) younger patients (18 to 60 years old) with SSI due to *S. aureus*, and (3) elderly surgical patients without SSI. Patients between 60 and 70 years old were excluded to allow for more distinct age separation of the patient groups. Differences in the distribution of surgical procedures among the patient groups were controlled for in multivariate analyses.

The two study hospitals were Duke University Medical Center, a 750-bed, tertiary-care hospital, and Durham Regional Medical Center, a 350-bed community hospital. Each had an active infection control surveillance program and used standard National Nosocomial Infections Surveillance (NNIS) System criteria for identifying SSI.[9] The study received full approval from the Duke University Medical Center and Durham Regional Hospital institutional review boards.

Variables

Outcome variables were 90-day mortality (inhospital and outpatient), total hospital-days (including re-admissions), and hospital charges. For hospital charges, the reference year was 2000 and prior charges were discounted at a 3% annual rate. Actual costs were not available and charges were used as a surrogate for cost. Hospital re-admissions during the 90-day postoperative period were included in the analysis.

The following data were collected prospectively from infection control databases: patient demographics, type of surgical procedure, NNIS System risk index score,[11] American Society of Anesthesiologists (ASA) score,[12] duration of surgery, and wound class. For patients with SSI, the type of infecting organism, site of isolation, and culture date (ie, infection date) were also recorded. Additional data collected retrospectively from hospital databases included comorbid illnesses (determined by the codes of the International Classification of Diseases, ninth revision [ICD-9]) and admission to the intensive care unit (ICU). The presence of diabetes mellitus was also determined by the presence of charges for insulin and glucometers during hospitalization. The Charlson score was calculated for each study subject using ICD-9 codes.[13] For the 90-day postoperative period, total hospital-days and 90-day inpatient mortality were obtained from the admission–discharge–transfer database and from patient charts. Mortality, including out-of-hospital death, was also determined through the U.S. Social Security Death Index.[14] Hospital charges were obtained from the hospital financial databases.

Statistical Analysis

Statistical analysis was performed using SAS software (version 8.1; SAS Institute, Inc., Cary, NC). Two comparisons were studied: (1) elderly patients who developed SSI due to *S. aureus* versus uninfected patients and (2) elderly patients with SSI due to *S. aureus* versus infected younger patients. Continuous variables were compared in bivariate analysis by using the Wilcoxon rank sum test or Student's *t* test; dichotomous and ordinal variables were compared using the chi-square or Fisher's exact test.

The independent impact of SSI due to *S. aureus* on elderly surgical patients and of older age (70 years or older) on patients with SSI due to *S. aureus* were assessed by multivariate analysis for mortality, hospital-days, and hospital charges. Risk models for mortality were developed using logistic regression. Linear regression (after log transformation) was used to develop risk models for hospital charges and hospital-days. The inverse log value was calculated for beta coefficients of variables included in the predictor models, and these effect measures were described as multiplicative effects on length of stay and cost and odds ratio (OR) for mortality. Variables with a *P* value of .2 or less on bivariate analysis were included as candidate variables for the multivariate models. Models were derived using a stepwise selection procedure and only variables with an adjusted *P* value of .05 or less were included in the final models. Predictors in derived models were checked for confounding and co-linearity. If the addition of a confounding variable affected the beta coefficient for the effect measure of a candidate variable by more than 10%, the confounding variable was included in the model. For analyses restricted to patients with SSI due to *S. aureus*, age of 70 years or older was forced into final risk models if it was not selected using the stepwise procedure. All tests were two-tailed, and a *P* value of .05 or less was considered statistically significant.

Adjusted mean attributable outcomes per SSI were calculated for total hospital-days and charges. The following formula is an example of how adjusted mean attributable outcomes were determined for charges, comparing elderly patients with SSI due to *S. aureus* with uninfected elderly patients: mean attributable charges per SSI = ([mean charges for uninfected patients] × [inverse log of beta coefficient for adjusted SSI variable]) - (mean charges for uninfected patients).

RESULTS

A total of 286 patients was studied: 96 elderly and 131 younger patients had SSI due to *S. aureus* and 59

TABLE 1
CHARACTERISTICS OF THE STUDY PATIENTS

Characteristic	Elderly With SSI Due to *Staphylococcus aureus* (n = 96)	Uninfected Elderly (n = 59)	*P*, Elderly With SSI Due to *S. aureus* vs Uninfected Elderly	Younger With SSI Due to *S. aureus* (n = 131)	*P*, Elderly With SSI Due to *S. aureus* vs Younger With SSI Due to *S. aureus*
Mean age, y (± SD)	75.5 (± 4.9)	75.8 (± 4.4)	.43	45.9 (± 11.0)	< .001
Male	37 (38.5%)	24 (40.7%)	.87	70 (53.4%)	.03
Surgical procedure					
Cardiothoracic	52 (54.2%)	28 (47.5%)	.52	38 (29.0%)	< .001
Orthopedic	25 (26.0%)	15 (25.4%)	.92	52 (39.7%)	.05
Neurosurgical	8 (8.3%)	7 (11.9%)	.66	16 (12.2%)	.47
Vascular	4 (4.2%)	1 (1.7%)	.65	5 (3.8%)	1.0
Obstetric/gynecologic	4 (4.2%)	1 (1.7%)	.65	8 (6.1%)	.73
Gastrointestinal	3 (3.1%)	7 (11.9%)	.04	12 (9.2%)	.12
Comorbid condition*					
Diabetes	45 (46.9%)	24 (40.7%)	.51	43 (32.8%)	.04
Lung disease	20 (20.8%)	10 (17.0%)	.68	14 (10.7%)	.04
Renal disease	12 (12.5%)	3 (5.1%)	.17	9 (6.9%)	.17
Hypertension	58 (60.4%)	26 (44.1%)	.07	48 (36.6%)	< .001
Tobacco use	8 (8.3%)	3 (5.1%)	.53	24 (18.3%)	.04
Alcohol use	2 (2.1%)	0	.52	5 (3.8%)	.70
Peripheral vascular disease	9 (9.4%)	2 (3.4%)	.21	8 (6.1%)	.63
Obesity	6 (6.3%)	4 (6.8%)	1.00	15 (11.5%)	.25
Malignancy	15 (15.6%)	8 (13.6%)	.82	8 (6.1%)	.03
Liver disease	1 (1.0%)	0	1.00	4 (3.1%)	.40
Hematologic disorder	0	0	-	3 (2.3%)	.26
Rheumatologic disorder	2 (2.1%)	2 (3.4%)	.64	7 (5.3%)	.31
Median Charlson score (IQR)	3 (1 to 4)	1 (0 to 3)	.02	1 (0 to 3)	< .001
Methicillin-resistant *S. aureus* SSI	57 (59.4%)	0	NA	41 (31.3%)	< .001
Received care at Duke University Medical Center	73 (76.0%)	38 (64.4%)	.14	78 (59.5%)	.01
Median ASA score (IQR)	4 (3 to 4)	3 (3 to 4)	.07	3 (2 to 4)	< .001
Median operative duration, min (IQR)	222 (147 to 288)	194 (124 to 295)	.47	192 (113 to 286)	.14
Median wound class (IQR)	1 (1 to 1)	1 (1 to 1)	.07	1 (1 to 1)	.03
Median NNIS System risk index score (IQR)	1 (1 to 2)	1 (1 to 2)	.27	1 (1 to 2)	.31
Median no. of hospital-days before surgery (IQR)	1 (0 to 4)	1 (0 to 4)	.37	0 (0 to 1)	< .001
Median length of stay prior to infection, d (IQR)	8 (4 to 13)	NA	NA	5 (2 to 9)	< .001
No. of patients with ICU stay before surgery	8 (8.3%)	7 (11.9%)	.58	9 (6.9%)	.80
Median no. of ICU-days before surgery (IQR)	0 (0 to 0)	0 (0 to 0)	.43	0 (0 to 0)	.74
Median no. of ICU-days prior to infection (IQR)	1 (0 to 2)	NA	NA	0 (0 to 1)	.002

SSI = surgical-site infection; SD = standard deviation; IQR = interquartile range; ASA = American Society of Anesthesiologists; NA = not available; NNIS = National Nosocomial Infections Surveillance; ICU = intensive care unit.
*Determined by the codes of the International Classification of Diseases, ninth revision.

elderly patients were uninfected. The reason for the smaller number of uninfected control-patients was related to the nested cohort study design. In the original cohort,[8] selection criteria for uninfected patients were not based on age. The two most common operative procedures performed were cardiothoracic (n = 118, 41%) and orthopedic (n = 92, 32%) (Table 1). The distributions of the types of procedures among the three patient groups were similar, although more uninfected elderly patients had gastrointestinal procedures, more elderly patients with SSIs had cardiothoracic procedures, and more young patients with SSIs had orthopedic procedures (Table 1).

TABLE 2
NINETY-DAY POSTOPERATIVE MORTALITY, HOSPITAL-DAYS, AND HOSPITAL CHARGES, UNADJUSTED, BY PATIENT GROUP

	Elderly With SSI Due to *S. aureus* (n = 96)	Uninfected Elderly (n = 59)	*P*, Elderly With SSI Due to *S. aureus* vs Uninfected Elderly	Younger With SSI Due to *S. aureus* (n = 131)	*P*, Elderly With SSI Due to *S. aureus* vs Younger With SSI Due to *S. aureus*
90-day postoperative mortality	21 (21.9%)	3 (5.1%)	.005*	7 (5.3%)	< .001†
Median total hospital-days after surgery (mean; IQR)	22 (25.2; 12 to 35)	7 (8.0; 4 to 10)	< .001	14 (19.7; 7 to 25)	< .001
Median hospital-days after infection (mean; IQR)	13 (18.0; 7 to 24)	NA	NA	9 (14.7; 3 to 17)	.001
Median hospital charges (mean; IQR)	$85,648 ($98,131; $40,038 to $132,502)	$32,023 ($41,117; $18,582 to $55,071)	< .001	$45,767 ($78,127; $23,048 to $91,107)	< .001

SSI = surgical-site infection; IQR = interquartile range; NA = not available.
*Odds ratio (OR), 5.2; 95% confidence interval (CI_{95}), 1.5 to 18.4.
†OR, 5.0; CI_{95}, 2.0 to 12.2.

Elderly Patients With SSI Due to S. aureus *Compared With Uninfected Elderly Patients*

Patient demographics and characteristics are listed in Table 1. There were no statistically significant differences between infected and uninfected elderly patients.

Mortality

Twenty-two percent (n = 21) of the elderly patients with *S. aureus* SSI died during the 90-day postoperative period compared with only 5.1% (n = 3) of the uninfected elderly patients (OR, 5.2; 95% confidence interval [CI_{95}], 1.5 to 18.4; P = .005) (Table 2). Age, ASA score, and Charlson score were significant predictors of death. Elderly patients with SSI due to *S. aureus* remained at increased risk for 90-day mortality compared with uninfected elderly patients on multivariate analysis, after adjustment for ASA score greater than 3 and age older than 80 years (OR, 5.4; CI_{95}, 1.5 to 20.1; P = .01) (Table 3).

Hospital-Days

Uninfected elderly patients had significantly fewer hospital-days after surgery (median, 7) than did elderly patients with SSI due to *S. aureus* (median, 22; P < .001) (Table 2). The following variables were associated with increased postoperative hospital-days: diabetes, renal disease, hypertension, Charlson score, receiving care at Duke University Medical Center, ASA score, duration of surgery, and hospital-days before surgery. After diabetes, renal disease, pulmonary disease, malignancy, ASA score greater than 3, hospital-days before surgery, and receiving care at Duke University Medical Center were controlled for, there was a significant association between SSI due to *S. aureus* and an increase in total hospital-days on multivariate analysis (2.5-fold increase, P < .001) (Table 3). The mean attributable increase in postoperative hospital-days was 12 days per SSI due to *S. aureus* among elderly patients.

Hospital Charges

Median hospital charges were approximately $50,000 greater among the elderly patients with SSI due to *S. aureus* (median, $85,648; interquartile range [IQR], $40,038 to $132,502) than the elderly patients without SSI (median, $32,023; IQR, $18,582 to $55,071; P < .001). Other predictors of increased hospital charges were diabetes, lung disease, renal disease, hypertension, malignancy, rheumatologic disease, Charlson score, receiving care at Duke University Medical Center, ASA score, duration of surgery, wound class, hospital-days before surgery, and duration of ICU stay before surgery. The results of the multivariate analysis for hospital charges are provided in Table 3. Among elderly patients, after adjusting for diabetes, renal disease, rheumatologic disorder, malignancy, ASA score greater than 3, duration of surgery, duration of hospital stay before surgery, and receiving care at Duke University Medical Center, SSI due to *S. aureus* was significantly associated with a 2.0-fold increase in median hospital charges (P < .001). The mean attributable charge per SSI due to *S. aureus* among elderly patients was $41,117. These findings were unchanged when patients who died were excluded from the analysis.

Elderly Patients With SSI Due to S. aureus *Versus Younger Patients With SSI*

Elderly patients with SSI due to *S. aureus* were less likely to be male (38.5% vs 53.4%; P = .03) and to use

TABLE 3
MULTIVARIATE MODELS FOR MORTALITY, TOTAL HOSPITAL-DAYS, AND HOSPITAL CHARGES: ELDERLY PATIENTS WITH SURGICAL-SITE INFECTION DUE TO *STAPHYLOCOCCUS AUREUS* COMPARED WITH UNINFECTED ELDERLY PATIENTS

Outcome	OR* (CI_{95}) for SSI in Elderly vs Uninfected	Attributable to SSI Due to *S. aureus*, Mean	*P*
Mortality†	5.4 (1.5 to 20.1)	-	.01
Total hospital-days after surgery‡	2.5 (2.0 to 3.1)	12	< .001
Hospital charges§	2.0 (1.7 to 2.4)	$41,117	< .001

OR = odds ratio; CI_{95} = 95% confidence interval; SSI = surgical-site infection.
*Odds ratio for mortality; multiplicative effect for total hospital-days after surgery and hospital charges.
†Other variable in the model was age > 80 years; controlled for American Society of Anesthesiologists (ASA) score > 3.
‡Other variables in the model were diabetes, renal disease, ASA score > 3, and hospital stay before surgery; controlled for pulmonary disease, malignancy, and receiving care at Duke University Medical Center .
§Other variables in the model were diabetes, renal disease, ASA score > 3, duration of surgery, hospital stay prior to surgery, and receiving care at Duke University Medical Center; controlled for rheumatologic disorder and malignancy.

TABLE 4
MULTIVARIATE MODELS FOR MORTALITY, TOTAL HOSPITAL-DAYS, AND HOSPITAL CHARGES: ELDERLY PATIENTS WITH SURGICAL-SITE INFECTION DUE TO *STAPHYLOCOCCUS AUREUS* COMPARED WITH INFECTED YOUNGER PATIENTS

Outcome	OR* (CI_{95}) for Age of at Least 70 Years Compared With Age of 18 to 60 Years	Attributable to Age of at Least 70 Years, Mean	*P*
Mortality†	2.9 (1.1 to 7.6)	-	.03
Total hospital-days after infection‡	1.1 (0.9 to 1.4)	0.9	.45
Hospital charges§	1.1 (0.9 to 1.3)	$2,746	.54

OR = odds ratio; CI_{95} = 95% confidence interval.
*Odds ratio for binary outcomes; multiplicative effect for continuous outcomes (length of stay and cost).
†Other variable in the model was American Society of Anesthesiologists (ASA) score of 3 or higher; controlled for cardiothoracic surgery and methicillin-resistant *S. aureus* SSI.
‡Other variables in the model were renal disease, ASA score of 3 or higher, hospital stay of at least 10 days before infection, and duration of surgery more than 200 minutes; controlled for gender, diabetes, duration of intensive care unit stay before infection, and receiving care at Duke University Medical Center.
§Other variables in the model were diabetes, renal disease, ASA score of 3 or higher, hospital stay of at least 10 days before infection, duration of intensive care unit stay more than 5 days before infection, duration of surgery more than 200 minutes, and receiving care at Duke University Medical Center; controlled for cardiothoracic surgery.

tobacco (8.3% vs 18.3%; $P = .04$) and more likely to have diabetes (46.9% vs 32.8%; $P = .04$), lung disease (20.8% vs 10.7%; $P = .04$), hypertension (60.4% vs 36.6%; $P < .001$), malignancy (15.6% vs 6.1%; $P = .03$), and MRSA infection (59.4% vs 31.3%; $P < .001$) and to have received care at Duke University Medical Center (76.0% vs 59.5%; $P = .01$) than were infected younger patients (Table 1). The ASA scores were higher (median values, 4 vs 3; $P < .001$) and wound classes were greater ($P = .03$) for infected elderly patients. Additionally, the median number of hospital-days and ICU-days prior to infection was higher among elderly patients with SSI due to *S. aureus* (8 days: IQR, 4 to 13 days; 1 day: IQR, 0 to 2 days, respectively), compared with younger patients (5 days: IQR, 2 to 9 days, $P < .001$; 0 days: IQR, 0 to 1 day, $P = .002$).

Mortality

Seven younger patients with SSI due to *S. aureus* (5.3%) died within the 90-day postoperative period, whereas 21 infected elderly patients (21.9%) died during the same period (OR, 5.0; CI_{95}, 2.0 to 12.2; $P < .001$) (Table 2). Other significant predictors of death in infected elderly patients included lung disease, Charlson score, SSI caused by MRSA, ASA score, NNIS System risk index score, hospital-days before infection, and ICU-days before infection. In a multivariate model, elderly patients with SSI were at a significantly increased risk for death compared with younger patients with SSI (OR, 2.9; CI_{95}, 1.1 to 7.6; $P = .03$) (Table 4). The model included ASA scores of 3 and higher, and was controlled for the confounding effects of cardiothoracic surgery and SSI caused by MRSA.

Hospital-Days

Younger infected patients had fewer hospital-days after infection (median, 9 days; IQR, 3 to 17 days) than did infected elderly patients (median, 13 days; IQR, 7 to 24 days; $P = .001$) (Table 2). Other predictors for total hospital-days after infection were diabetes, lung disease, renal disease, hypertension, Charlson score, receiving care at Duke University Medical Center, SSI caused by MRSA, ASA score, duration of surgery, NNIS System risk index score, number of hospital-days before surgery and infection, and number of ICU-days prior to surgery and infection. There was not a significant association between increased total hospital-days after infection and being 70 years or older on multivariate analysis (1.1-fold increase, $P = .45$) (Table 4). Significant predictors identified on multivariate analysis included renal disease, ASA scores of 3 and higher, duration of surgery more than 200 minutes, and hospital stay of at least 10 days before infection. The model was controlled for the confounding effects of gender, diabetes, duration of ICU stay before infection, and receiving care at Duke University Medical Center.

Hospital Charges

Elderly patients with SSI due to *S. aureus* had significantly higher 90-day postoperative hospital charges (median, $85,648; IQR, $40,038 to $132,502) than did infected younger patients (median, $45,767; IQR, $23,048 to $91,107; $P < .001$) (Table 2). Other predictors of increased hospital charges included the presence of diabetes, lung, renal, and peripheral vascular disease, hypertension, Charlson score, receiving care at Duke University Medical Center, SSI caused by MRSA, ASA score, duration of surgery, NNIS System risk index score, number of ICU-days prior to infection, and length

of stay from admission to infection. On multivariate analysis, there was not a significant association between being 70 years or older and increased hospital charges (1.1-fold increase, $P = .54$) (Table 4). Independent predictors of increased charges included diabetes, renal disease, ASA score of 3 or greater, hospital stay of at least 10 days before infection, ICU stay of more than 5 days before infection, duration of surgery of more than 200 minutes, and receiving care at Duke University Medical Center. The model was controlled for the confounding effect of cardiothoracic surgery. These findings were unchanged when patients who died were excluded from the analysis.

DISCUSSION

This study specifically addressed clinical and fiscal outcomes among elderly patients with SSI due to *S. aureus*. We used two statistical models involving comparisons among three patient groups to examine the impact of SSI due to *S. aureus* on the outcomes of elderly patients and the impact of age on clinical outcomes of patients with SSI. The results of these analyses are complementary and demonstrate a significant adverse impact of SSI on elderly surgical patients.

Among elderly patients, SSI due to *S. aureus* was independently associated with a greater than 5-fold increase in mortality, a mean attributable excess of more than 12 hospital-days per SSI, and mean attributable excess costs of more than $40,000 per SSI. Kirkland et al. reported similar results among adults of all ages undergoing surgery: SSI due to any organism was associated with adverse outcomes, albeit of lesser magnitude than in the current study.[15] In the study by Kirkland et al., SSI was associated with a 2-fold increase in mortality, a mean excess of 6.5 hospital-days per SSI, and mean attributable excess costs of $3,089 per SSI.[15] The effects of age and *S. aureus* as an infecting organism were not specifically studied.

Investigators have examined the impact of age on clinical outcomes for bacteremia due to *S. aureus* infections and on other nosocomial infections.[16,17] To the best of our knowledge, no prior studies have analyzed the impact of older age on the clinical and fiscal outcomes of patients with SSIs. The adjusted risk for mortality in our study was approximately three times greater in elderly versus younger patients (60 years or younger). These findings were similar to those of Raymond et al., who analyzed the impact of postoperative nosocomial infection, excluding SSI, on mortality. Raymond et al. compared patients 70 years and older with patients younger than 70 years. Elderly patients had significantly higher crude mortality (21.7% vs 8.1%; $P < .001$) and mortality attributable to pneumonia (31.0% vs 17.2%; $P = .005$).[17] Our findings were also similar to those of McClelland et al., who demonstrated greater than 2-fold higher mortality associated with *S. aureus* bacteremia from any source (adjusted odds ratio, 2.30; CI_{95}, 1.13 to 4.69) in patients 66 to 90 years old compared with those 18 to 60 years old.[16] Infected elderly patients in our study had increased charges and hospital-days compared with younger patients. However, these relationships did not maintain statistical significance on multivariate analysis. Therefore, being 70 years or older per se did not independently increase charges or hospital stay. Instead, associated comorbid illnesses were probably the important factors.

Our study had several limitations. First, patients were selected from a previously defined cohort that was assembled to study the impact of methicillin resistance on SSI caused by *S. aureus*. Future study cohorts should be larger and specifically designed to address outcomes among elderly surgical patients. Second, our study included patients undergoing a variety of surgeries, and the distributions of procedures were not identical among the study groups. This limitation was addressed by controlling for differences in the proportion of patients undergoing particular procedures on multivariate analyses. In addition, we controlled for differences in the proportion of underlying comorbid illnesses between the patient groups using ICD-9 codes, ASA score, and duration of hospitalization and ICU stay prior to infection and surgery. We recognize that increased duration of hospitalization and costs in elderly surgical patients might have been due to delays in nursing home or rehabilitation unit placement. These data were not available in the current study, but future studies should examine the impact of nursing home and rehabilitation unit placement on outcomes in elderly surgical patients. Finally, actual costs were not available and charges were used as a surrogate for cost.

Elderly patients with SSI due to *S. aureus* are at increased risk for adverse clinical and fiscal outcomes compared with both uninfected elderly patients and younger patients with SSIs. Age of at least 70 years is a distinct, easily identifiable variable associated with poor outcomes among patients with SSIs. Future studies, including prospective, interventional trials geared specifically toward elderly patients, should address the SSI risk factors and prevention.

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