Original Investigation

Financial Impact of Surgical Site Infections on Hospitals
The Hospital Management Perspective

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IMPORTANCE Surgical site infections (SSIs) may increase health care costs, but few studies have conducted an analysis from the perspective of hospital administrators.

OBJECTIVE To determine the change in hospital profit due to SSIs.

DESIGN Retrospective study of data from January 1, 2007, to December 31, 2010.

SETTING The study was performed at 4 of The Johns Hopkins Health System acute care hospitals in Maryland: Johns Hopkins Bayview (560 beds); Howard County General Hospital (238 beds); The Johns Hopkins Hospital (946 beds); and Suburban Hospital (229 beds).

PARTICIPANTS Eligible patients for the study included those patients admitted to the 4 hospitals between January 1, 2007, and December 31, 2010, with complete data and the correct *International Classification of Diseases, Ninth Revision* code, as determined by the infection preventionist. Infection preventionists performed complete medical record review using National Healthcare Safety Network definitions to identify SSIs. Patients were stratified using the All Patient Refined Diagnosis Related Groups to estimate the change in hospital profit due to SSIs.

EXPOSURE Surgical site infections.

MAIN OUTCOMES AND MEASURES The outcomes of the study were the difference in daily total charges, length of stay (LOS), 30-day readmission rate, and profit for patients with an SSI when compared with patients without an SSI. The hypothesis, formulated prior to data collection, that patients with an SSI have higher daily total costs, a longer LOS, and higher 30-day readmission rates than patients without an SSI, was tested using a nonpaired Mann-Whitney *U* test, an analysis of covariance, and a Pearson χ^2 test. Hospital charges were used as a proxy for hospital cost.

RESULTS The daily total charges, mean LOS, and 30-day readmission rate for patients with an SSI compared with patients without an SSI were $7493 vs $7924 ($P = .99$); 10.56 days vs 5.64 days ($P < .001$); and 51.94 vs 8.19 readmissions per 100 procedures ($P < .001$). The change in profit due SSIs was $2 268 589.

CONCLUSIONS AND RELEVANCE The data suggest that hospitals have a financial incentive to reduce SSIs, but hospitals should expect to see an increase in both cost and revenue when SSIs are reduced.

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The US Health and Human Services Agency for Healthcare Research and Quality states that health care–associated infections were the most common serious complication of hospital care in the United States in 2008.[1] The Centers for Disease Control and Prevention estimates that there are 45 million inpatient surgical procedures performed annually in the United States.[2] Approximately 20% of the estimated 2 million nosocomial infections in the United States each year are surgical site infections (SSIs)[3] that have associated costs,[3-26] morbidity, and mortality.[10,13,18-20,24-27] While most agree about the negative clinical outcomes associated with SSIs, there is little consensus on the financial ramifications to the hospital.[7,12,17,24,27] The objective of this study was to estimate the change in hospital profit due to SSIs.

Methods

The study was authorized by The Johns Hopkins Hospital internal review board with a waiver of informed consent.

Definitions

We defined hospital cost as the financial amount a hospital spends to provide services. Hospital revenue is the financial amount earned through business operations. Hospital charges are the amount issued to the payers and patients. Real charges and costs are charges and costs adjusted for inflation. The admission All Patient Refined Diagnosis Related Group (APR-DRG) and complexity score are calculated based on the patient's present-on-admission diagnoses and other relevant characteristics.[28] The APR-DRG is a system used to stratify patients by resource use and has been used to classify patients for reimbursement purposes.[28] See eAppendix 1 in Supplement for supplemental definitions.

Outcome Variable

The primary outcomes of the study were the difference in daily hospital charges, intensive care unit (ICU) length of stay (LOS), floor LOS, 30-day readmission rate, and hospital profit for patients with an SSI when compared with patients without an SSI. Hospital charges were assumed to be a proxy for hospital cost; the terms will be used interchangeably. The daily charges were analyzed as a total and in 8 subcategories: room and board charges; operating room charges; pharmacy charges; radiology charges; laboratory charges; supply charges; therapy charges; and other charges. Using the Producer Price Index for hospitals from the US Bureau of Labor Statistics, all financial values referenced are measured in real dollars as of December 2010.[29]

Patient Population

A retrospective study was performed at 4 of The Johns Hopkins Health System acute care hospitals in Maryland: Johns Hopkins Bayview, a 560-bed academic tertiary care center; Howard County General Hospital, a 238-bed tertiary care center; The Johns Hopkins Hospital, a 946-bed academic tertiary care center; and Suburban Hospital, a 229-bed tertiary care center. Billing, laboratory, and medical record data were compiled for patients admitted to the hospitals or having a surgical procedure, according to *International Classification of Diseases, Ninth Revision* procedure codes, between January 1, 2007, and December 31, 2010. Suburban Hospital's data were compiled for January 1, 2008, to December 31, 2010, only. The surgical procedures were identified using electronic health records.

Complete medical record review was performed by trained infection preventionists using National Healthcare Safety Network surveillance definitions to identify SSIs, as previously described.[30-32] Follow-up contact with the surgeon was used to increase the detection rate for SSIs at all the hospitals except The Johns Hopkins Hospital. Patients undergoing the following inpatient surgical procedures were included in the study[30]:

- Nonpediatric coronary artery bypass graft chest and/or leg incision.
- Cesarean section.
- Colon surgery.
- Nonpediatric craniotomy.
- Hip prosthesis.
- Knee prosthesis.
- Nonpediatric laminectomy.
- Spinal fusion and refusion.

Eligible patients for the study included those patients with complete data and the correct *International Classification of Diseases, Ninth Revision* code, as determined by the infection preventionists. The data were stored in a Microsoft Access database.

Hypothesis Testing

The ICU LOS; floor LOS; daily total charges; daily room and board charges; daily operating room charges; daily pharmacy charges; daily radiology charges; daily laboratory charges; daily supply charges; daily therapy charges; and daily other charges were compiled for all patients. The daily hospital charges were calculated for each encounter by dividing the hospital charges by the patient's LOS. These continuous variables were used to test the hypothesis that the case patients, patients with an SSI, will have higher daily hospital costs, a longer LOS, and higher 30-day readmission rates than the control patients, patients undergoing the same procedure who did not contract an SSI.

For the procedures with a sample size of 25 or more, normality was tested using an Anderson-Darling test. If normally distributed, a nonpaired single-tailed Welch *t* test was used to test the hypothesis; otherwise, a single-tailed Mann-Whitney *U* test was used. For procedures with a sample size less than 25, a single-tailed Mann-Whitney *U* test was used to test the hypothesis. An analysis of covariance was also used to test the hypothesis while controlling for surgical procedure, admission APR-DRG, and admission complexity score. A Pearson χ^2 test was used to test the hypothesis that patients with an SSI will have a higher 30-day readmission rate. An α level of .05 was used. The statistical analysis was conducted using Minitab 16 Statistical Software (Minitab Inc) and SPSS (IBM).

Financial Analysis

For the financial analysis, a second control group was formed. This second control group comprised all patients admitted to the health system during the study period who did not contract an SSI. The control group patients were grouped by their admission APR-DRG and complexity score. Eligible patients for the financial analysis were those patients with all required data available in their electronic health record; admission APR-DRG and complexity score were available only for patients admitted after June 1, 2007.

After being grouped by their admission APR-DRG and complexity score, the mean floor LOS, ICU LOS, and daily total hospital charges were calculated for each admission APR-DRG and complexity score present in the control group. The difference between the floor LOS, ICU LOS, and daily total hospital charges was taken between the case patients (patients with an SSI) and the average of the control patients (patients without an SSI who had the same admission APR-DRG and complexity score as the case patient).

The differences in floor and ICU LOS found in the previous step for all patients with an SSI were multiplied by the mean charge for a floor day and ICU day from the patient's respective hospital. Concurrently, the difference in daily total hospital charges found in the previous step was multiplied by the total LOS for all patients with an SSI. These results were used to provide an estimate of the change in revenue and cost, respectively, for the health system due to SSIs. The change in revenue minus the change in cost was calculated to estimate the change in health system profit due to SSIs.

Results

Over the study period, there were 399 627 inpatient admissions, 25 849 surgical procedures of interest, and 618 SSIs identified, resulting in an SSI rate of 2.76 per 100 surgical procedures. Twenty-two thousand three hundred seventy-eight procedures and 618 SSIs were eligible for the hypothesis testing while 348 445 inpatient admissions, 17 392 procedures, and 547 SSIs were eligible for the covariance and financial analysis. Fifty-one thousand one hundred eighty-two admissions, 4896 procedures, and 71 SSIs were not eligible for the covariance and financial analysis since their record did not contain the admission APR-DRG and complexity score (**Table 1**).

Table 1. Number of Procedures Reviewed and SSIs Identified: 2007-2010[a]

NHSN-Defined Surgical Procedure	No. of Procedures (% of Total)	No. of SSIs (% of Total)
Adult CABG	1988 (9)	66 (11)
Adult craniotomy	3829 (17)	99 (16)
Adult laminectomy	2553 (11)	45 (7)
Adult spinal fusion	4404 (20)	179 (29)
Adult spinal refusion	542 (2)	12 (2)
Cesarean section	2607 (12)	110 (18)
Colon surgery	318 (1)	6 (1)
Hip prosthesis	2204 (10)	37 (6)
Knee prosthesis	3190 (14)	27 (4)
Pediatric spinal fusion or refusion	743 (3)	37 (6)
Total	**22 378 (100)**	**618 (100)**

Abbreviations: CABG, coronary artery bypass graft; NHSN, National Healthcare Safety Network; SSI, surgical site infection.

[a] Johns Hopkins Bayview; Howard County General Hospital; The Johns Hopkins Hospital; and Suburban Hospital.

The daily total charges for patients with an SSI were \$7493 (95% CI, \$7101 to \$7884) vs \$7924 (95% CI, \$7788 to \$8060) for patients without an SSI ($P = .99$). The patients with an SSI had a mean LOS of 10.56 days (95% CI, 9.50 to 11.62) vs 5.64 days (95% CI, 5.34 to 5.95) for patients without an SSI ($P < .001$). After adjusting for surgical procedure, admission APR-DRG, and admission complexity score, there remained an increased LOS and lower daily total charges in patients with an SSI compared with those without SSIs (eAppendix 2 in Supplement). The 30-day readmission rate for patients with an SSI vs patients without an SSI was 51.94 vs 8.19 readmissions per 100 procedures (odds ratio, 12.12; 95% CI, 10.27 to 14.29) ($P < .001$). Among patients with an SSI, there were 321 patients with at least 1 thirty-day readmission and 402 thirty-day readmissions in total. Among patients without an SSI, there were 1782 patients with at least 1 thirty-day readmission and 2139 thirty-day readmissions in total. The 547 patients with an SSI and eligible for the financial analysis had 2081 more hospital days (693 ICU days and 1389 non-ICU days) but lower daily total hospital charges of −\$132 (95% CI, −\$476 to \$212) ($P = .45$) when compared with patients without an SSI and the case patients' same admission APR-DRG and complexity score (**Table 2**).

If all 547 SSIs were eliminated, the data suggest that The Johns Hopkins Health System would experience a cost increase of \$9 124 029 (\$2 606 865.43 annually) and a billable capacity increase of 362 admissions (103 annually), equating to a revenue increase of \$11 392 618 (\$3 255 034 annually). Additionally, if it is assumed that payers refuse to reimburse for 30-day readmissions[9] related to SSIs, then the elimination of SSIs would provide The Johns Hopkins Health System an increase in revenue of approximately \$21 288 486 (\$6 082 425 annually) over the study period by increasing their available billable capacity by 922 admissions (264 annually). The data suggest that the total change in profit over the period for the health system, if they eliminated all SSIs, would be \$2 268 589, \$12 164 457 if it is assumed 30-day readmissions would not be reimbursed (**Table 3**).

Discussion

While the topic of financial impact of SSIs may seem trivial, it is not. These infections can be a source of readmissions and a driver of hospital performance. Hence, hospitals have a mandate to improve patient care and safety, which requires infrastructure that can support interventions focused on decreasing adverse events such as SSIs. To support these interests, hospitals and their administrators need data to help balance budgets and support infection prevention and other groups focused on improving performance. Unfortunately, hospitals are failing to see the major reduction in their cost by reducing

Table 2. Metrics for Patients With or Without an SSI: 2007-2010[a]

Metric	Mean (95% CI) Patients With SSI	Mean (95% CI) Control Patients	*P* Value
LOS, d	10.56 (9.50-11.62)	5.64 (5.34-5.95)	<.001
ICU LOS, d	2.84 (2.28-3.41)	1.27 (1.21-1.33)	<.001
Non-ICU LOS, d	7.72 (7.01-8.43)	4.38 (4.32-4.44)	<.001
Total charges, $	58 822 (43 352-74 292)	35 827 (36 348-35 305)	<.001
Daily total charges, $	7493 (7101-7884)	7924 (7788-8060)	.99
Daily room and board charges, $	1664 (1597-1730)	1639 (1627-1650)	.23
Daily operating room charges, $	1271 (1169-1373)	1618 (1595-1641)	>.99
Daily pharmacy charges, $	255 (206-304)	229 (217-240)	.15
Daily radiology charges, $	293 (261-325)	320 (313-328)	.95
Daily laboratory charges, $	334 (311-358)	307 (301-313)	.01
Daily supply charges, $	2872 (2577-3167)	2739 (2690-2787)	.19
Daily therapy charges, $	217 (202-231)	243 (239-246)	>.99
Daily other charges, $	636 (573-700)	650 (635-664)	.69
30-d Inpatient readmission rate per 100 procedures	51.94 (47.92-55.94)	8.19 (7.83-8.56)	<.001
No. of patients with at least one 30-d inpatient readmission	321	1782	NA
No. of 30-d inpatient readmissions	402	2139	NA

Abbreviations: ICU, intensive care unit; LOS, length of stay; NA, not applicable; SSI, surgical site infection.

[a] Mean real daily charges shown but Mann-Whitney nonparametric test used.

Table 3. Financial Impact of SSIs at The Johns Hopkins Health System: June 1, 2007, to December 31, 2010[a]

The Johns Hopkins Health System	$ Change in Health System Cost if SSIs Are Eliminated	Change in Health System Revenue if SSIs Are Eliminated	Change in Health System Profit if SSIs Are Eliminated	Change in Health System Profit if SSIs Are Eliminated and 30-d Readmissions Not Reimbursed
Adult CABG	1 642 780	3 395 583	1 752 803	3 190 164
Adult craniotomy	1 746 906	2 423 582	676 676	2 362 416
Adult laminectomy	579 743	719 592	139 849	1 090 285
Adult spinal fusion	4 154 204	3 621 380	(532 824)	3 321 434
Adult spinal refusion	285 609	134 741	(150 868)	173 549
Cesarean section	(59 952)	740 045	799 997	950 064
Colon surgery	117 849	153 153	35 304	53 365
Hip prosthesis	228 855	39 693	(189 162)	636 957
Knee prosthesis	12 754	(3388)	(16 142)	350 419
Pediatric spinal fusion or refusion	415 281	168 236	(247 045)	35 803
Health system totals	9 124 029	11 392 618	2 268 589	12 164 457
Health system annual figures	2 606 865.43	3 255 034	648 168	3 475 559

Abbreviations: CABG, coronary artery bypass graft; SSI, surgical site infection.

[a] Admission All Patient Refined Diagnosis Related Group and complexity score available for patients admitted after June 1, 2007.

SSIs.[12] We attempted to rethink the approach to the financial calculations of SSIs and help demonstrate the financial ramifications associated with SSIs.

A number of previous publications have cited that the change in incidence of health care–associated infections is directly related to the change in hospital cost.[3-11,13-26] This paradigm is the status quo and what much of the infection control and quality improvement community are basing their return on investment calculations on. The current method of calculating the change in hospital cost due to SSIs that we have observed most frequently is as follows. Assume patients with an SSI have costs of approximately $79 134, and the average patient without an SSI had total hospital costs of approximately $44 727. Taking the difference ($79 134 − $44 727), we derive the cost savings of preventing an SSI as $34 407. However, recent publications have challenged this paradigm.[12,33] A recent article claims that quality improvement leads to improvements in profit for hospitals by creating additional capacity to treat patients, but quality improvement will not drastically alter the "typically rigid" hospital costs.[33] This is further supported by a publication citing that hospitals have high fixed costs, up to 84%.[34]

The interpretation of cost often leads administrators and clinicians to confusion. The "lost opportunity to house new patients or increase capacity" will often be referenced appropriately by economists as a cost, an opportunity cost, but from a hospital administrator's or manager's perspective, this lost opportunity is not a cost, as previously defined, but rather a

Table 4. Example to Demonstrate the Change in Hospital Cost, Revenue, and Profit With Respect to the Change in Prevelance of SSIs

Assumed		Maximum No. of Admissions[a]	Assumed Revenue per Admission, $	Total Revenue, $[b]	Assumed Total Cost, $	Total Profit, $[c]
SSI Rate, %	Mean LOS, d					
0	5	500	30 000	15 000 000	12 500 000	2 500 000
25	6.25	400	30 000	12 000 000	12 500 000	(500 000)
50	7.5	333	30 000	9 990 000	12 500 000	(2 510 000)

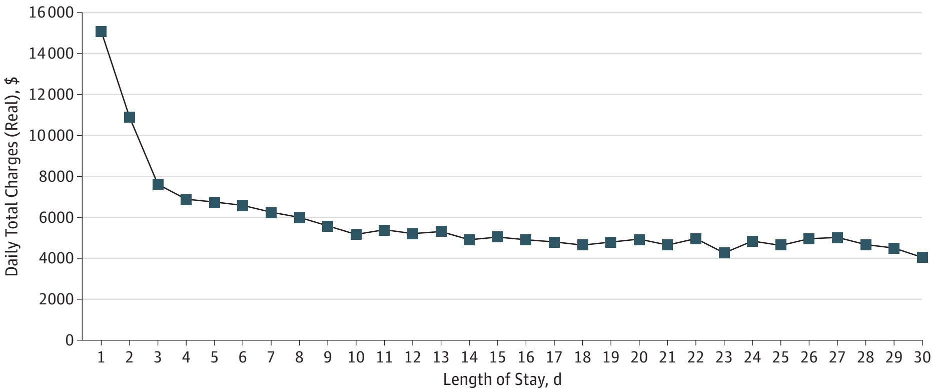
Abbreviations: LOS, length of stay; SSI, surgical site infection.

[a] (25 Beds × 100 d)/Mean LOS = Maximum No. of Admissions.

[b] Maximum No. of Admissions × Revenue Per Admission = Total Revenue.

[c] Total Revenue − Total Cost = Total Profit.

Figure 1. Mean Daily Total Charges for a Patient vs the Length of Stay for the Patient



loss of potential revenue. This concept is illustrated in the following example.

For ease of calculation, assume a 25-bed unit has to plan a 100-calendar day budget with these factors:

- The 25-bed unit will have a 100% occupancy rate.
- The total cost for a bed day is fixed at $5000 per bed, yielding the total cost for the unit of $12 500 000 ($5000 per bed × 25 beds × 100 days).
- All patients admitted have the same APR-DRG with reimbursement fixed at $30 000 per admission.
- Patients with an SSI have a mean LOS of 10 days and patients without an SSI have a mean LOS of 5 days.

For a unit where 50% of the patients contract an SSI, the mean LOS will be 7.5 days, the maximum number of admissions will be 333, total revenue will be $9 900 000, and total profit will be ($2 510 000). However, if the SSI rate is 0%, the mean LOS will be 5 days, the maximum number of admissions will be 500, total revenue will be $15 000 000, and total profit will be $2 500 000 (**Table 4**).

Clarifying the semantics and concepts will provide administrators and clinicians the opportunity to understand their financial calculations. The method used under the current paradigm, as previously described, will provide the change in costs due to SSIs from the payer's perspective, not the hospital's perspective. For example, the data suggest a patient with an SSI will have an LOS of 10 days and total charges of approximately $79 134. Assume that SSI was prevented. The data suggest that the LOS for the patient would decrease to 5 days and the patient would accrue a charge of $44 727. The difference in charges, $34 307, would be the amount that the payer, the insurance company, or the patient would not have to expend. So, the payer would reduce their costs by $34 307.

In the same situation where the SSI was prevented, the hospital would reduce their revenue by $34 307 and would spend approximately $34 307 less on the patient since they only cared for the patient for 5 days. However, the hospital has a bed that is now empty for 5 days. This bed cannot be instantly staffed or unstaffed, so there is a cost to keeping the bed. This leaves 2 possible scenarios: (1) the hospital closes the bed or (2) the hospital uses the 5 days of empty bed space and admits an additional patient, known as backfilling the bed.

In situation 1, the hospital can reduce their cost if they reduce SSIs. When an SSI is prevented, the hospital will not have a patient to backfill the bed, so the hospital can choose to lay off or repurpose the staff; sell the capital equipment; or eliminate all expenditure associated with the bed. The closing of the bed will lead to a reduction in hospital cost and increase hospital profit in the short term. In the long term, closing the bed will reduce the maximum possible revenue the hospital can receive since fewer beds will be available to patients.

In situation 2, the hospital may have the ability to backfill the bed if an SSI is prevented. Under a case-based payment system, the data suggest the hospital will receive additional revenue if an SSI is prevented, since the hospital could admit 2 patients at $44 727 per case ($89 454 total charges) instead of a single patient with an SSI at $79 134 in charges. In this scenario, hospital revenue would increase when an SSI is prevented, but it is unclear how hospital cost is affected.

It was not surprising that patients with an SSI had higher total costs than patients without an SSI, but it was surprising

Figure 2. Equation to Determine Change in Profit Due to a Single Surgical Site Infection (SSI)

$$\left(\begin{array}{c}\text{Change in Hospital}\\ \text{Profit Due to}\\ \text{1 Preventable SSI}\end{array}\right) = \Sigma_{n=1}^{i} \left\{\begin{array}{l} \overbrace{\left(\begin{array}{c}\text{Change in}\\ \text{ICU LOS}\\ \text{if 1 SSI Is}\\ \text{Prevented}\end{array}\right) \times \left(\begin{array}{c}\text{Revenue}\\ \text{per ICU Day}\end{array}\right) + \left(\begin{array}{c}\text{Change in}\\ \text{Non-ICU LOS}\\ \text{if 1 SSI Is}\\ \text{Prevented}\end{array}\right) \times \left(\begin{array}{c}\text{Revenue per}\\ \text{Non-ICU Day}\end{array}\right)}^{\boxed{\text{Change in Hospital Revenue}}} \\ \underbrace{\left(\begin{array}{c}\text{Change in}\\ \text{Daily Hospital}\\ \text{Cost if 1 SSI}\\ \text{Is Prevented}\end{array}\right) \times \left(\begin{array}{c}\text{LOS for}\\ \text{a Patient}\\ \text{With an SSI}\end{array}\right) - \left(\begin{array}{c}\text{Cost to}\\ \text{Obtain}\\ \text{Backfill}\\ \text{Patients}\end{array}\right) - \left(\frac{\begin{array}{c}\text{Cost of Intervention}\\ \text{That Prevented SSI}\end{array}}{\begin{array}{c}\text{No. of SSIs Prevented}\\ \text{by Intervention}\end{array}}\right)}_{\boxed{\text{Change in Hospital Cost}}} \end{array}\right\}$$

The equation is used for all *i* SSIs. The results must be summed for all *i* SSIs to derive the total change in profit for the health system or hospital due to SSIs. ICU indicates intensive care unit and LOS, length of stay.

Figure 3. Equation to Determine Change in Profit Due to a Single Surgical Site Infection (SSI), Assuming That Payers Will Not Reimburse for Related 30-Day Readmissions

$$\left(\begin{array}{c}\text{Change in Hospital}\\ \text{Profit Due to}\\ \text{1 Preventable SSI}\end{array}\right) = \Sigma_{n=1}^{i} \left\{\begin{array}{l} \left(\begin{array}{c}\text{Change in}\\ \text{ICU LOS}\\ \text{if 1 SSI Is}\\ \text{Prevented}\end{array}\right) \times \left(\begin{array}{c}\text{Revenue}\\ \text{per ICU Day}\end{array}\right) + \left(\begin{array}{c}\text{Change in}\\ \text{Non-ICU LOS}\\ \text{if 1 SSI Is}\\ \text{Prevented}\end{array}\right) \times \left(\begin{array}{c}\text{Revenue per}\\ \text{Non-ICU Day}\end{array}\right) \\ - \left(\begin{array}{c}\text{Change in}\\ \text{Daily Hospital}\\ \text{Cost if 1 SSI}\\ \text{Is Prevented}\end{array}\right) \times \left(\begin{array}{c}\text{LOS for}\\ \text{a Patient}\\ \text{With an SSI}\end{array}\right) - \left(\begin{array}{c}\text{Cost to}\\ \text{Obtain}\\ \text{Backfill}\\ \text{Patients}\end{array}\right) - \left(\frac{\begin{array}{c}\text{Cost of Intervention}\\ \text{That Prevented SSI}\end{array}}{\begin{array}{c}\text{No. of SSIs Prevented}\\ \text{by Intervention}\end{array}}\right) \\ + \left(\begin{array}{c}\text{ICU LOS}\\ \text{for 30-d}\\ \text{Readmission Not}\\ \text{Reimbursed}\end{array}\right) \times \left(\begin{array}{c}\text{Revenue}\\ \text{per ICU Day}\end{array}\right) + \left(\begin{array}{c}\text{Non-ICU LOS}\\ \text{for 30-d}\\ \text{Readmission Not}\\ \text{Reimbursed}\end{array}\right) \times \left(\begin{array}{c}\text{Revenue per}\\ \text{Non-ICU Day}\end{array}\right) \end{array}\right\}$$

The equation is used for all *i* SSIs. The results must be summed for all *i* SSIs to derive the total change in profit for the health system or hospital due to SSIs. ICU indicates intensive care unit and LOS, length of stay.

that patients with an SSI had lower daily costs (**Figure 1**). The data suggest that the reduction of SSIs will decrease the hospital's mean LOS, which could lead to an increase in daily total hospital cost and hence an increase in total hospital cost.

The Equation

We propose that the change in hospital profit due to the prevention of 1 SSI can be described in the equation in **Figure 2**. This equation can be summed across *i* patients with an SSI in the health system/hospital to determine the change in profit.

We calculate the change in hospital cost and revenue by stratifying by the admission APR-DRG and complexity score, as previously described. We then subtract the cost to obtain the backfill patients. This cost will vary widely because some hospitals have easy access to additional market share, making this cost low, where other hospitals will need to embark on a costly marketing campaign to attract additional customers. We then subtract the cost of the intervention that prevented the SSI. The cost of the intervention is divided by the number of SSIs prevented because the cost should be distributed equally across all the SSIs prevented. We then add the missed reimbursement if payers refused to reimburse for 30-day readmission related to SSIs (**Figure 3**).

Taking the difference between the change in hospital cost and hospital revenue due to preventing a single SSI, we sum across all *i* SSIs to derive the change in hospital profit due to SSIs. The data in this study suggest that the net loss in profits due to SSIs for The Johns Hopkins Health System was between $4147 and $22 239 per SSI, not accounting for the cost to backfill patients or the cost of the intervention to prevent the SSIs.

Limitations

This study had a couple of limitations. First, hospital charges were assumed to be an accurate proxy for hospital costs. This is not a suggested method, but the study was conducted in the state of Maryland, which was assumed to provide an accurate proxy given Maryland's all-payer reimbursement system. Second, a time-dependent bias, as described by Barnett et al,[35] can lead to overestimating the financial impact of SSIs. We adjusted for the time-dependent bias by selecting controls with the same admission APR-DRG and complexity score as the case patients for the financial analysis, but more accurate methods may be available.

Conclusions

Clinicians can spur hospital executives to invest in costly interventions or technology aimed at the reduction of SSIs by providing a cost-benefit analysis. When conducting such an analysis, the use of proper financial terminology is crucial. With the increasing need for additional infection prevention initiatives, which tend to require additional funding, clinicians must take care in presenting accurate financial figures to maintain the financial well-being of health care institutions and promote the safety of patients. Infection control and quality improvement professionals can use the equation given in Figure 2 to develop interventions that they project are cost appropriate. Payers should look to withhold reimbursement for SSI-related readmissions, as this makes SSI prevention more cost-effective.

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