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Hospital Acquired Conditions Following Spinal Surgery: Epidemiology and Risk Factors

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Abstract

Hospital acquired conditions (HACs) are an often-preventable source of financial, emotional, and physical burden on patients. HACs also impose an increasingly alarming economic toll on the health care system as a whole. Every year, over 45,000 HACs occur, costing the healthcare system $2 billion (roughly $40,000 per patient per HAC). Recent policy changes implemented by Medicare and Medicaid penalize the poorest-performing hospitals in regard to HACs in an attempt to decrease their occurrence. The Centers for Medicare and Medicaid Services (CMS) currently has identified 14 categories of HACs. We highlight major HACs following spinal procedures (spinal fusion and laminectomy), identify their risk factors, and assess their economic influence. HACs occur after roughly 5% of spinal surgeries, with the most frequent being falls/trauma and surgical site infections (SSIs). The primary risk factors can be divided into patient-specific and institution-specific, several of which are preventable or modifiable. Our team has identified the most common risk factors for HACs in the setting of elective spinal surgery. Efforts aimed at mitigating these risk factors are imperative to decreasing the occurrence of HACs.

Keywords: Total knee arthroplasty; Osteoarthritis; Rheumatoid arthritis; Outdoor walking; Survival rate

Introduction

Part of The Deficit Reduction Act of 2005 was aimed at identifying conditions that (1) are high cost, high volume, or both, (2) result in cases being assigned to a diagnosis-related group that has a higher payment when present as a secondary diagnosis, and (3) could reasonably have been prevented through the use of evidence-based guidelines [1]. Three years following this act, the Centers for Medicare and Medicaid Services (CMS) ratified policy changes that would deny coverage of hospital costs due to hospital-acquired conditions (HACs) [2]. HACs can be defined as conditions that develop during a hospital stay in which a patient sought care for a separate condition [3]. However, this was again changed in 2015 to the Hospital-Acquired Condition Reduction Program, which reduces Medicare payments by 1 percent for the lowest quartile-performing hospitals on quality measures of specific preventable HACs [4].

The CMS branded 14 categories of HACs which include: foreign objects retained after surgery, air embolism, blood incompatibility, stage III and IV pressure ulcers, falls and trauma, manifestations of poor glycemic control, catheter-associate urinary tract infection (CA-UTI), vascular catheter-associated infection, surgical site infections (SSIs) following coronary artery by-pass graft (CABG), SSIs following bariatric surgery for obesity, SSIs following certain orthopedic procedures such as spine, neck, shoulder, and elbow, SSIs following cardiac implantable electronic device (CIED), deep vein thrombosis (DVT)/pulmonary embolism (PE) following certain orthopedic procedures, and iatrogenic pneumothorax with venous catheterization [1-3].

The incidence of HACs across a recent inpatient sample of 351 million admissions was 4% [5]. The rate of HACs varies based upon patient, surgical, and hospital-specific risk factors. This variation has led to increased research in identifying these risk factors and discovering solutions to reduce these risks.

We center on HACs that occur after two of the most common spinal orthopaedic procedures in the United States: spinal fusion (463,200 cases per year) and spinal laminectomy (438,200) [6]. According to the National Inpatient Sample database, rate of elective fusions increased 62.3% in the last decade, from 122,679 cases in 2004 to 199,140 cases in 2015 [7]. This increased volume was most accounted for by patients 65 years of age and older [7]. The largest increases were for spondylolisthesis (111%) and scoliosis (186.6%) [7]. However, disc degeneration, herniation, and stenosis accounted for 42.3% of all elective fusions in 2015 [7].

Our objective is to present an evidence-based review emphasizing the risk factors of HACs following common spinal surgeries during inpatient stays and their economic impact so that it can be utilized to help decrease the likelihood of HACs for these two spinal surgeries. To do so, several databases and manually retrieved cross-references were searched including Pub-Med, Ovid via Medline, Web of Science, Cochrane, and Embase. Search terms included “hospi-tal acquired condition”, “HAC”, “30-day complications”, “spinal fusion”, “laminectomy”, and “risk factors”. We limited the patient population to those who underwent elective spinal fusion or laminectomy. Primary outcomes evaluated were the type of, and incidence of, HACs following these surgeries.

Epidemiology

Following spinal fusions, the rate of HAC incidence is often dependent on several variables of the performed procedures. In those undergoing cervical fusions, the incidence of HACs was 4.6%, with the vast majority of these (95.2%) being falls and trauma, followed by SSIs with a 3.7% incidence rate [8]. Following thoracolumbar fusions, HAC frequency increases to 5.2%, with most similarly comprising of falls and trauma (87%) [8]. SSI accounted for the second most HACs in this group at 11%. [8] In those undergoing any sort of spinal fusion secondary to deformity, Di Capua et al. noticed HACs occur at a rate of 5.4%. In this study, the leading cause of HAC was CA-UTI (2.1%), followed by SSI (1.8%) and VTE (1.8%) [9]. It is appropriate to discuss laminectomies and fusions together, as often times these two procedures are performed simultaneously. Unfortunately, current research of the association between HACs and laminectomy is fairly limited. Although not representative of the typical spinal decompression through laminectomy patient, in a study on laminectomy for intradural extramedullary spinal tumors, it was found that there was an overall HAC rate of 6.5% [10]. Studies assessing the incidence of DVT, PE, and SSI in lumbar laminectomy utilizing the California State Inpatient Database data from 2008 to 2009 reported 1.4% of patients experienced DVT and 0.2% experienced either SSI or PE [11].

Economic impact of HACs.

HACs, irrespective of type, result in increased costs both during inpatient care and further down the episode of care. Coomer and Kandilov investigated the financial impact of 6 HACs (DVT/PE, stage III and IV ulcers, falls and trauma, vascular catheter-associated infection, CA-UTI, SSI) in Medicare patients and found that these six alone incited a yearly burden of $20.5 million on Medicare beneficiaries. The study notes a difference in total beneficiary liability be-tween HAC cases and the control group of $231 for DVT/PE, $1,151 for CA-UTI, $1,476 for falls and trauma, $1,971 for vascular catheter-associated infection, $2,150 for SSI, and $3,242 for stage III and IV pressure ulcers. The components of the total beneficiary liability included index hospital and transfers, readmissions, skilled nursing and long-term care facilities utilization, physician liabilities during the index hospital admissions and in follow ups, and lastly outpatient liabilities [12]. However, these aforementioned costs are solely comprised of Medicare-beneficiaries accrued sum and do not entirely account for the systemwide economic burden in the United States. In 2016, a total of 48,771 HACs were reported in U.S. hospitals, resulting in an excess hospital operational cost over $2 billion (roughly $40,000 per patient per HAC) [13]. Along with this direct fiscal burden, enduring a HAC added on average 8.17 days to each patient’s hospital stay, which can lead to indirect hidden costs such as consuming beds that can be used for other patients or delaying return to work [13]. These costs can vary according to the nature and severity of HAC a patient experience.

Hospital-acquired infections, for example, can be very costly. Among CMS HACs, CA-UTI sits on the lower financial end of the spectrum, approximately $896 per case, while SSI and vascular catheter-associated infections cost $20,785 and $45,814, respectively [14]. The costliest are stage IV ulcers, costing an average of $129,240 per case [14] (Table 1).

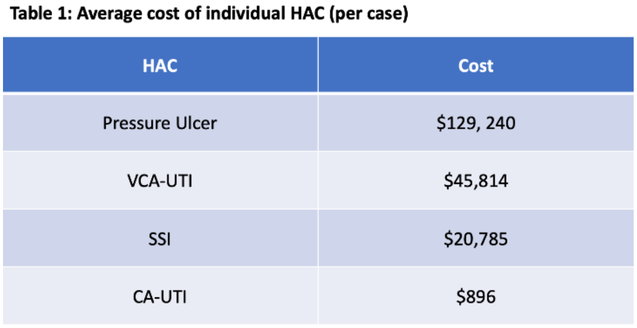

Table 1: Average cost of individual HAC (per case)

HAC	Cost
Pressure Ulcer	$129, 240
VCA-UTI	$45,814
SSI	$20,785
CA-UTI	$896

Table 1: Average cost of Individual HAC (per case).

As illustrated above, each HAC possesses its own degree of financial burden. Interesting-y, there are also differences in costs associated with HACs depending on what type of procedure a patient undergoes. For example, those undergoing elective spinal surgery that experience a HAC will accrue additional payments of $8,893 on average [15]. Only those undergoing bariatric ($9,975) and cardiothoracic ($10,868) surgeries have greater additional payments [15]. In addition to the primary concern of patient comorbidities quality of life, the economic impact of HACs on the patient and the healthcare system overall are substantial, further highlighting the im-portance of eliminating their occurrence.

To determine which hospitals are subject to the reduction in Medicare payments, CMS calculates a total HAC score that utilizes two domains: PSI-90 composite score and the National Healthcare Safety Network (NHSN). Factors that contribute to the PSI-90 composite score include PSI 03, 06, 08, 09, 10, 11, 12, 13, 14, and 15 which are calculated from the claims a hospital submits to Medicare. The NHSN is measured from data taken from patients’ charts and includes both Medicare beneficiaries and patients with other insurances [16] The CMS then assigns points for these two domains, with the best performing hospitals having the lowest scores. The higher the HAC score, the more likely a hospital is subject to the 1% penalty [16].

Risk factors of HACs

Patient-Specific Risk Factors

Age:

`Age > 55 years: A study reviewed 1012 operations on 918 patients undergoing lumbar surgery and compared the average age between the cohort of patients who experienced a perioperative complication (57.3) and the cohort who did not (53.7). Imagama et al. found that perioperative complications were more frequent in older patients ($p < 0.01$) [16].

Age >65 years: Deyo et al. investigated a large cohort of patients following surgery for lumbar spinal stenosis (LSS) over the age of 65 and reported that 3.1% of the patients had medical complications and 1.2% had wound complications, concluding that increasing age had a direct relationship to an increase in major complications and mortality [17]. Similarly, Wang et al. reported the incidences of DVT and adverse drug reaction in patients over the age of 75 was 2.27% and 1.14%, respectively [18]. Bydon et al. investigated the safe-ty of spinal fusion in elderly patients and found that patients between the ages of 65 and 75 undergoing lumbar fusion had a 13.46% complication rate, 4.42% higher than the <65 cohort. This is further evidence that age > 65 years is a risk factor for postoperative com-plications [19]. Tang et al. found that in a population of patients with an average age of 66.8 years that underwent surgery for degenerative lumbar scoliosis, over 5% had major medical complications. The incidence of DVT/PE, postoperative-pneumonia, wound complications, and UTI were 2.11%, 2.11%, 1.69%, and 0.84%, respectively [20]. These findings suggest a correlation between of patients ages 65 and over to HACs.

Other studies revealed that patients between the age of 75 to 85 undergoing lumbar surgery had an increased risk for HACs [19]. Complications included SSI, UTI and DVT which were in 4.68%, 5.53% and 2.13%. Complication rates in patients in this co-hort was 16.17%, almost double the rate for patients under 65 years old [19].

Age >90 years: Elderly patients aged ≥ 90 years are at a higher risk for complications after spinal surgery. The effects of age and comorbidities have been studied and shown that patients of this age have a 5.2 times higher risk for complications and adverse outcomes after sur-gery than patients of all ages [21]. Due to the small population of patients age >90 years and the clear increased risk they are at for surgery, not many studies have investigated their risk of HACs after lumbar surgery.

Body Mass Index (BMI):

Marquez-Lara et al. reported that following lumbar spine surgery, patients with a BMI < 30 are at increased risks of VTE events and superficial SSI, while morbid obesity (BMI > 40) significantly increased the risks of UTI [22]. Chen et al. conducted a retrospective cohort study that aimed at identifying the influence BMI has on complication and readmission rates following lumbar spine fusion. The study found cumulative increases of 6.44% in infection, 3.69% in wound dehiscence, and 1.35% in readmission within 90-days for each successive BMI cohort [23]. As for underweight patients (BMI <18.5), Flippin et al. mentions in their study of patient outcomes following lumbar spine surgery that it's likely these patients are suffering from nutritional deficiency or end stage cancer.

BMI 18.5 – 29.9 (Non-Obese): Pneumonia rates were shown to be higher in the non-obese/control group (6.19%) when compared to the obesity II (3.24%) and III group (3.27%). [23]

BMI 30 – 34.9 (Obesity I): Multivariate analysis comparing obesity I patients to nonobese controls showed no difference in any complication rates between groups. [23]

BMI 35 – 39.9 (Obesity II): The obesity II group had significantly higher odds of infection (odds ratio [OR]: 1.82, 95% confidence interval [CI]: 1.28–2.62, P = 0.001), wound dehiscence (OR: 3.08, 95% CI: 1.70–6.18, P = 0.0006), and 30-day readmission (OR: 1.32, 95% CI: 1.11–1.58, P = 0.002) compared with the controls. [23]

BMI > 40 (Obesity III): The obesity III group had significantly higher odds of acute renal failure (OR: 2.14, 95% CI: 1.20–4.06, P = 0.014), infection (OR: 2.43, 95% CI: 1.72–3.48, P < 0.0001), wound dehiscence (OR: 3.76, 95% CI: 2.08–7.51, P < 0.0001), 30-day readmission (OR: 1.62, 95% CI: 1.36–1.93, P < 0.0001), and 90-day readmission (OR: 1.53, 95% CI: 1.31–1.79, P < 0.0001) compared with controls.[23]

Sex:

Male gender has been shown to be a risk factor for post-operative SSI. Following thoracolumbar spinal surgery, Deng et al reported 11 patients (0.49%) experienced postoperative deep SSI and those that were male were at increased odds ($p = 0.006$). They concluded that despite preventative measures for SSI, male gender remained an independent risk factor associated with post-operative deep SSI [24]. Ogihara et al. revealed a similar association with male gender [25]. Heyer et al., on the other hand, reported that female patients were at an increased risk for superficial SSI ($p=0.016$) and UTI ($OR=1.63$, $p < 0.001$), while males were at an increased risk for pneumonia ($p = 0.019$) and unplanned reintubation ($p = 0.008$). Additionally, women more frequently required transfusions ($OR=1.63$, $p < 0.001$) and had longer hospital stays ($p < 0.001$) than men. They concluded that a patient's gender is an independent risk factor for multiple com-plications post-spinal surgery and it's impact on surgical outcomes should be considered for pre-operative optimization and postoperative expectations. It's suggested that both men and woman are counseled preoperatively to discuss their risks for postoperative complications and that medical approaches should be tailored according to sex [26].

Race:

In a retrospective cohort study, Sanford et al. found that African American and Native American patients experienced more frequent post-operative complications compared to Caucasians. African Americans were shown to have a longer length of stay in all cervical procedures, lumbar fusions, and decompression laminectomy. They were also at greater risk of DVT in lumbar fusion and increased risk SSIs and pulmonary embolism in decompression laminectomy. Na-ive American race proved to be an independent risk factor for SSIs following cervical fusion and decompression laminectomy [27]. This suggests that there is an increased clinical burden among often socioeconomically disadvantaged populations who also face inequality. [27]

Comborbidities:

Previous History of Spinal Surgery: *Patients who perviously underwent spinal surgery had a strong association with wound complications (4.6% vs. 1.0% among those without prior surgery); making previous spine surgery a risk factor for HAC in patients undergoing lumbar surgery [17].*

Diabetes Mellitus: Insulin dependent diabetes has been shown to increase the likelihood of surgical complication (OR = 1.72), and deep SSI following thoracolumbar spinal surgery is also increased in patients with diabetes ($p = 0.05$) [20, 24].

Cardiorespiratory Disease: Patients with a history of hypertension were at greater risk of developing a VTE compared to patients with no history of hypertension (OR = 1.785; 95% CI, 1.516–2.103; $P < 0.001$) [28].

Active smokers are at higher risk of developing SSIs (OR=1.27, 95% CI, 1.01-1.58) and other wound complications (OR= 1.37; 95% CI, 1.02-1.85) when compared to those who are never smokers [29].

COPD ($P = 0.031$) and dyspnea ($P = 0.041$) on exertion have been shown to be strong risk factors for postoperative complications following spinal surgery [20].

Renal Disease: Among elderly patients undergoing lumbar spinal fusion surgery, those with severe chronic kidney disease (CKD) had increased rates of all medical complications when compared to the control group (21.3% *vs.* 14.2%, OR = 1.64). 90-day mortality and 1-year mortality were also shown to be higher in the renal group compared to the control [30].

Martin et al. used estimated glomerular filtration rate (eGFR) to determine whether patients had mild, moderate, or severe renal disease and found that those who had moderate to severe renal disease were at increased risk of wound complications, reoperation rates, and blood transfusions. However, only rate of blood transfusions was found to be statistically significant [31].

· **Electrolyte Disturbances**: In a study conducted by Horowitz et al., patients undergoing anterior lumbar interbody fusion (ALIF) with perioperative fluid and electrolyte imbalances were four times more likely to experience post-operative ileus, greater LOS, and an additional cost ($2,349 ± $419) [32]. This suggests that monitoring electrolyte balances in patients undergoing ALIF could be a potential method in reducing complications following the procedure although more studies need to be conducted regarding this subject.

Coagulopathies: Patients with any level of anemia have been shown to experience significantly in-creased length of stay, SSIs, UTIs, DVTs, and thrombophlebitis. Of those with mild, moderate, and severe anemia, the moderately anemic group was found to have the highest risk of experiencing an HAC [33].

Perioperative blood transfusion has been associated with an increased risk in post-operative infections as well as longer LOS and other morbid complications [34]. This in-crease in infections could be explained by transfusion related immunosuppression but more research needs to be conducted to explain this.

Preoperative Steroid Use: Steroid use for chronic conditions may increase a patient’s likelihood of surgical complication (OR = 1.55) [20].

In a retrospective cohort study conducted by Ranson et al., chronic steroid use in patients undergoing posterior lumbar fusion was associated with a 2-fold increased risk of superficial SSIs and deep SSIs, as well as a 2.5-fold increased risk of wound dehiscence [35]. It is well known that the anti-inflammatory action of steroids functions via immuno-suppression leading to a decreased ability to eliminate pathogens leading to an increase chance of infection.

Chronic steroid use was also found to be associated with a 2.5-fold increased risk of PE [35]. Steroids are known to induce a hypercoagulable state as well as potentially cause endothelial damage and vascular wall dysfunction leading to an increased risk of VTE.

Psychiatric Illness: Menendez et al. found that patients with depression, schizophrenia, and dementia were associated with higher rates of adverse events compared to patients with no diagnosed psychiatric condition [36]. Patients with a preoperative psychiatric disorder are at risk for HACs following spinal surgery [18,36]. Perhaps it may be considered to conduct presurgical psychological screening of candidates undergoing spinal surgery in an attempt to enhance perioperative outcomes.

Nutritional Status: Kurosu et al. found that patients undergoing cervical posterior fusion with a prog-nostic nutritional status (PNI) < 50 saw longer hospital stays, lower discharge to home ratio, higher occurrence delirium, and more medical complications. Patients with a PNI < 50 were more likely to experience an SSI, UTI, or pneumonia. This indicates that a better nutritional status may reduce the risk of such medical complications following surgery [37].

Salvetti et al. discussed the measure of prealbumin as a marker for nutritional status in patients. They found that those undergoing elective spinal surgery who had a pre-operative prealbumin of less than 20 (malnutrition status) were at a significantly increased risk for SSIs [38]. This study demonstrates that preoperative albumin levels may be useful in risk stratification for patients. However, it should be noted that due to albumins long half-life (~20 days) and lack of specificity, it’s not always considered the best marker for nutritional assessment since there are many variables that can effect albumin levels (Table 2).

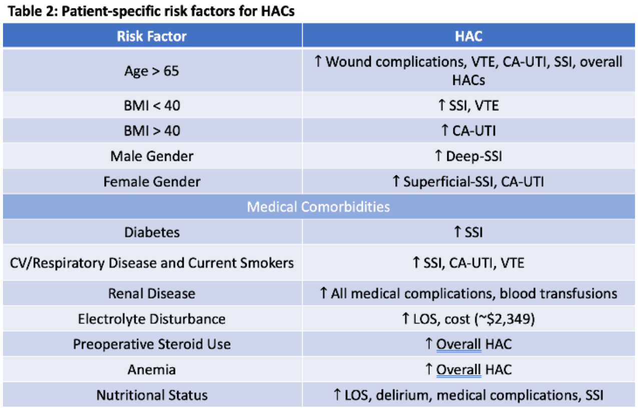

Table 2: Patient-specific risk factors for HACs

Risk Factor	HAC
Age > 65	↑ Wound complications, VTE, CA-UTI, SSI, overall HACs
BMI < 40	↑ SSI, VTE
BMI > 40	↑ CA-UTI
Male Gender	↑ Deep-SSI
Female Gender	↑ Superficial-SSI, CA-UTI
Medical Comorbidities	
Diabetes	↑ SSI
CV/Respiratory Disease and Current Smokers	↑ SSI, CA-UTI, VTE
Renal Disease	↑ All medical complications, blood transfusions
Electrolyte Disturbance	↑ LOS, cost (~$2,349)
Preoperative Steroid Use	↑ Overall HAC
Anemia	↑ Overall HAC
Nutritional Status	↑ LOS, delirium, medical complications, SSI

Table 2: Patient-specific risk factors for HAC.

Surgeon-Specific Risk Factors for HACs

Antimicrobial Technique: Shlobin et al. noted that patients undergoing posterior lumbar spinal fusion (PLSF) were at increased risk of developing SSIs when the irrigation used was cefazolin (P < 0.001, OR = 4.37) or bacitracin compared to patients who underwent gentamicin irrigation (OR = 4.37, p < 0.010). Readmission and reoperation were also more likely in patients who underwent cefazolin or bacitracin irrigation compared to gentamicin [39]. **Operative time:** Di Capua et al. demonstrated operating time as a risk factor, as those with surgeries lasting greater than or equal to 4 hours had higher rates of HACs [9]. Other trials have demonstrated similar results, making operative time a significant risk factor for HAC occurrence [25,40]. Of note, spinal fusion for deformity corrections tends to be a longer and more complex surgery, which can cause even further complications. Wang et al. assessed complications associated with lumbar surgeries in patients over the age of 75 and found the length of operation time to be a contributing factor to both systemic and wound complications (p=0.003) [28]. Moreover, Pesenti et al. noted a significant positive association between SSI and both operative time and number of levels fused [41].

In addition to duration of the operation, time at which the operation occurs plays a role in HAC risk stratification. Neifert et al. concluded that late surgical start time is associated with longer LOS (0.45 days, 95% CI, 0.18-0.72, p = 0.001) and higher cost (95% CI, $339-$2348, p = 0.009) in patients undergoing posterior lumbar fusion (PLF). Surgical start time was grouped into those starting before 2:00 P.M. and those starting after 2:00 P.M., with the exclusion of surgical procedures starting between 12:00 AM and 6:00 AM. Potential areas to note regarding the difference in patient outcome in regard to start time are hospital staffing, staff fatigue later in the day, and hospital resource availability [42].

Minimally Invasive *vs.* Open Spine Surgery: Ee et al. compared the risk of developing SSIs in minimally invasive spinal surgery (MIS) *vs.* open spinal surgery. They found that patients undergoing open spinal surgery were 5.77 times more likely to develop an SSI as compared to patients who underwent MIS [43]. Parker et al. came to a similar conclusion by demonstrating that the cumulative incidence of SSI was significantly lower in MIS *vs.* open spinal surgery (0.6% *vs.* 4.0%, p =0.0005). Parker et al estimated that the decrease in SSI would save their $98,974 per 100 MIS-TLIF procedures performed [44] (Table 3).

Anesthesia: Sarkar et al. noted significantly less blood loss, less OR time, better post-op analgesia, and decreased incidence of vomiting and nausea when patients underwent spinal anesthetic (8.4%) versus general anesthetic (29.6%) for lumbar spine instrumented fusion surgery [45]. Two mechanisms proposed to explain the decreased perioperative blood loss in the spinal anesthetic group is (1) vasodilation and hypotension caused by sympathetic blockade and (2) spontaneous ventilation which causes lower intra-thoracic pressure and consequently less distention of epidural veins leading to less bleeding [45]. Mclain et al similarly showed that spinal anesthesia reduced the rate of complication following spinal fusion [46] (Table 3).

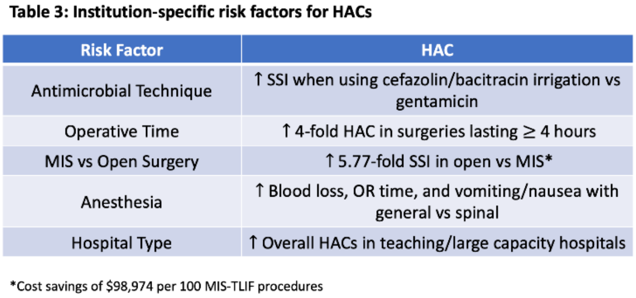

Table 3: Institution-specific risk factors for HACs

Risk Factor	HAC
Antimicrobial Technique	↑ SSI when using cefazolin/bacitracin irrigation vs gentamicin
Operative Time	↑ 4-fold HAC in surgeries lasting ≥ 4 hours
MIS vs Open Surgery	↑ 5.77-fold SSI in open vs MIS*
Anesthesia	↑ Blood loss, OR time, and vomiting/nausea with general vs spinal
Hospital Type	↑ Overall HACs in teaching/large capacity hospitals

*Cost savings of $98,974 per 100 MIS-TLIF procedures

Table 3: Institution-Specific (Hospital) Risk Factors for HACs.

Institution-Specific (Hospital) Risk Factors for HACs

Surgical Volume: Li et al. demonstrated that higher surgeon volume is associated with lower complications and shorter length of hospital stay [47]. Dasenbrock et al., on the other hand, found that greater hospital volume was not associated with superior spinal surgery outcomes [48].

Geography: When comparing common spinal procedures among high volume spinal surgeons in both urban and rural hospitals, there was found to be no notable difference in surgical outcomes. This suggests that surgical outcomes relied more on a surgeon’s experience, skill, and clinical knowledge as opposed to hospital resources [48].

Hospital type: Following cervical fusion, teaching hospitals and others with larger capacity may be asso-ciated with increased risk for HAC [49]. In teaching hospitals, this may be due in part to the in-volvement of trainees and students in cases, which indirectly leads to longer operating times and potentially more complications. Emergent procedures have higher rates of HACs compared to elective cases [49] This could be explained by potential time for preoperative assessment and medical optimization that cannot be performed adequately in emergencies where spinal cord is at risk, in addition to the different nature of the procedure in those settings, [49].

Day of Admission: Wen et al. noted weekend admissions are associated with a 45.3% HAC incidence rate compared to a 4.59% rate in weekday admissions [49]. Attenello et al. similarly reported higher HAC rates to be associated with weekend admission as well as emergent procedures [8]. This finding may be due to the fact that weekend admissions tend to be for emergent cases that do not receive adequate perioperative medical optimization, in addition to the staff shortage and smaller teams over the weekends.

Conclusion

Hospital acquired conditions are often preventable occurrences that cost the patient, and healthcare system as a whole, a substantial amount every year. More importantly, they impose unnecessary physical and emotional burden on the patient. As Medicare's new Deficit Reduction Act penalizes poor-performing hospitals in this regard, there is economic incentive to reduce the rates of HACs. Our review has identified risk factors for HACs in the setting of spinal surgery. Patient-specific factors include age >55, active tobacco use, BMI >35, potential gender and racial factors, and numerous medical conditions. Surgeon related factors include antimicrobial technique, operative time, MIS *vs.* open surgery, and anesthetic technique. Institution related factors include the hospital type and time of surgery.

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