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Infection Control and Prevention: A Review of Hospital-Acquired Infections and the Economic Implications

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ABSTRACT

The Centers for Disease Control and Prevention estimates that 2 million patients suffer from hospital-acquired infections every year and nearly 100,000 of them die. Most of these medical errors are preventable. Hospital-acquired infections result in up to $4.5 billion in additional healthcare expenses annually. The U.S. government has responded to this financial loss by focusing on healthcare quality report cards and by taking strong action to curb healthcare spending. The Medicare Program has proposed changes to the Hospital Inpatient Prospective Payment System and Fiscal Year Rates: Proposed Rule CMS 1488-P-Healthcare-associated infection. Payment will be linked to performance. Under the new rule, payment will be withheld from hospitals for care associated with treating certain catheter-associated urinary tract infections, vascular catheter-associated infections, and mediastinitis after coronary artery bypass graft surgery. Infection-prevention strategies are essential. In the healthcare setting, the infection control department is categorized as non-revenue-producing. Funds dedicated to resources such as staff, educational programs, and prevention measures are vastly limited. Hospital leaders will need to balance the upfront cost needed to prevent hospital-related infections with the non-reimbursed expense accrued secondary to potentially preventable infections. The purpose of this paper is to present case studies and cost analysis of hospital-acquired infections and present strategies that reduce infections and cost.

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INTRODUCTION

Healthcare spending and cost control measures are a priority in many well-developed countries. In the United States, more money per capita is spent on healthcare, as compared with other developed countries. The share of the gross domestic product (GDP) devoted to healthcare grew from 8.8% of GDP in 1980, to 15.2% of GDP in 2003. This 7% increase in the healthcare share of the GDP is larger than increases seen in other high-income countries.[1] In light of this fact, the health status of most Americans does not correlate with the amount of dollars invested. Instead, healthcare outcomes, particularly for malignant neoplasms, cerebrovascular diseases, diabetes, pneumonia, and influenza, have not improved.[2] Moreover, federal dollars are being spent, wastefully, on conditions caused by preventable medical errors, including hospital-acquired infections (HAIs).

The Centers for Disease Control and Prevention (CDC) estimates that 2 million patients suffer from HAIs every year and nearly 100,000 of them die.[3] HAIs result in up to $4.5 billion in additional healthcare expenses annually. HAIs are responsible for more deaths in the United States than the top leading causes of death.[4] These infections, hospitalizations, intangibles, such as grief and anxiety, and dollars spent are all preventable.

The U.S. government has responded to this financial loss by focusing on healthcare quality report cards and by taking strong action to curb healthcare spending. A plan is in place to improve patient outcomes by public display of hospital performance

and by tightening the flow of guaranteed dollars that hospitals need to remain operational. Hospitals across the nation are being forced to display data that had been privileged and confidential to the hospital only. Mandatory reporting legislation is aimed at getting healthcare facilities to make changes to reduce infections. Government advocacy toward infection prevention does not stop at mandatory reporting. The Medicare Program has proposed changes to the Hospital Inpatient Prospective Payment System and Fiscal Year Rates' Proposed Rule Centers for Medicare and Medicaid Services (CMS) 1488-P-Healthcare-associated infection. Payment will be linked to performance (known as ''P4P''). Under the new rule, payment will be withheld from hospitals for care associated with treating mediastinitis after coronary artery bypass graft (CABG) surgery, catheter-associated urinary tract infections, and vascular catheter-associated infections.

In the United States, healthcare executives have largely ignored HAIs. Many assumed that HAIs made money and that prevention cost more money than it saved. Given the US reimbursement system, complications add some money, but after 3 days of treatment for complications, reimbursement decreases. The cost of care for patients with complications such as HAIs can exceed the reimbursement. HAIs have not been on the executive radar for cost interventions. This will change. Beginning October 2008, the government insurer, CMS, will no longer reimburse for conditions that are not present on admission, particularly mediastinitis after CABG surgery, catheter-associated urinary tract infections, and vascular catheter-associated infections. Hospitals will have to pay for HAIs. The rule prohibits hospitals from passing the cost onto patients. Because of the expected changes in the reimbursement schedule, healthcare executives are now focused on infection prevention. Unlike in the past, infections are present on hospital scorecards along with the financial data.

A Study on the Efficacy of Nosocomial Infection Control (SENIC) conducted in the 1980s evaluated the nosocomial infection prevention and control programs in the United States. The SENIC project 'bottom line' was that 32% of infections that would have occurred in the absence of well-organized infection surveillance and control programs were potentially preventable.[5] Powered by this information, healthcare facilities were charged to implement effective infection prevention and control strategies. Infection control programs are reviewed during Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and other regulatory agency inspections. Infection control departments are categorized as non-revenue-producing. Funds dedicated to resources such as staff, educational programs, and prevention measures are vastly limited. Hospital leaders will need to balance the up-front cost needed for prevention and the unpaid cost for poor compliance with preventable patient care. Avoiding HAIs helps the bottom-line financial picture. Patients without HAIs are discharged sooner, allowing bed access for new patients. Assuming fixed costs stay the same, available bed days increase volumes and revenue. Factors to consider for infection prevention and the economic implications for certain cases are described below.

HAIs are infections that occur more than 48 hours post-admission. HAIs are caused by viral, bacterial, and fungal pathogens. An important predisposing factor to HAIs is the use of instrumentation or devices for intubation, delivery of therapeutic agents, or drainage of body fluids during patient care as supportive measures. Infection control professionals collect data on device-related infections, i.e. catheter-associated urinary tract infections, vascular catheter-associated infections, and ventilator-associated pneumonias. Unlike other hospital-acquired infections, as we describe later, device-related infections are linked directly to medical care.

According to the National Nosocomial Infection Surveillance Report, in 2006, 8833 device-related infections in adults were reported from participating healthcare facilities.[6] There were 3759 catheter-associated urinary tract infections reported from 433 locations. Catheter-associated urinary tract infections accounted for most of the infections. There were 2681 vascular catheter-associated infections reported and 2393 ventilator-associated pneumonias from 548 locations. It is possible that CMS chose to restrict payment on catheter-associated urinary tract infections and vascular catheter-associated infections, because of the high numbers and the fact that infection control professionals all agree on the standardized definition for data collection methods.

To understand the economic burden of HAIs, the resources and related costs of interest include incremental costs that may be directly attributable to the infection and not the underlying admitting diagnosis. Stone et al. reviewed studies in which individual (vs. aggregate) costs of patient outcomes were calculated.[7] Of the 70 studies, 39 were in the United States, 17 in Europe, 4 in Australia/New Zealand, and 10 were from other countries. Although there is a wide range of variance in cost, the mean attributable cost was $1006, $36,441, and $9669 for catheter-associated urinary tract infections, vascular catheter-associated infections, and ventilator-associated pneumonias, respectively (Table).

In addition to attributable cost, length of stay (LOS) is affected by HAIs. Perencevich et al. reviewed

Attributable Costs: HAI Cost Analysis, January 2001–June 2004[7]

Type of HAI	Attributable Costs Mean (SD)	Range
Surgical site	$25,546 (39,875)	$1783 to $134,602
Vascular catheter-associated infection	$36,441 (37,078)	$1882 to $107,156
Ventilator associated-pneumonia	$9669 (2920)	$7904 to $12,034
Catheter-associated urinary tract infections	$1006 (503)	$650 to $1361

HAI = hospital-acquired infections.

reports of attributable costs and excess LOS associated with various HAIs.[8] The excess LOS was 12 and 9 days for vascular catheter-associated infections and ventilator-associated pneumonias, respectively. Excess LOS for catheter-associated urinary tract infections can range from 1 to 3.8 days.

Mediastinitis after CABG surgery is also one of the HAIs that CMS will not reimburse. Mediastinitis, an infection involving the mediastinum, is a surgical emergency with a high mortality rate. The attributable cost for this CABG-associated surgical site infection can range from $7874 to $26,668 with an excess LOS ranging from 20 to 30 days.[8]

Infection control professionals are tasked with the responsibility of reducing these HAIs that are directly correlated with invasive procedures. Many participate in the Institute for Healthcare Improvement (IHI) 5 Million Lives Saved Campaign. Toolkits are provided to assist infection control professionals in prevention of vascular catheter-associated infections (also known as central line infections) and ventilator-associated pneumonia. Toolkits are also available for surgical site infection prevention. In addition, the CDC and JCAHO provide guidelines for infection prevention.

Briefly, vascular catheter-associated infections are prevented by the following measures: (1) practice good hand hygiene, (2) use maximal barrier precautions during catheter insertion, (3) use chlorhexidine skin antisepsis when inserting and during the care of the insertion site, (4) use of optimal site selection - subclavian vein is preferred for non-tunneled catheters, and (5) remove the catheter when it is no longer needed. Catheter-associated urinary tract infections are prevented by the following measures: (1) good hand hygiene, (2) good perineal care through adequate washing of the catheter and the site of insertion routinely, (3) securing the catheter to prevent biofilm dislodgement and irritation, and (4) removing the catheter when no longer needed. Ventilator-associated pneumonias are preventable when the 4 key ventilator bundle components are performed: (1) elevation of the head of the bed to an angle between 30 and 45 degrees, (2) peptic ulcer disease prophylaxis, (3) deep venous thrombosis prophylaxis, and (4) removal of the intubation tubing when deemed unnecessary (e.g., daily sedative interruptions and daily assessment of readiness to extubate).

It is important that CABG-associated infections, because of the high mortality rate, be prevented. Key indicators for prevention of all surgical site infections include giving the patient the most appropriate, effective antibiotic within 1 hour of incision, discontinuing the antibiotic within 24 hours of incision closure, and use of clippers for hair removal or not removing hair at all. In cardiothoracic surgery patients, glucose levels should be monitored during the first 48 hours after surgery and maintained below 200 mg/dL.

Methicillin-resistant *Staphylococcus aureus* (MRSA), *Clostridium difficile*, and vancomycin-resistant *Enterococcus* (VRE) are bacteria that cause HAIs and have received a large amount of attention in recent years. Infections with these bacteria, as with all, are easily prevented with good hand hygiene practice and environmental disinfection. However, many facilities struggle to reduce these infections as well.

MRSA is *S. aureus* with resistance against beta-lactams, particularly methicillin, oxacillin, and penicillin. Like *S. aureus* that are sensitive to methicillin (MSSA), MRSA can be found on the skin and in the noses of healthy people. Like MSSA, MRSA can cause superficial skin infections such as abscesses and boils. MRSA has the potential to develop into a deadly bloodstream infection and/or a deadly pneumonia. As many as 1.2 million hospital patients are infected with MRSA each year in the United States. A recent MRSA prevalence study found that 34 of 1000 patients had active MRSA infections, and 12 of 1000 patients were colonized with MRSA, which amounts to an MRSA incidence rate of 46 per 1000 patients.[9] Patients with MRSA bacteremia have additional hospital LOS of 2 days compared to patients without. Additionally, MRSA bacteremia can add additional hospital charges of up to $7272.[10] Patients who develop surgical site infections caused by MRSA have additional hospital LOS of 5 days and additional charges of $39,572.[11]

C. difficile causes a toxin-mediated diarrhea. Like MRSA, *C. difficile* targets hospitalized and immunocompromised patients, as well as healthy individuals.

Infectious diarrhea, with fatal outcomes, has been reported in all types of patients.[12–14] The rate of *C. difficile* acquisition is estimated to be 13% in patients with hospital stays of up to 2 weeks and 50% in those with hospital stays longer than 4 weeks.[12] Patients who share a room with a *C. difficile*-positive patient acquire the organism after an estimated hospital stay of 3.2 days, as compared with a hospital stay of 18.9 days for other patients.[13] The cost of *C. difficile* infection can reach $3669, which is 54% greater than the cost without the infection.[14]

VRE are *Enterococcus* species with resistance to one of the last resort antibiotics available. *Enterococcus* species normally reside in the intestines. Generally, VRE may inhabit a host and cause no discernable problems. Development of disease depends upon certain risk factors, including host-, hospital-, and medication-related variables. Patients with comorbidities are at increased risk of death, with 30% attributable mortality due to vancomycin resistance. These patients have an excess LOS of 2.9 to 27 days depending on the health status of the patient.[15] Hospital costs in VRE cases have been shown to be $52,449 as compared with that in non-VRE controls of $31,915 (relative risk = 1.4, $p < .001$).[16]

The potential problem with VRE is that it is capable of genetically transferring its resistance genes to such organisms as MRSA. Vancomycin-resistant MRSA (VR-MRSA) is a major threat, because it is expected to be highly communicable and difficult to treat because of limited antibiotic therapy. Even 1 case of VR-MRSA gives medical professionals around the world cause to tremble.

The aforementioned cases of infections are not the only types of HAIs that could potentially occur. Infection control professionals focus efforts to control the spread of other infectious diseases as well, such as multi-drug resistant microorganisms, chickenpox, tuberculosis, rotavirus, group B *Streptococci*, pertussis, Respiratory Syncytial Virus, bacterial meningitis, influenza, parvovirus B19, acquired immunodeficiency syndrome, hepatitis B, lice, scabies, and other respiratory, contact, and droplet-spread infections. The prevention-related tasks are plentiful, but the resources dedicated to infection prevention are vastly limited.

The up-front costs of prevention are small compared to the cost expended for HAIs. Typically, hospitals budget $100,000 for infection control programs. The budget is committed to employee salaries and benefits (not including management), office supplies, office space rent, and general and administrative costs. To cover educational tools such as new videos, frequently updated hand hygiene materials, or new electronic infectious diseases surveillance systems, $100,000 would not be enough. Since infection control is a non-revenue-producing department, $100,000 may be seen as sufficient. However, if a hospital monitors infection rates over time and shows infection reduction year after year, infection control should be considered a revenue-saving department. The resources saved should then be reinvested into further improvements for the department.

A possible infection control report could show the following trends (2006 vs. 2007): vascular-catheter associated infection (20 vs. 10), catheter-associated urinary tract infection (80 vs. 20), ventilator-associated pneumonia (18 vs. 4), and mediastinitis post-CABG (10 vs. 2). Using the attributable cost mean of $1006, $36,441, and $9669 for catheter-associated urinary tract infections, vascular catheter-associated infections, and ventilator-associated pneumonias, respectively, and $26,668 for mediastinitis, one can easily calculate the cost saving in 2007 versus 2006. In 1 year, there would be a cost savings of $773,480. Portions of these savings could be allocated to advance training of infection control staff, recruitment of more infection control professionals, and payment for new and updated educational tools and patient care equipment designed to assist infection prevention.

Graves in 2004 conducted sophisticated studies on the incremental benefits and incremental costs of infection prevention strategies.[17] The work explains how to calculate an incremental cost-effectiveness ratio when deciding to invest money in infection prevention strategies.

Cost containment and budget restraints have infection control and hospital leaders more interested than ever in the economic evidence regarding the attributable costs of HAIs and the cost-effectiveness of interventions aimed at reducing the morbidity and mortality associated with HAIs. Sufficient studies are available in the literature to provide benchmark data. With upcoming changes to the Medicare reimbursement schedule, infection prevention and control will be a major focus on hospital score, along with the financial reports. An understanding of infection prevention and its economic implications will allow infection control professionals to make better informed decisions.

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