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What is This?
The Business Case for Quality: Economic Analysis of the Michigan Keystone Patient Safety Program in ICUs

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Abstract
Health care-associated infections affect an estimated 5% of hospitalized patients and represent one of the leading causes of illness and death in the United States. This study calculates the costs and benefits of a patient safety program in intensive care units in 6 hospitals that were part of the Michigan Keystone ICU Patient Safety Program. On average, 29.9 catheter-related bloodstream infections and 18.0 cases of ventilator-associated pneumonia were averted per hospital on an annual basis. The average cost of the intervention is $3375 per infection averted, measured in 2007 dollars. The cost of the intervention is substantially less than estimates of the additional health care costs associated with these infections, which range from $12,208 to $56,167 per infection episode. These results do not take into account the additional effect of the Michigan Keystone program in terms of reducing cases of sepsis or its effects in terms of preventing mortality, improving teamwork, and reducing nurse turnover.

Keywords
hospital-acquired infections, nosocomial infections, economic evaluation, Keystone Program, business case for quality

Health care-associated infections (HAIs) are one of the most common complications of hospital care and a leading cause of death in the United States.1,3 HAIs affected an estimated 5% of patients hospitalized in the United States in 2002.4 These infections include surgical site infections (SSIs), catheter-associated urinary tract infections (CAUTIs), central
line-associated bloodstream infections (CLABSIs), ventila-
tor-associated pneumonia (VAP), and chest tube insertion
infections. Together, the first 4 categories account for more
than 75% of hospital-acquired HAIs. In 2002, they resulted
in 1.7 million infections and an estimated 99 000 deaths,
most of which resulted from CLABSIs and VAP.5

Between 45% and 65% of intensive care unit (ICU)
patients require mechanical ventilation,4 and an estimated
15% to 25% of hospitalized patients receive short-term
indwelling urinary catheters; the highest rates of urinary
catheter use are in ICUs.7,8 Approximately 48% of ICU
patients in the United States have central venous catheters,
accounting for 15 million central line days annually. There
are approximately 40 000 cases of VAP annually, leading
to an estimated 6000 deaths.9

The 2009 National Healthcare Quality Report, released
in April 2010 by the Agency for Healthcare Research and
Quality (AHRQ), finds that little progress has been made
toward eliminating HAIs.10 However, the Centers for
Disease Control and Prevention (CDC) recently reported
hopeful news: The estimated number of CLABSIs in ICUs
decreased by 58% between 2001 and 2009, from 43 000 to
18 000.9 In the United States, in 1992, HAIs were the fifth
leading cause of death in acute care hospitals.11

The health and economic impacts of these infections
are extensive.12 Estimates of the total financial burden
related to HAIs in the United States range from $4.5 to
$45 billion annually.4,11,13,14 Published estimates of the impact
of a CLABSI include an 18% increase in the probability of mortality and a 13-day increase in ICU
length of stay (LOS).12,13 Cost estimates for CLABSIs
range widely. A 2001 US study found that, after adjust-
ing for demographics and severity of disease, CLABSIs
are associated with an increase of $56 167 in total hospital
costs.16 The leading causes of variation are the small sample
sizes of the studies, difficulty in allocating inpatient costs,
differences in the time frames used, the economic perspec-
tive employed, and the cost categories included.17,18

A 2007 review of the literature identified costs per
CLABSI ranging from $2820 to $13 000, with a mean of
$10 531 in 2005 US dollars, equivalent to $12 208 in 2010
US dollars.19 A detailed study of the additional marginal
costs associated with these infections in Calgary, Canada,
found somewhat higher costs attributable to ICU-acquired
bloodstream infections (BSI) of $25 155 Canadian dollars
per case, equal to $19 199 in 2010 US dollars.18 Estimates
that include the extra LOS in a hospital resulting from
these infections range up to $22 939 for CLABSIs and

Preventing HAIs: The Need
for a Business Case
Increased attention has been focused on hospital-acquired
HAIs, and it has become clear that some HAIs are pre-
ventable. But as prevention efforts move forward, a lack
of evidence of a strong return on investment for hospitals
and health care payers presents a potential roadblock to
further efforts to prevent infections.20 Under current pay-
ment mechanisms, financial investments by provider or-
ganizations in patient safety and quality improvement often
are not recovered. In fact, if these improvements lead to
reductions in LOS or in the case-mix index, they may actu-
ally result in reduced revenues per patient for the provider,
even though health care payers realize savings.

As a result, there is a need for a viable business case for
initiatives to improve quality and patient safety. The term
business case in health care has been coined to describe
a situation in which the organization investing in an inter-
vention realizes a positive return on investment within a
defined time period and using an accepted discount rate.
Beyond the purely financial aspect within the specified
time period, a business case in health care may be based
on improvements in organizational function and sustain-
ability that have long-term benefits.21

Current reimbursement structures in the US health care
system do not provide incentives to reduce HAIs.22 Payment
incentives for hospitals, whether based on per-case or
fee-for-service payment, typically encourage volume
rather than outcomes—although this is changing with a
movement toward quality-based purchasing. To date,
few published studies have demonstrated an economic
argument for infection control and other aspects of qual-
ity improvement, and patient safety advocates are in
agreement that a lack of evidence of a financial payoff is
a barrier to further progress in this area.19,23,24 Our study
calculates the results of a patient safety intervention in
the form of a cost-effectiveness analysis presented as the cost
per infection averted and also conducts an economic cost-
benefit analysis from the hospital perspective for the imple-
mentation of a patient safety initiative.

The Michigan Keystone
ICU Patient Safety Program
The Michigan Keystone ICU Patient Safety Program was
based on the Johns Hopkins Quality and Safety Research
Group (QSRG) improvement program and facilitated by
QSRG faculty. It included 2 key components: (a) a
Comprehensive Unit-Based Safety Program, which included
interventions to improve safety culture, teamwork, and
communication; a daily goals sheet; and other communi-
cation tools; and (b) specific interventions to improve
compliance with evidence-based care to reduce CLABSIs
and VAP that were derived using the QSRG method for
Translating Evidence into Practice. A total of 108 ICUs in
the state participated; 103 ICUs reported data.

The mean rate of incidence for CLABSIs decreased
from 7.7 per 1000 catheter days at baseline to 1.3 at 16 to 18
months follow-up, and to 1.1 at 34 to 36 months follow-up.
The median rates for CLABSIs decreased from 2.7 at baseline to 0 at 16 to 18 months and thereafter.25,26 VAP decreased from a mean of 6.9 (median 5.5) per 1000 ventilator-days at baseline to 3.4 (median 0) at 16 to 18 months, and to 2.4 (median 0) at 28 to 30 months postimplementation ($P < .001$) (S. M. Berenholtz et al, unpublished data, February 2011).

**Methods**

For the economic analysis, we used the perspective of the hospital. For the in-depth costing analysis, the Michigan Health and Hospital Association (MHA) chose a subsample of 6 hospitals that participated in the main Keystone ICU project. To be as representative as possible of the overall sample, this subsample includes all the ICUs in the 6 hospitals, which represent the following types of institutions:

- A large academic medical center
- A medium-size community hospital (100-400 beds) with intensivist and/or hospitalist staffing
- A medium-size community hospital (100-400 beds) without intensivist and/or hospitalist staffing
- A rural hospital (51-100 beds) with intensivist/hospitalist staffing
- A rural hospital (51-100 beds) without intensivist/hospitalist staffing
- A small rural hospital (26-50 beds)

To derive the sample, hospital ICUs were stratified by total hospital beds, teaching status, and urban versus rural status and then randomly sampled within these strata to obtain the sample of 6 hospitals for the costing exercise. Within the medium-size community hospital and the larger rural hospital strata, the MHA sampled until selecting 1 hospital with and 1 hospital without ICU intensivist or hospitalist staffing, operationalized as ICUs in which intensivists or hospitalists conduct daily rounds on the majority of ICU patients, consistent with the Leapfrog Group’s definition.27

To maintain the confidentiality of the hospitals and their staff, we have not listed the hospital names in this article. All 6 hospitals started the BSI intervention in the time period of June to September 2004. Five started the VAP intervention during this same time frame; 1 began the VAP intervention in January 2005.

**Activity-Based Costing**

The incremental operational costs of the Keystone ICU project (ie, salary costs for hospital staff; costs for equipment, supplies, laboratory, pharmaceutical) were calculated using activity-based costing (ABC) techniques.28,29 ABC allocates indirect costs (ie, personnel salaries and benefits) by defining the programs’ principal activities and assigning costs through these activities. ABC uses interviews to determine the distribution of individuals’ time among these activities. Indirect costs are linked to services through time allocation. The result is an estimate of unit costs that is potentially more accurate than when indirect costs are allocated in proportion to outputs (volume costing) or by using ratios to convert charges to costs (cost-to-charge ratios). The principal reason for enhanced accuracy is that indirect costs are allocated in proportion to personnel time, which more closely mirrors the actual consumption of resources than does allocation based on volume or on a standardized ratio at the department level.30

Additionally, ABC allows for the costing of incremental inputs, including supplies and labor, associated with a quality improvement intervention.

To carry out ABC, we conducted a series of semistructured interviews with staff in each of the 6 hospitals to determine the inputs into intensive care before and after the implementation of the intervention. These interviews followed a set questionnaire focusing on the principal activities of each type of staff and the time spent on each activity. In each hospital, these interviews included the following staff categories and numbers of individuals:

- ICU director
- Intensivists (2-3)
- Other physicians (2-3)
- ICU nurses (3-4)
- Keystone ICU team leaders (1-2)
- Senior-level hospital administrators (1-2)
- Infection prevention staff (1-2)
- Pharmacists (1-2)

The cost categories collected included the following:

- **Initial education and training** expenses for the Keystone ICU project, including time spent organizing and planning the training and education sessions, communicating and meeting with representatives from the MHA and the Keystone Center, and other preparation for the program. Material costs include facility rental, transportation, supplies, and food.
- **Capital purchases** and investments associated with the intervention, including necessary equipment such as BSI line carts and central line insertion carts.
- **Ongoing time spent on the intervention**, including continued training and meetings, as a percentage of total time commitment for each staff category.
- **Average annual salary** for each category of personnel working in the ICU, including nurses (by category), physicians (by category), administrators, support staff, and other specialist staff (eg,
Calculating Cases Averted

To calculate the number of CLABSI and VAP cases averted by the intervention for each hospital, we extracted the estimated median and mean CLABSI and VAP rates—expressed as the number of cases per 1000 days of exposure on the catheter or ventilator per 3-month interval of time—from the published articles describing the Keystone ICU Patient Safety Program.25,26 We compared the estimated mean and median rates during the final quarter of the sustainability period to the corresponding baseline rate to obtain the cases averted per 1000 days of exposure per quarter and then converted this to cases averted in a 1-year time period.

The number of infections averted for a given quarter (3-month period) is calculated as the difference between the baseline rate of infections per 1000 catheter days and the rate for that quarter, multiplied by the number of catheter or ventilator days (in thousands) for that quarter. We also calculated the number of infections averted using the median number of infections averted by hospital. We then applied the rates of cases averted to the average number of days of exposure for all ICUs that participated in the project for fiscal year 2008, which is the most recent 12-month period with complete data corresponding to the time period for the costing analysis.

Results

The results of interviews with hospital staff show that, on average, clinical staff currently spend the following percentages of their total working time on activities associated with the Keystone ICU intervention: nurses, 8.9%; physicians, 12.2%; respiratory therapists, 12.5%; infection control practitioners, 7.5%; and pharmacists, 6.5%. These percentages include a range of activities. For example, the ongoing activities for nurses associated with the Keystone project include the following:

- Reviewing journal articles
- Assisting with the placement of central lines
- Completing rounds and assessing central lines
- Coaching calls
- Changing tubing (every 36 hours)
- Changing intravenous fluids (every 12 hours)
- Administrative time
- Time spent on conferences, monthly and bimonthly meetings, and support activities

Salary, benefits, and other costs were obtained directly from each hospital. Costing and outcomes results are presented as an aggregate for the 6 hospitals, with the average costs per hospital presented by category (Table 1).

In the 3 years following the intervention, the 6 hospitals averaged 4532 catheter line days per year. The intervention resulted in a decrease in the mean level of CLABSIs from 7.7 to 1.1 per 1000 catheter days at the end of 36 months; the median rate decreased from 2.7 to 0 over the same time period.26 Applying the mean rate shows that, on average, 29.9 CLABSIs were averted annually at each of the 6 hospitals by fiscal year 2008.

The overall mean VAP rate decreased from 6.9 per 1000 ventilator-days at baseline to 2.4 at 30 months post-implementation; the median VAP rate decreased from 5.5 to 0 (S. M. Berenholtz et al, unpublished data, February 2011). Applying the mean rate to the number of ventilator days in each ICU shows that the intervention averted 18.0 cases of VAP at each hospital on an annual basis. Summing together VAP and CLABSI rates, the intervention averted 47.9 infections per hospital on an annualized basis. Therefore, cost of the intervention is $3375 per infection averted, measured in 2007 dollars. If the median hospital infection rate is used as the main outcome measure rather than the mean, the cost per infection averted is $4725.

Discussion

The cost of the intervention is modest when compared with the health care costs associated with these infections. In the United States, CLABSIs are associated with excess mortality as well as extra hospital costs, which range from $12,208 to $56,167 per case.12,15,16,19,36,37 Even using the conservative estimates of infection costs, the Keystone ICU Patient Safety Program clearly is financially beneficial to hospitals—directly comparing costs incurred to costs averted—as well as being cost-effective in terms of...
Table 1. Annualized Costs of Implementation of the Keystone ICU Patient Safety Program, Average per Hospital

<table>
<thead>
<tr>
<th></th>
<th>FY 2004-2005</th>
<th>FY 2008 (Annualized)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Startup costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education and training expenses (per diem)</td>
<td>$3035</td>
<td>$691</td>
</tr>
<tr>
<td>Nurses (8 on average per hospital)</td>
<td>$19,534</td>
<td>$4,397</td>
</tr>
<tr>
<td>Physicians (2 on average per hospital)</td>
<td>$33,357</td>
<td>$7,591</td>
</tr>
<tr>
<td>Respiratory therapists</td>
<td>$3,459</td>
<td>$787</td>
</tr>
<tr>
<td>Infection control staff</td>
<td>$1,488</td>
<td>$339</td>
</tr>
<tr>
<td>Pharmacists</td>
<td>$2,047</td>
<td>$466</td>
</tr>
<tr>
<td>BSI line cart/central line insertion cart</td>
<td>$1,500</td>
<td>$341</td>
</tr>
<tr>
<td><strong>Ongoing costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurses (8.9% of time on average)</td>
<td>$47,652</td>
<td></td>
</tr>
<tr>
<td>Physicians (12.2% of time)</td>
<td>$64,123</td>
<td></td>
</tr>
<tr>
<td>Respiratory therapists (12.5% of time)</td>
<td>$6,666</td>
<td></td>
</tr>
<tr>
<td>Infection control preventionists (7.5% of time)</td>
<td>$4,000</td>
<td></td>
</tr>
<tr>
<td>Pharmacists (6.5% of time)</td>
<td>$4,764</td>
<td></td>
</tr>
<tr>
<td>Chlorhexidine</td>
<td>$2,058</td>
<td></td>
</tr>
<tr>
<td>Oral care kits</td>
<td>$6,000</td>
<td></td>
</tr>
<tr>
<td>Sterile central line dressing kits</td>
<td>$10,000</td>
<td></td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td>$161,584</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: ICU, intensive care unit; FY, fiscal year; BSI, blood stream infection.

...cost per CLABSI averted. The potential implications of these findings are large; estimates of the total financial burden currently attributable to HAIs in the United States range from $4.5 to $45 billion annually.4,14

Using the average hospital cost and infections averted, and an estimate of averted costs of $36 500 per CLABSI and $10 000 per VAP, the difference between the financial benefits and the costs of the intervention for the average hospital is $1.1 million per year. In economic terms, the patient safety intervention is dominant in that, without question, the benefits exceed the costs. Because the costs are concentrated in the beginning years of the intervention, the further the horizon of the study is extended into the future, the more this is true.

In addition, our results do not take into account the positive effects of the Keystone ICU Patient Safety Program on cases of sepsis, on an improved culture of patient safety, and on staff turnover. Considerable mortality also results from CLABSI and VAP. The CDC estimates that there are 250 000 cases of CLABSI in hospitals in the United States per year, with an attributable mortality rate of 12% to 25%; similar results have been found in Canada.18,38,39 Applying this rate to our intervention in Michigan suggests that between 3.4 and 7.2 deaths from CLABSI per hospital have been prevented annually by the Keystone ICU project.

It would be ideal to be able to compare the ABC results with results obtained from other costing methods and sources, including cost-to-charge ratios and annual Medicare cost reports (collected through UB-92 forms). The principal issue is that these sources provide estimates in terms of conditions, procedures, and hospital days. These estimates do not lend themselves to micro-costing for a new intervention such as the Keystone ICU Patient Safety Program, which leads to marginal increases in resources used (ie, personnel time, equipment, supplies) and the indirect costs that support these resources.

This difference lies at the core of the rationale for using ABC and other micro-costing methods to calculate the cost of new health care interventions, technologies, and programs.30,40,41 ABC can be adapted readily to calculate the cost of a new intervention, and to conduct cost-effectiveness analysis, while traditional costing methodologies and cost-to-charge ratios cannot.32,43

This study has several limitations. First, the hospitals selected may not be representative of Michigan or US hospitals. However, a diverse group of hospitals was selected for the costing study in terms of key characteristics that might affect the costing results, including hospital size, urban versus rural status, and teaching status. The outcomes of the program were similar in this subset of hospitals and in the overall sample in Michigan.

Additionally, our methods of measuring costs focus on the provider perspective and did not include longer term health care costs, productivity losses, or a society perspective. This likely underestimates the savings. People who stay in the ICU generally have longer stays in a rehabilitation facility, greater use of home health services, and longer absences from work. These costs are likely to be substantially greater than the hospital costs. Third, the results from Michigan may not be generalizable to the country. However,
Rhode Island has implemented the Hopkins program with similar results, as has the Adventist health system. A total of 35 US states are implementing the program currently. Finally, we did not include the cost of the funding from AHRQ to conduct the study.

Despite these limitations, this study has significant policy implications. There has been substantial uncertainty regarding the economic impact of reduced complications on hospital performance. Without a strong business case, hospitals may be reluctant to embark on meaningful efforts to improve safety. This study fills a knowledge gap by demonstrating cost savings that result from implementing patient safety programs. The return on investment is approximately 10 to 1.

On April 12, 2011, the US Department of Health and Human Services launched the Partnership for Patients, a public–private partnership designed to make hospital care both safer and less expensive. The principal goals of the partnership are to reduce hospital-acquired HAIs by 40% in 2013 compared with 2010 and to reduce hospital readmissions by 20% during the same time period.

The results of our study show that there is a strong connection between hospital quality and economic outcomes. In 2008, the Centers for Medicare and Medicaid Services (CMS) stopped paying hospitals for cases involving “never events”—potentially preventable adverse events including CAUTIs, SSIs, and CLABSIs. CMS’ action further aligns the incentives among hospitals, health care payers, and society overall. The results of this study should further encourage hospitals to implement the Keystone ICU Patient Safety Program and other robust quality improvement programs.

Acknowledgments
The authors are grateful for the collaboration of staff at each of the hospitals involved in this study, including the preparation and provision of financial data, and patience with staff interviews.

Authors’ Notes
Dr Waters had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Declaration of Conflicting Interests
The authors declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Drs Pronovost and Goeschel have received grant support from the Agency for Healthcare Research and Quality, the Robert Wood Johnson Foundation, the National Patient Safety Agency, and the World Health Organization to study and improve quality of care, including catheter-related bloodstream infections. They have received lecture fees from various health care organizations. Dr Goeschel also has received lecture fees from government agencies to speak on quality and patient safety. Dr Pronovost has received lecture fees from Lilly, Merck, Edward Life Sciences, and Sage for various speaking engagements. Dr Needham has had grant and contract support from the National Institutes of Health/National Heart, Lung, and Blood Institute and a clinician-scientists award from the Canadian Institutes of Health Research. Any conflicts of interest were resolved during the peer-review process. The other authors disclosed no conflicts of interest.

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