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Major Article

Epidemiology and economic impact of health care–associated infections and cost-effectiveness of infection control measures at a Thai university hospital

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Epidemiology
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Background: Data on clinical and economic impact of health care–associated infections (HAIs) from resource limited countries are limited. We aimed to determine epidemiology and economic impact of HAIs and cost-effectiveness of infection prevention and control measures in a resource-limited setting.

Methods: A retrospective cohort study was conducted among hospitalized patients at Siriraj Hospital, Thailand. Results from the cohort were subsequently used to conduct cost-effective analysis (CEA) to compare the comprehensive implementation of individualized bundling infection control measures (IBICMs) with regular infection control care.

Results: From February-May 2013, there were 515 hospitalizations (497 patients) with 7,848 hospitalization days. Cumulative incidence of HAIs was 23.30%, and the incidence rate of HAIs was 18.66 ± 44.19 per 1,000 hospitalization days. Hospital mortality among those with and without HAIs was 33.33% and 20.00%, respectively ($P < .001$). The adjusted cost attributable to HAIs was \$704.72 ± \$226.73 ($P < .001$). CEA identified IBICMs as a non-dominated strategy, with an incremental cost-effectiveness ratio of –\$20,444.62 per life saved.

Conclusions: HAI is significantly related with higher hospital mortality, longer length of stay, and higher hospitalization costs. IBICMs were confirmed to be cost-effective at Siriraj Hospital. Implementing this intervention could improve care quality and save costs.

Health care–associated infection (HAI) is considered a worldwide health burden.[1,2] In addition to an increase in patient morbidity and mortality, HAI results in longer hospital stays and greater hospitalization costs.[3-5] According to a recent meta-analysis study, the estimated costs for the 5 major HAIs were \$9.8 billion (95% confidence interval, \$8.3 billion-\$11.5 billion) per year.[5]

Various infection control (IC) strategies and bundles have been shown to be effective in preventing HAIs.[6-9] Many guidelines for preventing and controlling HAIs have been published[10-14]; however, the prevalence of HAI is still unacceptably high worldwide.[5,15-17] A recent study evaluating HAIs in U.S. hospitals estimated that approximately two-thirds of cases of central line–associated bloodstream infection (CLABSI) and catheter-associated urinary tract infection and more than half of those with ventilator-associated pneumonia and soft tissue and skin infection may be preventable with current evidence-based strategies.[18] In 2009, the Centers for Medicare and Medicaid Services stopped payment for some selected HAIs that occurred during hospital stays and were not present on admission.[19] That policy was designed to promote IC through the use of financial incentives.

In 2009, Korbkitjaroen et al conducted a cluster-randomized controlled study to evaluate the effectiveness of comprehensively implementing individualized bundling infection control measures (IBICMs) in general medical wards at Siriraj Hospital, Thailand.[9] The IBICMs consisted of a daily visit by the IC team until a given patient left the hospital. The IC team identified and then eliminated or minimized risk factors for developing hospital-acquired infection in each patient. The IBICMs were able to reduce the cumulative incidence of HAIs from 9.2% to 5.6% ($P = .003$). Despite their documented effectiveness, IBICMs have not yet been fully implemented at Siriraj Hospital because that would require additional resources.

Better understanding of the clinical and economic impact of HAIs would help convince policymakers to allocate more resources for infection prevention and control measures. Therefore, the present

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study aimed to determine the epidemiology and economic impact of HAIs and the cost-effectiveness of infection prevention and control measures.

MATERIALS AND METHODS

This study comprised 2 parts: (1) a retrospective cohort study to determine the epidemiology and economic impact of HAIs; and (2) a cost-effectiveness analysis of infection prevention and control measures.

Retrospective cohort study

Study design and settings

We conducted a retrospective cohort study among hospitalized patients in 6 general medical wards at Siriraj Hospital. Siriraj Hospital is a 2,200-bed university hospital, and it is the largest referral tertiary health care center in Bangkok, Thailand. The study protocol was approved by the Siriraj Institutional Review Board, which waived the need for informed consent from the patients.

Study population

Eligible patients were hospitalized adults (age ≥15 years) who were hospitalized in the 6 general medical wards from February-May 2013. We included only hospitalizations with length of stays ≤180 days.

Data collection

We obtained baseline characteristics, clinical data, and microbiologic data by performing chart review. Chart review was performed by 2 independent clinician investigators. The necessary data included demographics, previous hospitalization, underlying diseases, and diagnosis on admission and during hospitalization. We also collected data on central vascular catheter use, urinary catheter use, and ventilator support. For HAI patients, we further retrieved data on details of the HAIs, microbiologic data, and clinical outcomes, including hospital mortality and length of hospital stay. We obtained hospitalization costs directly from the hospital's administrative database.

Study definitions

We used Centers for Disease Control and Prevention (CDC) and National Healthcare Safety Network (NHSN) surveillance definitions for particular types of HAIs in diagnosing the kinds of infection.[20,21] We considered an infection to be an HAI if the date of the event of the CDC-NHSN site-specific infection criterion occurred on or after the third calendar day of admission.

Statistical analysis

We determined the cumulative incidence and incidence rate per 1,000 hospitalization days of the HAIs and each NHSN site-specific infection. Continuous variables are reported as mean ± SD, median, and range according to the data distribution. Categorical variables are indicated as frequency and percentages. We subsequently compared the baseline characteristics, clinical outcomes, and hospitalization costs of patients with and without HAIs. Univariate analysis was performed by χ^2 test or Fisher exact test for categorical variables and Student *t* test or Mann-Whitney *U* test for continuous variables.

Both unadjusted (simple linear regression) analysis and adjusted (multiple linear regression) analysis were performed to estimate the attributable length of stay and attributable costs of HAIs. Hospitalizations with an outlier length of stay and/or outlier cost of hospitalization (<5th or >95th percentile) were excluded from the analysis. Multiple linear regression model analysis was carried out by the stepwise method, including all associated variables with a *P* value of ≤.20 in univariate analyses.

All analyses were performed by using STATA/IC version 14.0 (STATA Corp, College Station, TX). A 2-tailed *P* value of <.05 was considered significant.

Cost-effectiveness analysis

Model structure

We used a model to compare IBICMs[9] with regular IC care measures. The simple decision tree model consisted of 2 strategies, regular IC care and the IBICM intervention, as shown in Figure 1. The model focused on hospital mortality and direct medical costs. Time and cost discounting were not considered in the model.

Model parameters

Epidemiologic data. During the period of retrospective cohort study, the regular measures for HAI prevention were taken place in the hospital. Therefore, the baseline epidemiologic data, including cumulative incidence of HAIs, hospital mortality, and length of hospital stay, were obtained from the retrospective cohort study.

Efficacy of the IBICM intervention. According to the study of Korbkitjaroen et al, the IBICMs were able to reduce the cumulative incidence of HAIs from 9.2% to 5.6%. Therefore, the relative risk reduction (RRR) of the IBICMs was 39.1% (95% confidence interval, 14.9-55.9).[9] The probability of developing HAI in the IBICM group was equal to the probability of developing HAI in the regular IC care group multiplied by (1 – the RRR of the IBICMs).

Cost data. All of the costs were estimated from the provider's perspective and are reported in U.S. dollars. Only direct medical costs were focused on in this study. Costs of hospitalization among those with and without HAIs were extrapolated from the retrospective cohort study. The cost of IBICMs included the cost of personal protective equipment, the cost of preprinted IC checklists, and an average salary of the IC nurse. The cost of IBICMs was calculated using the national pricelist.

Analysis

By using a simple decision tree model, we calculated the expected cost per hospitalization (U.S. dollars), expected lives saved, cost per expected life saved (CER), and incremental cost-effectiveness ratio (ICER) of each strategy. We subsequently performed sensitivity analyses of the IBICM cost and its effectiveness (RRR).

RESULTS

During the 4-month study period, there were 515 hospitalizations (for 497 patients) with 7,848 hospitalization days. Of those 515 hospitalizations, 66.41% of the patients were women, with a mean age of 62.47 ± 17.99 years. The mean length of stay was 15.23 ± 15.21 days, and hospital mortality was 23.11%.

Epidemiology and financial impact of HAIs

The cumulative incidence of HAIs was 23.30% (120/515), and the HAI incidence rate was 18.66 ± 44.19 per 1,000 hospitalization days. The distribution of CDC-NHSN site-specific infections appears in Table 1. The 3 leading sites of HAIs were lower respiratory tract infection (11.07%), urinary system infection (5.63%), and gastrointestinal tract infection (4.27%). Five common causative pathogens were *Staphylococcus aureus* (12.5%), *Escherichia coli* (10.8%), *Klebsiella pneumoniae* (10.8%), *Acinetobacter baumannii* (5.8%), and *Enterococcus* spp (5.8%). Full distribution of causative pathogens is available from the authors on request.