American Journal of Infection Control 43 (2015) 4-9

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

A decade of investment in infection prevention: A cost-effectiveness analysis

Andrew W. Dick PhD [a,*], Eli N. Perencevich MD, MS [b], Monika Pogorzelska-Maziarz PhD, MPH [c], Jack Zwanziger PhD [d], Elaine L. Larson PhD, FAAN [e,f], Patricia W. Stone PhD, FAAN [f]

[a] RAND Corporation, Pittsburgh, PA
[b] Divisions of General Internal Medicine and Infectious Diseases, Department of Internal Medicine University of Iowa, Carver College of Medicine and Iowa City VA Medical Center, Iowa City, IA
[c] Jefferson School of Nursing, Thomas Jefferson University, Philadelphia, PA
[d] Health Policy and Administration, School of Public Health, University of Illinois at Chicago, Chicago, IL
[e] Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY
[f] Center for Health Policy, School of Nursing, Columbia University, New York, NY

Key Words:
Central line–associated bloodstream infections
Ventilator-associated pneumonia
Cost analysis
Economic evaluation
Quality of life
Long-term costs

Background: Health care–associated infection (HAI) rates have fallen with the development of multifaceted infection prevention programs. These programs require ongoing investments, however. Our objective was to examine the cost-effectiveness of hospitals' ongoing investments in HAI prevention in intensive care units (ICUs).
Methods: Five years of Medicare data were combined with HAI rates and cost and quality of life estimates drawn from the literature. Life-years (LYs), quality-adjusted LYs (QALYs), and health care expenditures with and without central line–associated bloodstream infection (CLABSI) and/or ventilator-associated pneumonia (VAP), as well as incremental cost-effectiveness ratios (ICERs) of multifaceted HAI prevention programs, were modeled.
Results: Total LYs and QALYs gained per ICU due to infection prevention programs were 15.55 LY and 9.61 QALY for CLABSI and 10.84 LY and 6.55 QALY for VAP. Reductions in index admission ICU costs were $174,713.09 for CLABSI and $163,090.54 for VAP. The ICERs were $14,250.74 per LY gained and $23,277.86 per QALY gained.
Conclusions: Multifaceted HAI prevention programs are cost-effective. Our results underscore the importance of maintaining ongoing investments in HAI prevention. The welfare benefits implied by the advantageous ICERs would be lost if the investments were suspended.

Each year in the United States, approximately 1.7 million patients suffer a health care–associated infection (HAI), of whom nearly 100,000 die.[1] The estimated overall direct annual cost of HAIs ranges from $28 to $45 billion, and health care–associated sepsis and pneumonia are among the most costly in terms of mortality as well as financially.[2] In a study of patients who underwent invasive surgery, the attributable mean length of stay was 10.9 days, costs were $32,900, and mortality was 19.5% for each case of hospital-acquired sepsis; the corresponding values for hospital-acquired pneumonia were 14.0 days, $46,400, and 11.4%.[3] The majority of these infections are associated with external devices inserted in intensive care units (ICU), namely central line catheters and ventilators.[4]

Various evidence-based clinical interventions, including bundles and guidelines, have been published in an effort to decrease HAIs in the ICU.[5-7] Effective implementation of these interventions is crucial to support clinician adherence at the bedside and reduce HAI rates.[8-10] Indeed, focusing on improving the organizational culture by promoting standardized evidence-based practice protocols and providing clinician compliance audit and feedback loops,

* Address correspondence to Andrew W. Dick, PhD, RAND Corporation, 4570 Fifth Ave, Pittsburgh, PA 15213.
E-mail address: andrewd@rand.org (A.W. Dick).
This study was funded by the National Institute of Nursing Research (R01NR010107). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Nursing Research.
Conflicts of interest: None to report.

0196-6553/$36.00 - Copyright © 2015 by the Association for Professionals in Infection Control and Epidemiology, Inc. Published by Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.ajic.2014.07.014

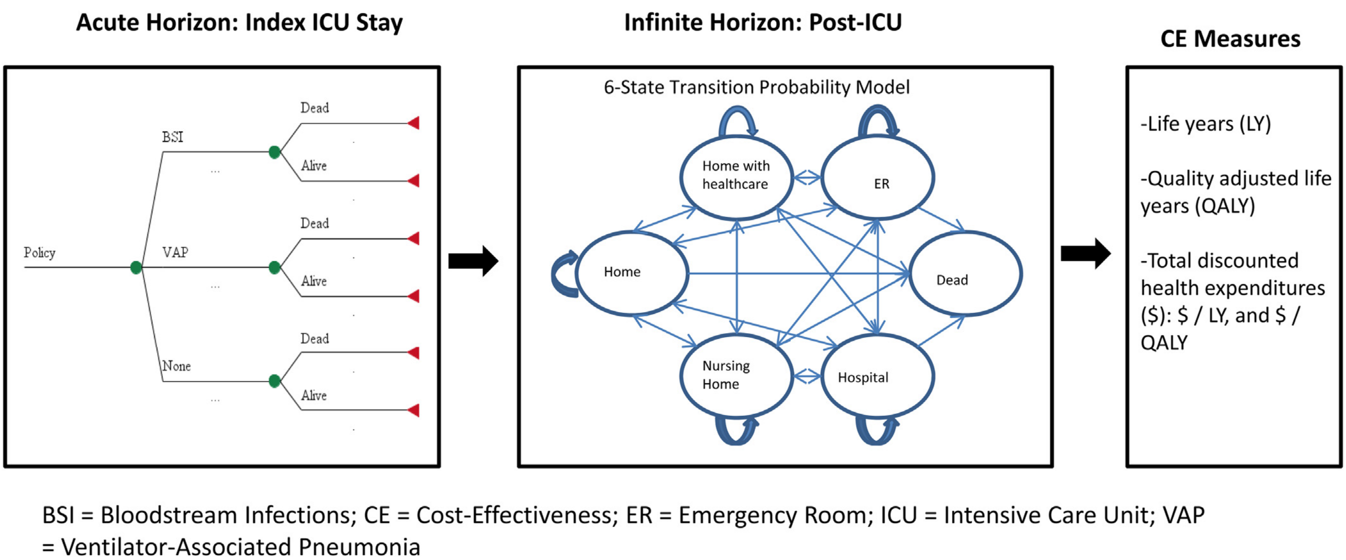

Fig 1. A long-term HAI cost-effectiveness policy model featuring a decision model for the index ICU stay and a 6-state transition probability model for the post-ICU stay.

expert-led educational sessions, and forums for dissemination are often needed to improve clinician adherence and patient safety. Such interventions are most often accomplished in hospitals by investing in multifaceted infection prevention programs.[7,11]

As a result of past investments, the United States has seen vast improvements in many HAI rates, with impressive progress toward the 5-year targets set out in the HAI Action Plan.[12] However, focusing on infection prevention uses limited and competing resources and requires an ongoing financial commitment by the institution. In addition, the foregoing cost and resource utilization estimates are limited to those directly incurred by the institution during the hospitalization in which the infection occurred. The societal welfare benefits of improved HAI prevention in the hospital include not only the immediate health benefits and cost reductions of infection prevention, but also the long-term benefits of improved survival and the value of future health care expenditures. Furthermore, these long-term posthospitalization costs are important to those needing a societal perspective, such as the Centers for Medicaid and Medicare Services (CMS), other insures, and those implementing accountable care organizations.

Cost-effectiveness modeling can guide public policy and institutional investment decisions by quantifying the long-term health and economic consequences attributable to different strategies, and help clarify the full impact of the infections, as well as the value of past and future investments in reducing infections. Using a societal perspective, the present study aimed to examine the cost-effectiveness of a hospital's ongoing investment in preventing HAIs in an ICU. To do so, we developed a model that estimates the attributable long-term patient outcomes and health care expenditures associated with a multifaceted infection prevention program designed to decrease the rates of central line–associated bloodstream infection (CLABSI) and ventilator-associated pneumonia (VAP). The comparator was usual care without an ongoing investment in an infection prevention program.

METHODS

Long-term cost-effectiveness HAI prevention policy model

We developed a long-term HAI cost-effectiveness policy model that starts with an index hospitalization during which an elderly subject has an ICU stay. Each subject's experience during the index ICU stay was characterized, including the probability of developing a CLABSI or VAP, the conditional probability of inpatient death due to the specific HAI type, and the incremental hospital costs associated with each infection. We modeled 5-year postdischarge experiences using a 6-state (ie, living in community, using home health care, living in a nursing home, inpatient hospital, emergency room visit, and dead) discrete-time dynamic model to estimate postdischarge survival, quality of life, and health care costs, each of which were conditional on having or not having experienced an HAI during the index ICU stay (Fig 1). We examined alternative assumptions about the lasting consequences of infections. The time horizon for the model was lifetime, and we calculated incremental cost-effectiveness ratios (ICERs) both as costs per life year (LY) and as costs per quality-adjusted LY (QALY). Because the intervention is applied at the unit level, we present ICERs at the unit level.

The ICU was chosen as the setting for this study because critically ill patients are at the greatest risk for infection, surveillance data regarding infections are readily available from ICUs, and evidence of efficacy of infection prevention programs exist and are the focus of national targets. The choice of elderly subjects is relevant, because the majority of ICU patients are elderly, and also pragmatic, because it allowed us to use Medicare data for long-term follow-up. The 6 health states were chosen because they reflect meaningful differences in quality of life and associated health care utilization.

Data

Base case model parameters were drawn from the literature (Table 1) or estimated from 2 unique datasets compiled by the research team. The first dataset was a cohort of 17,537 elderly Medicare patients admitted to 31 hospitals during 2002 with clinical data on HAI outcomes from infection surveillance conducted by infection preventionists and submitted to the Centers for Disease Control and Prevention's (CDC) National Nosocomial Infection Surveillance (NNIS) system. These data were augmented with 5 years of Medicare claims data that allowed us to assess the long-term health outcomes and health care utilization attributable to HAIs.[13] The second dataset was from a recent National Healthcare Safety Network (NHSN) research group in which 701 hospitals provided ICU-specific device utilization and HAI rates for