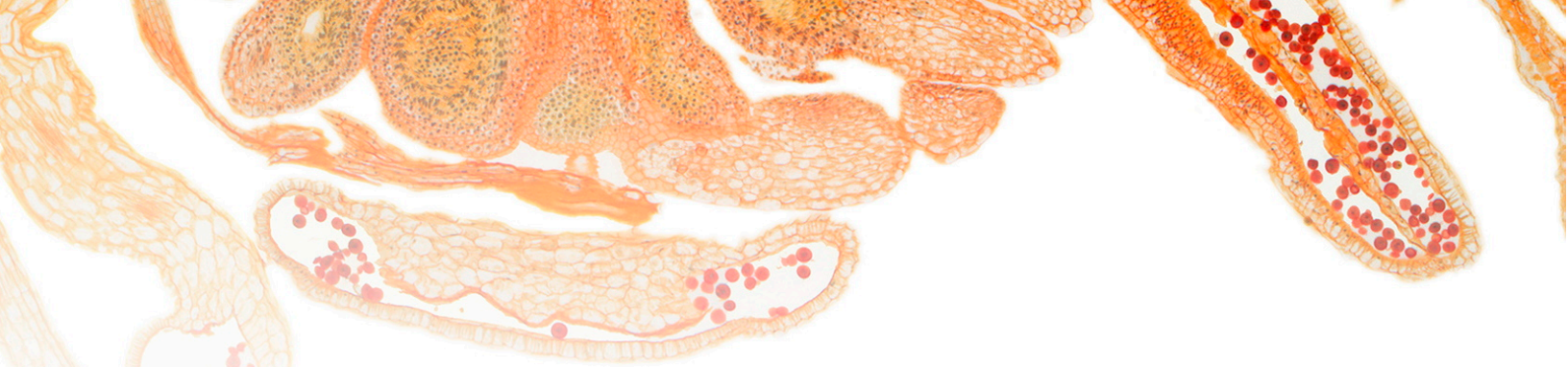

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How Should Economic Analyses Inform Nosocomial Infection Control?

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Abstract

Nosocomial infections are public health threats with often grave human costs. Because implementing screening and best outbreak response practices is costly for health care organizations, allocating resources for interventions requires consensus among stakeholders with a plurality of perspectives about how to weigh prospective interventions' risks and benefits. Economic analysis can facilitate decision making but is relatively new in nosocomial infection prevention and control. This article describes features of and reasons for economic analysis in this specific area and focuses on emerging challenges in antimicrobial stewardship.

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Nosocomial Infection Costs

Nosocomial infections are a pervasive and costly public health threat. The 5 major health care-associated infections—central line-associated bloodstream infections, ventilator-associated pneumonia, surgical site infections, *Clostridioides* (formerly *Clostridium) difficile* infection, and catheter-associated urinary tract infections—add an estimated $9.8 billion annually in direct US medical costs.[1] If direct, indirect, and societal nonmedical costs are combined, this figure sums up to $96 to $147 billion annually.[2] It has been estimated that, in 2002, approximately 1.7 million patients acquired a health care-associated infection in US hospitals.[3] Thereafter, health care-associated infections exhibited a decline,[4] and later surveys estimated a burden of 721 800 health care-associated infections in US hospitals in 2011.[5]

The notion that nosocomial infections are preventable causes of morbidity has led to the development of dynamic programs to control such infections. It has been estimated that up to 70% of catheter-associated bloodstream and urinary tract infections and up to 55% of ventilator-associated pneumonia and surgical site infections could be prevented, thereby saving thousands of lives and dollars spent.[6] Modern programs incorporate infection prevention policies, surveillance, outbreak response frameworks, and antimicrobial stewardship. These practices are endorsed by the Centers for Disease Control and Prevention in its compendium of basic infection prevention and control

guidelines, antibiotic resistance guidelines, and device- and procedure- associated guidelines.[7] Moreover, these infection control and antimicrobial stewardship programs can be supported by economic analyses and thereby result in cost-effective improvement of care and significant cost savings. In what follows, we will discuss the critical elements of an economic analysis that can shape changes in policies and practices to control nosocomial infections.

Prevention

Economic analysis is crucial to support the development of infection control programs, despite their implementation cost. Nevertheless, economic analysis is a relatively new area in infection prevention programs. Moreover, even when implemented in this context, economic studies are often limited to simple cost analyses and do not adhere to reporting standards.[8] For example, such analyses frequently report the gross spending per health care-associated infection on the assumption that savings from preventing a high-cost infection will outweigh the extra costs of expanding infection control programs.[9,10] Additionally, only a minority of cost analyses (weighted average of 6%) are incorporated in medical guidelines,[11] reinforcing disregard for cost-saving interventions.

Only a complete cost-effectiveness analysis can safely guide decisions. Such an analysis requires a core of 3 elements: the cost of the new infection prevention policy (in comparison to other interventions), the cost savings from prevented infections, and the clinical benefit.[12,13] If the measure of clinical benefit includes both duration and quality of life, then a cost-effectiveness analysis is extended to cost-utility analysis, with quality-adjusted life-years (QALYs) being the endpoint. Resulting comparisons of competing strategies are then made based on extra cost per QALY gained instead of extra cost per death averted (or extra cost per infection averted).[8,14] Thus, relative to alternatives, a new strategy may be less effective and either reduce or increase cost or more effective and either reduce or increase cost. If a new strategy improves outcomes at an increased cost, which is common, a threshold needs to be established to guide decisions by defining an upper limit of spending to gain one QALY (willingness-to-pay threshold).[15,16]

In the specific setting of nosocomial infections, the extraction of cost savings resulting from prevented infections is particularly challenging, especially for seriously ill patients who are already receiving high-cost care, regardless of their infection status. Moreover, apart from direct program implementation costs, there are collateral costs related to suboptimal treatment for nosocomial infections, drug adverse reactions, and the emergence of antibiotic resistance, all of which must be included in cost-savings calculations.[17] Additionally, infection prevention policies are unique in the sense that reducing prescribing of one class of antibiotic may be counteracted by prescribing of and emerging resistance to another class of antibiotic (known as “squeezing the balloon effect”),[18,19] which might compromise infection control plans and increase associated costs when antimicrobial restrictions are implemented.

Given these considerations, it is often impossible to define the most accurate values for the input variables. While the baseline assumptions can be considered “a best guess,” a sensitivity analysis over a range of input variables is necessary to determine the robustness of conclusions, as exemplified by methicillin-resistant *Staphylococcus aureus* infection prevention strategies in intensive-care units.[20] Unlike clinical studies, cost-effectiveness analyses until recently lacked a standardized guideline for how they should be conducted and reported. The publication of the Consolidated Health

Economic Evaluation Reporting Standards guidelines,[21] along with earlier influential recommendations,[22,23] has provided the framework for analysts to report the key elements of cost-effectiveness analysis, and these guidelines have been adopted in recent studies on health care-associated infections.[24,25]

Facilitating Decision Making

One challenge in economic analysis and in decision making is the differing perspectives of stakeholders. Clinicians focus mostly on the effectiveness of an intervention and less on the monetary cost. Health care administrators aim to optimize the allocation of resources and, in collaboration with clinicians, to improve health outcomes. For example, although it might be easy for administrators to adopt a universal influenza vaccination program for health care workers,[26] in an era of increasing health care complexity (and cost) and constrained budgets, more complex decision making can be a challenging task (see Table).

Table. Decision-Making Goals and Challenges for Health Care Organizations

Goal	Challenge
Fiscal resource stewardship	Optimize anticipated returns from limited resource investments. Manage risks of implementing cost-effective interventions that might not be affordable.
Balance different perspectives	Stakeholders have different, sometimes conflicting priorities (ie, organizations focus on cost-benefit analysis, clinicians and patients focus on effectiveness).
Manage lag between implementation and benefit	New interventions have immediate implementation cost but delayed and ambiguous benefits.
Adopt guidelines	Few guidelines adopt economic analyses to support intervention policies.
Manage emerging threats	Outbreaks and epidemics magnify risk aversion tendencies and preclude conducting valid economic analyses early.
Manage fiscal uncertainty	Account for uncertainty about whether pay-for-performance goals will be achieved by interventions implemented.
Forge consensus	Although necessary to optimize decisions, collaboration and forging consensus among policymakers, clinicians, epidemiologists, and other experts might be difficult.

Economic analyses need to focus on costs important to administrators and third-party payers, a task made more challenging by the fragmentation of care. Hospital administrators are interested primarily in costs paid by the hospital, not by the patient. Thus, they are unlikely to support costly interventions that may reduce nosocomial infections but have a worse cost-benefit profile than alternatives, as other hospital functions would be deprived of critical budgetary resources. They opt for a new strategy when it has a large incremental effect and a smaller incremental cost. Even when a cost-effectiveness analysis favors a new intervention, it may be rejected as unaffordable if it pertains to a large inpatient population and another intervention would have minimal impact on the nosocomial budget. From a regional or national perspective, costs have a wider definition, as they include hospital costs, out-of-pocket patient costs, and societal costs. Societal costs include health care utilization, time to seek care, outpatient caregiving, and loss of economic activity.

There needs to be a balance between proven and new strategies in using limited resources to maximize health outcomes. For example, the clinical best care practices to prevent infections, such as hand hygiene, sanitation, and screening, are not questioned and are considered cost-effective. The pertinent savings from such measures can be used to fund human resources, medical equipment and materials, information technology,[27] or antimicrobial stewardship programs.[28] However, administrators can be reluctant to introduce new interventions, particularly if there is an additional cost without a clear short-term benefit. A new intervention is associated with immediate additional spending on workforce or equipment, while the perceived benefits for an administrator and hospital may arise several years later owing to reductions in morbidity and mortality.[17,29]

Decision making becomes even more challenging in the setting of outbreaks, either at the local level or during a pandemic, such as the one brought about by the novel coronavirus (SARS-CoV-2).[30] High variability and uncertainty of input values arises when defining the economic analysis model. Many unknown components are involved in a new setting—namely, transmission rate, mortality rate and outbreak expected duration, novel surveillance detection tests, and new or repurposed drugs. An economic analysis may not be feasible to guide early decisions, and administrators and policymakers might be more disinclined to take risks.[31,32,33] To make things more complex, during an outbreak, if multiple interventions are introduced at once, conclusions about each intervention's effectiveness are confounded. As more data become available, revision of implemented strategies can enable selection of more cost-effective strategies.[30]

Nevertheless, there are hospital infection prevention policies that are nonnegotiable, regardless of any economic analyses. For example, nuclear acid testing of blood products to cover the window period for HIV infection is far from cost-effective,[34] but it is universally required for the zero-risk transfusion practice demanded by society. Moreover, the Centers for Medicare and Medicaid Services ties reimbursement to quality benchmarks using financial incentives (and disincentives), including the Hospital-Acquired Condition Program that comprises 5 major nosocomial infections: central line-associated bloodstream infections, surgical site infections, *Clostridioides* (formerly *Clostridium*) *difficile* infections, catheter-associated urinary tract infections, and methicillin-resistant *Staphylococcus aureus* infections. These infections weigh significantly in hospital reimbursement, and failure to achieve the established goals results in harm to the patient and additional financial cost to the hospital. In other

words, hospitals face both the burden of nosocomial infections and the added financial risks through pay-for-performance systems.[35]

Conclusion

In conclusion, quantitative and qualitative improvement of economic analysis in the field of nosocomial infection control would facilitate administrators' and policymakers' timely adoption of effective solutions and improve resource allocation for the benefit of health care organizations, physicians, and patients. Close collaboration among administrators, infection control experts, epidemiologists, and those with economic evaluation expertise is necessary to merge the evolving evidence-based guidelines with cost-effective platforms of interventions in a highly competitive health care environment. Such integration across the continuum of health care might optimize the quality of patient care, improve health outcomes, and contribute to patient satisfaction.

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