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Original article

Economic burden of healthcare-associated infection in US acute care hospitals: societal perspective

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Abstract

Background:
Assessing the costs of healthcare-associated infection (HAI) is challenging. Methodological issues abound. Previous estimates have been derived in diverse ways from varied perspectives in different settings with dissimilar data. Results can be confusing. Full societal costs, which are more inclusive than commonly reported direct hospital costs, have never been fully measured or reported.

Objective:
To update, combine, and expand previous cost estimates to determine the annual societal burden of illness (direct medical, non-medical, and indirect costs) arising from HAIs in US acute-care hospitals.

Methods:
The research approach encompassed literature and internet searches; reference identification, selection, and review; then data abstraction, compilation, and analyses to estimate full societal costs. Previously published systemic reviews, surveillance reports, and individual clinical studies, along with newly computed component costs, all contributed to final estimates.

Results:
HAIs in US acute-care hospitals lead to direct and indirect costs totaling \$96–\$147 billion annually. These results are subject to the same limitations as previous studies from which contributing data were derived.

Conclusion:
The enormous clinical and economic burden of infection places HAIs high on the list of devastating and costly illnesses, such as cancer, heart attack, stroke, and diabetes, thereby mandating further research and greater efforts to contain a pressing healthcare problem.

Introduction

Preventable infections arising during acute-care hospitalization levy huge tolls on patients, families, payers, and the provider hospitals where they occur[1–7]. Patients who contract these infections suffer substantially worse morbidity and mortality than uninfected patients. They experience longer length of hospital stay (LOS), more intensive care, higher risk of readmission, prolonged recovery time, and greater overall expenses or losses[8]. Providers incur more resource utilization, and payers absorb more costs. For the society at large, lost productivity and wage as well as related malpractice litigation add to the economic burden imposed by healthcare-associated infections (HAIs) arising in acute care hospitals in the US.

For many years, landmark research data have been recited in HAI reports. Such research has found that ~5% of hospitalized patients become infected during their inpatient stays, and practically 100,000 people die each year as a result[1,9], ranking HAI near cancer, heart disease, stroke, and diabetes as leading causes of death in the US[4]. A previous report from the Centers for Disease Control and Prevention estimated that HAI among US hospital inpatients accounts for $28–$45 billion annually in incremental direct costs, with the average infection incrementally consuming $16,359–$25,903 per index hospitalization[10]. The current analysis updates these figures and also broadens the analytic perspective to include the total societal impact of HAI, not just the cost to hospitals.

Study objectives

Update, combine, and expand previous cost estimates to determine the full annual societal burden of HAIs arising in US acute-care hospitals, including direct medical, nonmedical, and indirect costs.

Methods

Methods encompassed literature and internet searches; reference identification, selection, and review; and data abstraction, compilation, and retrospective analysis. Data-contributing references were sought primarily in the Medline database (1996–current), using the following search terms, alone and in combinations: HAI, hospital, hospital-acquired, hospital-associated, nosocomial, infection, surgical site, urinary tract, pulmonary, pneumonia, bloodstream, wound, bacteremia, septicemia, sepsis, bacterial, cost, economics, review, systemic, and analysis. Searches identified countless articles; those deemed potentially meaningful were appraised for relevance via their abstracts, then retrieved and reviewed for content, and explored for additional references. Further searches were conducted through Yahoo and Google search engines, using similar subject headings that yielded additional resources. Among all retrieved literature were systemic or modified reviews and surveillance reports, which became important data sources primarily because methodologies common to previous primary HAI cost studies—*chart reviews*, *matched comparisons*, and *regression analyses*—all have limitations[10–13].

- *Chart review* are limited by lack of comparable matched infection-free controls;
- *Matched comparisons* may be limited by variations in matching criteria and crucial differences between cohorts; and
- *Regression analyses* may be limited by failure to account for disease severity or patient time-at-risk.

The criteria for the selection of studies contributing to the systemic reviews used in the current research are cited elsewhere[12].

Complications unrelated to methodology also affect HAI studies; e.g., single- vs multi-site research, urban vs rural sites, primary vs tertiary hospitals where patients with different levels of disease severity and clinical needs are treated, variable infection-control programs, and different clinical protocols. Moreover, some studies may have included patients in the general hospital population or only those from specific services (e.g., medical or surgical), or specific wards (e.g., adult or pediatric), or even specific locations within the hospital (e.g., ICU or dialysis). Also, some assessments have been conducted into the consequences of all HAIs occurring at a study site; but, more commonly, others have covered only certain types of infections (e.g., surgical site infections [SSI], ventilator associated pneumonia [VAP], urinary tract infections [UTI], bloodstream infections [BSI], etc.), leading to varied clinical and economic outcomes. Estimates reported for a specific type of HAI cannot be universally extended to all HAIs or even to other individual types. Vice versa, estimates reported for all HAIs combined cannot be universally extended to specific types.

To circumvent many of these methodological issues, we relied in part on systematic and modified reviews[10–13] that gathered and qualified individual studies, combined their results, and computed blended cost estimates from merged data. We also drew from the Pennsylvania Health Care Cost Containment Council's 2010 statewide report[5] and filled residual data voids with information derived from other publications that dealt specifically with post-discharge diagnosed (PDD) infections, readmissions, outpatient care, professional fees, plus other epidemiologic, clinical, and economic matters that go beyond the index hospitalization.

Finally, because the HAI burden extends into the personal lives of patients, their personal caregivers, and the society at large, indirect costs were included to achieve a societal perspective. Such costs were not available in the publications that directly contributed data to the current study, but rather were computed as explained elsewhere in this paper.

Data abstraction

From principal data sources and other supportive references, we abstracted:

- Epidemiologic data, including total annual number and incidence of HAIs, total annual hospitalizations, readmission rates, and PDD infection rates;
- Clinical data, including mean incremental HAI-related LOS and consumption of material and human resources in both inpatient and outpatient settings;

- Economic data, including the cost of incrementally consumed clinical resources as well as the value of lost work days (graduated for both men and women) and life years (likewise graduated); and
- Legal data, including proportions of patients with medical-related injuries/deaths who file malpractice claims, proportion of claims that are settled or awarded, value of settlement or award.

Some abstracted data required reappraisals that are specifically discussed in the Results section along with a rationale for any renewed valuations.

Results

HAI incidence

The most commonly cited incidence rate for HAIs arising in US acute care hospitals is 4.5% of admissions[9]. A slightly higher rate (4.87%) can be inferred from Klevens *et al.*'s[9] report (1.7 million infections among 34.9 million admissions) that sourced data from the National Nosocomial Infections Surveillance (NNIS) System, the National Hospital Discharge Survey (NHDS), and the American Hospital Association Survey (AHAS). Also reported were 98,987 HAI-related annual deaths. Although source data were collected between 1990–2002, the Klevens *et al.* study stands as vital research that endures to this day. Since 2002, however, various infection control measures have been implemented, and some reduction in incidence has possibly occurred. Estimating the extent of that reduction is confounded by variability in HAI definitions, coding, documentation, surveillance, and reporting. Still, for completeness in a conservative approach, a lower rate was sought for the current study. It was estimated to be 3.9% based on data and information in Klevens *et al.*[9] and Kim and Black[14] and reflects a 12.5–20% reduction, respectively, from Klevens *et al.*'s 4.5% reported rate, which served as this study's established baseline incidence, and the 4.87% rate inferred from Klevens *et al.* This rough estimate is used only to suggest a possible lower range of projected societal costs based on uncertain reductions in overall HAI incidence since 2002.

Index hospitalization

The annual total of HAI index hospitalization was derived from yearly admissions as cited in Kaiser Foundation Health Facts[15] and the 2010 AHA Survey Database[16]. In 2010, 37,258,393 admissions took place in US acute-care private and federal hospitals. Using incidence rates of 3.9–4.5%, the numbers of HAI index hospitalizations were estimated to be 1,453,077 and 1,676,628, respectively.

Incremental LOS

A range of 8.9–10.2 days was used in the current study for incremental LOS. The 2010 Pennsylvania Health Cost Containment Council reports average incremental LOS as 16.9 days for patients with HAI[5]. A broader range (3–27 days) is reported in many other studies[17–26]. To resolve this discrepancy, an adjustment based on data from PHC4[5] and AHA[27] was applied to derive the range of 8.9–10.2 days.

Readmission rate

Limited information is available to pinpoint a readmission rate that applies to all combined HAIs. Related readmissions data, however, is found in PHC4[5] (31.3% HAI patients vs 6.3% non-HAI patients), suggesting an incremental index readmission rate of 25%.

Post-discharge diagnosed infections

Not all HAIs are diagnosed during the index hospitalization; some become apparent after hospital discharge (post-discharge diagnosed [PDD] infections)[5,28–32]. Although their characteristics are only modestly described in the literature, their incidence and costs have been studied and reported. Perhaps they occur across HAI types; regardless, they are almost exclusively reported as SSIs, the only type sufficiently mentioned in the literature to merit inclusion here. Accordingly, only PDD SSIs were counted in the current assessment. Estimates of PDD SSI case numbers vs total SSI numbers range from 47–84%[5,28–32]. Costs were abstracted directly from Perencevich *et al.*[32] after adjustment for healthcare inflation to 2010 dollars.

HAI incremental hospital cost

The incremental cost of hospitalization in which an infection occurred is derived from the CDC's study of direct HAI costs[10]. The CDC used two different inflation rates: (1) the consumer price index for all urban consumers (CPI-U) and the CPI for Inpatient Hospital Services (CPI-IHS). The same indices were used in the current study to inflate CDC dollar estimates to 2010 values. Thus, the CDC's low ($16,359) and high ($19,430) estimates from CPI-U adjustments became $17,070 and $20,274, and their estimates using CPI- IHS ($20,549 and $25,903) become $25,525 and $32,176, respectively, in our study. For consistency with Scott[10], our spread became $17,070–$32,176.

HAI-related professional fees (index hospitalization)

HAI-related professional fees are a component of total direct medical costs. Generally, they are billed separately from hospital charges and are not identified in hospital billing records. They arise from procedures or consultations that vary by type, site, and severity of the HAI and also by the specialty of the consultant and related fee schedules. These HAI healthcare encounters are poorly described in the literature, so related incremental fees are generally unavailable. For the current study, such fees were derived from the computed ratio of professional fees to hospital costs, based on commonly performed procedures and practices described in Healthcare Blue Book[33]. The mean ratio of 0.2443 and median ratio of 0.1968 were applied to calculations of incremental HAI-related direct medical (hospital) costs to estimate total incremental professional fees. Mean and median ratios reflect the numerical relationship between hospital costs and professional fees as a percentage.

Cost of readmission following index hospitalization

Hospital readmission within days to weeks of the index hospital discharge is common among patients who experience HAIs. These readmissions occur for various reasons including persistence, worsening, and complications of HAI. They do not include HAIs diagnosed in the post-discharge period (PDD infections). Costs associated with these readmissions are based on related LOS and professional fees.

Value of lost productivity and wage

The indirect costs of HAI include the value of work and wage lost during HAI management and recovery, as well as from disability or premature death. With premature death comes a loss of likely future earnings and benefits, which are commonly valued in economic assessments. A lost work day for an individual aged 45–64 is worth $149 (blended rate for men and women)[34]. The blended value of lost productivity due to premature death is $685,225 for individuals of the same age[34]. These values are respectively applied to total lost days, based on incremental LOS and lost lives.

Medical malpractice and wrongful death

Studies indicate that <10% of injured patients seek damages related to malpractice, with decisions variably rendered by trials (15%), juries (3–10%), and judges[35–37]. In 2005, the latest year studied by the Department of Justice (DOJ), the malpractice win rate was 23%[38]. Awards differ in litigated vs negotiated cases[38,39] and are frequently lowered through post-trial modifications, appeals, and extended settlements. Death was the most awarded outcome among successful cases, accounting for 22% of malpractice victims who prevailed at trial. In cases of infection, all winning patients suffered permanent damage. Based on these circumstances, only patients with HAI-related death (98,987 total number) were considered as potential claimants in the current study. Since awards for wrongful death are compensatory, they have been exchanged, dollar for dollar, with indirect costs, and are included in the total indirect sum.

Table 1. Societal cost of hospital-acquired infections.

Category	Societal low	Societal high
Direct costs (Billions)		
Index hospitalization	$24.8	$53.9
Professional fees index hospitalization	$4.9	$13.2
Post-discharge outpatient	$0.2	$0.2
Readmission post-index hospitalization	$3.4	$4.0
Professional fees readmission	$0.7	$1.0
Post-discharge diagnosed infection	$0.3	$1.7
Sub-totals	$34.3	$74
Indirect costs		
Lost wages, incapacitation	$2.5	$3.9
Lost future wages, premature death	$59.1	$68.7
Sub-totals	$61.6	$72.6
Total societal costs		
Societal cost of illness	$96*	$147*

*Individual costs were rounded to nearest 0.1 billion.

Full societal costs for HAIs arising in US acute care hospitals

The full range of societal costs for HAIs arising in US acute care hospitals and the individual component costs that contribute to the total $96–$147 billion annual economic burden are displayed in Table 1.

Discussion

HAI costs have been calculated in different ways from different perspectives with different data-sets leading to a broad range of results. Regardless, one thing is certain: the cost of infection is enormous. In fact, HAI has been compared to the most costly diseases in the world and holds a high ranking on comparative cost of illness tables[4].

Estimates from the current study for total societal costs range from $96–$147 billion for HAIs arising in US acute care hospitals only, not including infections occurring in non-hospital settings, such as skilled nursing and assisted-living facilities, community clinics, dialysis centers, and

private practices, to name just a few. To include such infections would greatly increase the costs reported here but would also require substantially more site-specific data, which are currently limited. Such vital work remains outstanding.

To facilitate calculations, several assumptions and some omissions were necessary. For example, specific costs for norovirus (the principal cause of infection outbreaks in US hospitals and 65% of all unit closures[40]), *Clostridium difficile* (another serious enteric infection[41]), and methicillin-resistant *Staphylococcus aureus* (MRSA) were not independently included in our assessment but were assumed to have been included in the systematic reviews from which we abstracted data. A verbal conversation with Scott legitimized this assumption. These infections add significantly to HAI occurrences and costs and possibly offset conceivable declines in the rate of other HAIs.

In our review of HAI health economic literature, it was noted that some researchers have criticized the nature of costs reported in previous assessments[42–45]. They feel that opportunity costs, rather than incremental direct costs, more fairly reflect the economic impact of HAI on hospitals. This issue certainly merits consideration, but becomes less meaningful from the societal perspective in which gross costs are the focus.

In closing, emphasis must be placed on the inaccuracy of HAI cost assessments. For the current study, we attempted to thoughtfully navigate common problems in COI analyses by drawing some key data from systemic reviews that correct or compensate for many but not all confounding factors. Thus, the broad limitations inherent in most HAI outcomes research must be stated whenever discussing study results, including ours.

Conclusion

Future studies and outcomes can be improved with better standards and tools. To that end, some considerations are in order. They include: (1) improved surveillance systems, uniform clinical and economic measures for HAI cost accounting, standards for assessments, and precise reporting of results (reliable prevention strategies are dependent on such considerations); (2) renewed efforts to further improve infection control programs with better or novel interventions, planned assessments, and subsequent modifications of protocols for optimal impact; and possibly (3) greater incentives and disincentives to encourage compliance with best practice. Combined, these considerations may lead to lower HAI incidence and related economic benefits that are especially desired in the current cost-conscious healthcare environment.

Transparency

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Declaration of relationships

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