Health Care Costing: Data, Methods, Current Applications

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Health care costs continue to grow rapidly, straining budgets and raising questions about whether consumers are getting good value for the money spent. There has never been a more pressing need for conceptually sound and empirically accurate estimates of health care costs, for a variety of applications. For example, cost estimates are pivotal in the setting of public and private health care budgets at all levels and establishing reimbursement rates; in cost-effectiveness analyses and other economic evaluations; and in assessing the impact of investments in research to prevent, detect, and treat disease.

Yet, the development of valid, reliable, feasible, and comparable (across studies) measures of health care cost has proved to be challenging, both in the United States and elsewhere. Substantial variation exists across studies in data and methods, even for cost studies with seemingly a similar intent.

One major source of difficulty lies with the data. In most health cost analyses, the data for measuring and valuing resource use were created for purposes other than health care costing (primarily reimbursement) and hence are imperfectly designed for the task at hand. The alternative approach, to collect the cost data de novo, is often expensive, and there is not yet consensus on how best to do it. Health care costs are inherently difficult to measure, whatever the choice of data source(s). For multiple reasons, the posted prices of health care goods and services often do not convey accurate or useful information about economic cost. The health care system produces literally thousands of heterogeneous products, whose individual “prices” are often not observed in the complex maze of pricing for bundled services. Moreover, observed prices may reflect differences in market power between buyers and sellers (as reflected, for example, in negotiated price discounts), efforts to cross-subsidize unprofitable services, and other market imperfections and idiosyncrasies.

A second source of difficulties in health care costing is the absence of professional consensus on some data and methods issues. At a general level, there is universal agreement that the cost of any health care activity should be defined in terms of the “economic opportunity costs” of the component resources, with each resource valued in its next best use. In reality, there are substantial variations in how this textbook definition is applied because it provides little specific guidance on a number of practical issues. These include the components (or types) of cost to be included in the analysis, the assignment of opportunity cost values to these components, when and how to combine multiple data sources, key conceptual and study design issues (eg, identifying the cost attributable to a specific disease or activity), statistical challenges (eg, how best to handle heavily right-skewed cost data), and effective approaches for reporting findings.

Similarly, within specific arenas of application (eg, cost-effectiveness analysis [CEA]), there may be broad consensus regarding certain operating principles (eg, emphasis on the societal perspective), but little guidance on how best to bring data and
methods to bear in specific applications, given their context-specific assumptions and constraints.

In recent years, multiple workshops, conferences, and expert panels have sought to understand and improve the state of the science in such important areas as CEA and the measurement of patient-reported outcomes. Notably less attention has been devoted expressly to the cost side of the equation—notwithstanding substantial variation in how costing principles are interpreted and applied in practice.

In response, the US Agency for Healthcare Research and Quality and the National Cancer Institute cosponsored a workshop on, “Health Care Costs: Standardized Methods and Estimates for Research and Policy Applications,” held December 6 and 7, 2007, in Rockville, MD. Through podium presentations and focused group discussion, about 45 invited participants analyzed a number of related topics. These included the arenas of application for health cost studies; a range of data and methods issues encompassing fundamental concepts, practical approaches for measuring cost, and the statistical analysis of cost data; and next steps toward a research agenda to advance the field. Workshop participants included a diverse group of government officials and academic researchers who are nationally recognized authorities in health cost estimation and policy application. The workshop agenda and presentations are available at: http://healthservices.cancer.gov/publications/workshop/hcc/agenda.html.

The articles appearing in this Medical Care special issue, which is cosponsored by the Agency for Healthcare Research and Quality, the National Cancer Institute, and the US Department of Veterans Affairs, are a direct outgrowth of the presentations and discussions at the workshop. Building on the workshop’s original goals, the main aims of this supplement are to:

- Examine current applications and standard practices in health care cost estimation.
- Discuss methodological and empirical challenges.
- Identify best practices in the measurement, statistical analysis, and application of health care costs.
- Assess potential advantages, limitations, and challenges to developing standardized approaches to the conduct and reporting of cost analyses.
- Inform the research agenda on improving the scientific quality and decision relevance of health cost analyses.

By implication, a major purpose of this volume is to assess the current state of the science in health costing to identify the most promising opportunities for strengthening both data and analytical methods.

Guided by these main aims, we identified major topic areas and specific issues in health care costing that collectively gave form and shape to the workshop agenda and that, likewise, are reflected in the content and sequencing of the 21 articles comprising this volume. In what follows, we preview these major topics areas while providing a snapshot summary of the individual articles within each area.

**ARENAS OF APPLICATION**

Although there are multiple uses for cost estimates in health care research and policy making, the majority of applications fall into 2 broad categories:

- Assessments of the aggregate economic burden of disease and illness, typically at the population level, eg, the net cost impact in the United States of cardiovascular disease in 2008. Such burden-of-illness studies may focus not only on the overall burden of specific diseases or disease groups, but also on the cost implications of health behaviors (eg, smoking) and health “conditions” (eg, obesity) that have multiple health consequences. Burden-of-illness studies may also assess population level interventions to impact costs and health outcomes by influencing behaviors (eg, cigarette excise taxes) or reducing population disease and illness rates.
- Economic evaluations of specific health care interventions or programs, eg, the cost-effectiveness of screening for pre-diabetes. Such evaluations may also include cost-benefit and cost-identification analyses, as well as budget impact analyses to assess the financial impact and feasibility of interventions.

The 4 articles in this section contribute to our understanding of these application arenas. Taking a national-level perspective, Rosen and Cutler critically assess current approaches to cost-of-illness (COI) estimation, noting the central features of the National Health Expenditure Accounts (NHEA) as produced by the US Centers for Medicare and Medicaid Services. They pursue the important and provocative question of how the NHEA might be extended to include “disease-based accounts” that could provide macro-level information for health resource allocation decisions. Implicit is that COI estimates alone may serve to rank-order diseases according to burden, but provide no information about the potential payoffs (in health status or cost reductions) from alternative investments to reduce burden. To pursue this larger agenda, the authors point out, a number of challenges must be met. These include linking micro (individual)-level spending observations with macro (national)-level total spending, selecting the specific set of diseases for analysis, and appropriately allocating observed macro health spending across these diseases. A particularly vexing problem is how to avoid double counting costs in closely allied disease categories, eg, ensuring that costs attributed to diabetes are not also included in end-stage renal disease, and vice versa. This article complements, and should be read in conjunction with, the article describing the development of NHEA in greater detail by Heffler et al (as mentioned later).

The articles by Marshall and Hux, Hoerger, and Neumann focus on the pivotal, though sometimes underemphasized, role of cost in CEAs. Randomized clinical trials are a potentially valuable source of cost data for CEAs, especially since health outcomes data are being collected in parallel on the same subjects, Marshall and Hux note. But there are important issues that must be addressed in successfully applying these cost and outcomes data in an economic evaluation, especially when (as is often the case) the trial was...
never designed for that purpose. These issues include external validity (are the patients in the trial representative of the population to which the CEA would apply?), the trial’s limited duration relative to the CEA’s more extended time horizon (censored data), and missing data. The authors emphasize the importance of appropriate study design, analytical methods, and attention to detail in data collection as ways to enhance the validity of trial-generated cost data.

Many of these broadly applicable points are effectively illustrated and amplified in Hoerger’s article on current efforts to identify and apply cost estimates in CEAs of diabetes interventions. Because virtually no clinical trials or clinically detailed observational studies follow individual diabetes patients over the long-term, CEAs that take the (appropriate) life-time perspective require the application of simulation models that forecast cost and health outcomes across the life-cycle, conditional on intervention. The development of clinically valid models for complex chronic diseases such as diabetes is expensive, data-intensive, and time-consuming. One unfortunate result has been that the seemingly important matter of cost estimation receives short-shrift—what Hoerger characterizes as the “grab-and-go” approach to populating CEA models with cost values drawn from whatever data sources happen to be readily available.

Citing data from the Tufts Medical Center Cost-Effectiveness Analysis Registry that he and colleagues established to comprehensively catalog and evaluate the methodological quality of CEAs across diseases over time, Neumann concludes that there has been substantial variation in the choice and application of costing methods across studies. While he reports that adherence to sound principles has increased over time, some problems persist. These include mischaracterization of the perspective of the cost calculations—for example, sometimes claiming a “societal” perspective when the analyses, perhaps omitting patient and family time costs, are more closely consistent with a payer perspective. Other ongoing concerns include a lack of transparency about the costing methods employed, and misuse of terminology. Neumann urges greater attention to understanding how the choice of costing method influences CEA calculations and recommendations.

DERIVING INCIDENCE COST AND PREVALENCE COST OF DISEASE: FROM CONCEPT TO ESTIMATION

Using cancer to illustrate, Barlow provides an overview of the 2 general options for estimating disease costs: the incidence approach and the prevalence approach. As he notes, the prevalence costs of a disease are often reported for a specific calendar year, and are based on the costs of medical care in that year for all individuals diagnosed with or living with that disease. Prevalence cost estimates thus encompass care delivered to individuals across the disease trajectory, including the newly diagnosed, the long-term survivors, as well as those at the end-of-life. In contrast, cost estimates using incidence approaches include only the newly diagnosed, and are typically longitudinal estimates of medical costs following diagnosis with disease. When applied in CEAs, incidence cost estimates can be useful inputs for policy decisions about coverage of interventions to prevent or treat disease or for specific treatments. Barlow’s article complements, and should be read in conjunction with, the 2 below by Yabroff et al, which compare commonly used approaches for estimating incidence and prevalence costs in cancer patients.

Prevalence cost estimates can be used to inform health policy decisions on the structure of insurance benefits, (spending-level-based) eligibility criteria for public programs, and budgeting for future program costs. Heffler et al describe the NHEA, the official government estimates of aggregate US health care spending in a calendar year. They discuss the methods and data sources used to develop the NHEA, recent findings, applications, and strengths and limitations of NHEA. One limitation is the absence of individual-level health expenditure data—a gap being filled, in part, by the Medical Expenditure Panel Survey (MEPS), which yields individual-level prevalence estimates of expenditures. Cohen and colleagues provide an overview of the MEPS, a widely used, comprehensive, nationally representative source of data on health care use and expenditures in the United States.

Riley describes the uses of administrative data in estimating health care costs. Common sources include health insurance claims and encounter data associated with private insurance, Medicare, Medicaid, the Veterans Health Administration, and other public programs. Administrative data can be used to evaluate spending in a calendar year for all individuals with a specific condition (prevalence costs) or linked longitudinally for enrolled individuals with a specific condition to evaluate spending following initial diagnosis (incidence costs). Importantly, these data systems apply only to specific enrolled populations, are collected for purposes other than research, and therefore have limitations related to generalizability and completeness. Administrative data are frequently linked to other data sources, including disease registries, which provide detailed clinical information at the time of diagnosis not available from claims. One of the most prominent linked data bases is the Surveillance, Epidemiology, and End Results tumor registry data linked to Medicare claims (SEER-Medicare), which can be used to estimate incidence or prevalence costs associated with cancer care.

To assess the impact of different approaches to estimating the incidence costs of cancer care, Yabroff et al used the linked SEER-Medicare data to evaluate 3 approaches: a SEER-Medicare cohort, a cohort identified from Medicare claims only, and a modeled phase of care approach using SEER-Medicare. In a similar evaluation of different approaches for estimating prevalence costs of cancer care, Yabroff et al compared estimates from SEER-Medicare, Medicare claims alone, and the MEPS. They found that incidence cost estimates vary substantially depending on the identification of newly diagnosed patients and methods for estimating longitudinal costs. Prevalence cost estimates also vary depending on the data source, patient selection, and the proportion of long-term survivors included in the sample. Both types of estimates reflect the payers included in the data source.
COST DETERMINATION FOR HEALTH CARE SERVICES: APPRAISING THE OPTIONS

As indicated above, a variety of data sources are available for identifying the economic costs of health care services. Options include, but extend well beyond, administrative data from third-party payers (possibly linked with disease registries), and population-based surveys of health care resource consumption. Two articles examine some additional approaches, while a third critically appraises the basic options for health care cost determination.

Fishman and Hornbrook review and illustrate with real-world examples 3 approaches for assigning costs to health services in ways that focus on both the quantity of real resources consumed and the unit prices assigned to each resource. The approaches, which are especially applicable within well-defined health care systems, include (1) direct estimation of health care costs through microcosting, which may include activity-based accounting, and step-down allocation models to derive departmental-level unit costs; (2) “macro-costing” techniques, wherein total cost per case is modeled as a function of a set of predictor variables (eg, disease type, demographics, health system attributes), setting the stage for efficient derivation of cost-per-case estimates, conditional on these covariates; and (3) “standardized resource use assignments” that determine unit cost on the basis of prior judgments about the relative resource intensity of the service (as seen, for example, in the Resource-Based Relative Value Scale system for paying physicians). Fishman and Hornbrook conclude that each of these cost weighting systems can be resource-intensive to execute and lead to certain distortions in cost determination, but each has the potential to distinguish appropriately between accounting costs and genuine economic costs.

An in-depth appraisal of microcosting techniques is provided by Frick, who discusses rationales for different approaches, methods issues, arenas of application, strengths and limitations, and the elements of a research agenda to improve the quality and usefulness of studies that estimate health care costs “from the ground up.” Microcosting may be particularly appropriate for assigning costs to new technologies or programs, valuing nonmarket goods, and studying fine-tuned differences in the costs of procedures or services when other (more macro) approaches to costing might fail to detect true differences. Common arenas of application include CEAs and budget impact modeling.

Barnett provides a critical assessment of 4 major methods used by US researchers for determining health care costs and summarizes advantages, disadvantages, and issues of concern for each. These methods include microcosting, activity-based cost allocation systems, cost-adjusted charges or total reimbursement (payments), and gross-costing. (Note that the first 2 of these fit within the Fishman-Hornbrook category of direct estimation of health care costs, while the fourth method is akin to their macro-costing technique.) Barnett concludes with a proposed 14-point checklist for evaluating the scientific quality of any cost-determination method when applied to real-world data. The checklist embraces important general principles, eg, the inclusion of all relevant cost elements, adoption of the societal perspective, use of a sufficiently long time horizon, and valuing resources at their economic opportunity costs.

IMPORTANT NONMEDICAL CARE COSTS

While the majority of health cost analyses focus on the direct costs of medical care goods and services provided within the health care system, important costs also arise outside this system. In particular, individuals who participate in disease prevention and screening programs or who undergo treatment are contributing their own time, and thus incur an opportunity cost. In addition, individuals with disease or illness will tend to be less productive in the labor market and also in nonmarket uses of their time, including household tasks and leisure; such productivity losses are swift and sure for those whose ill health leads to premature death. These productivity deficits represent a genuine opportunity cost to society (and likely an income reduction to the individual) and should be considered in any comprehensive assessment of the burden of disease. Likewise, in the evaluation of interventions to reduce disease burden, these nonmedical care components of burden should be candidates for inclusion (and in a way consistent with the methodological assumptions and perspective of the analysis).

In this regard, Russell notes that the time an individual devotes to preventing, detecting, or treating disease is frequently an important component of overall disease burden. Such “time costs” can vary significantly across diseases and interventions, in ways that can influence conclusions from CEAs. But despite recommendations more than a decade ago by the US Panel on Cost-Effectiveness in Health and Medicine, the time costs associated with individuals’ participation in their own health care are rarely included in CEAs. Nor are such costs usually considered in broader, burden-of-illness calculations (whether or not the intent is program evaluation). Russell argues that it is feasible even now to begin measuring time costs on a routine basis. For example, one can assign values to the time patients spend on physician visits and hospital stays with appropriate wage rate data and by capitalizing on such secondary data sources as the American Time Use Survey. Although such approaches only approximate the individual’s true time costs, the alternative is to ignore time costs altogether and thus effectively assign them a zero value—clearly a biased estimate, as Russell points out.

Following an assessment of the major COI studies performed in the United States over the past 4 decades, Grosse et al present 2007 estimates of economic productivity, by age and sex, for the US population. Such estimates can provide the pivotal baseline for subsequent calculations of the dollar value of productivity losses resulting from disease and illness. The authors use the most recently available data on both market and nonmarket productivity. For the former, they use actual hours worked and convert to a total productivity estimate via multiplication by estimates of total hourly compensation (wage plus nonwage plus tax payments). For nonmarket productivity, they draw on the latest data available from the American Time Use Survey.
Grosse et al note that such COI analyses have been criticized both for over-estimating and under-estimating the economic impact of death and disability. Moreover, there has been ongoing debate among CEA practitioners about what portions of the cost burden of illness should be included as (monetized) “costs” in the numerator of the CE ratio and what portions can validly be assumed to be captured in the (non-monetized) “effectiveness” measure in the denominator (with the latter frequently taking the form of quality-adjusted life years). In addition, many economists continue to argue strongly in favor of willingness-to-pay and other demand-revealing approaches to evaluating the burden of disease and the value of disease reduction. These important methodological discussions will likely continue, and will undoubtedly benefit from ongoing and new efforts to generate ever-more-accurate data on the nonmedical (as well as medical) resource costs of disease.

STATISTICAL ANALYSIS OF HEALTH COST DATA

Several features of health care cost data pose challenges for econometric studies undertaken to draw inferences about the influence of specific factors on costs or to derive predictions of cost, conditional on these factors. These features, which may appear singly or in combination depending on the particular cost data set, have the effect of rendering implausible an important assumption underlying most standard regression models—namely, that the dependent variable (here cost) is normally distributed. This will generally lead to problems in valid inference and prediction, unless appropriate correctives are successfully applied. The 3 articles in this section discuss current approaches to handling these problems and some challenges that remain.

With a focus on the needs of the health policy decision maker, Mullaly20 discusses alternative econometric model specifications intended to cope with problematic aspects of health care cost (or expenditure) data. Analyses to explain and predict health care costs can inform a range of policy decisions, including risk-adjusted provider payment, provider utilization evaluation, COI assessment, the cost components of program evaluations, and projections of the economic burden of disease and illness. Accordingly, he stresses the importance of reporting findings in ways that promote clarity, transparency, and the drawing of appropriate causal inferences.

After an assessment of the progress achieved over the past 40 years in the econometric analysis of cost data, Basu and Manning21 discuss, in turn, a range of analytical issues now under active investigation. Some cut across virtually all applications (eg, when will comparatively simple modeling approaches such as ordinary least squares yield robust and defensible estimates?). Others arise particularly in intervention evaluation studies (eg, what sample sizes are adequate for cost inferences in clinical trials, which are typically powered for efficacy, not cost?). The authors discuss future directions for advancing the science of cost prediction (eg, identifying the criteria for evaluating alternative prediction models). As Basu and Manning suggest, the statistical analysis of cost data is a still evolving enterprise, with promising new approaches continuing to be introduced and evaluated.

Huang22 focuses on the problem of drawing valid statistical inferences and predictions about lifetime disease costs using data from time-bounded studies where observations on costs may be right-censored. This most frequently occurs in clinical trials where the fixed study duration is shorter than the longest survival times in the sample. But it can arise also in observational studies where survival times in the study population exceed the (preset) time horizon of existing data sets or the length of the data collection period. Huang analyzes 2 key statistical issues. The first is “induced dependent censoring,” wherein the link between survival time and cost accumulation at the individual level is an influential consideration in the analysis. The second issue is “marginal identifiability” of the distribution of costs—that is, the ability to estimate a well-defined cost function when a significant fraction of individuals incur additional costs after they are censored (and thus are unobservable). Huang discusses promising statistical models to address these issues.

TAKING STOCK

The volume’s final article appraises the current state-of-the-science in health costing and discusses options for enhancing both data and methods.23 A number of specific challenges are addressed within several broad topic areas: assaying and extending the boundaries of health cost analyses, attributing cost correctly to the disease or intervention of interest, assigning unit costs to resources appropriately, and arriving at statistically sound conclusions for the application at hand. A major recurring theme is the need to conduct many more head-to-head, comparative studies to examine the sensitivity of cost estimates to the choice of data set and methods of analysis. Also emphasized is the importance of strengthening the empirical base for health costing by enhancing existing data resources and developing new ones. The article concludes by examining the rationales for, and possible approaches toward, greater standardization in the conduct and reporting of health cost analyses.

Perhaps in no other area of health services research is that old trope, “the devil is in the details,” more apt than in health costing analysis. Whatever the arena of application, the most pressing challenges arise not with identifying the appropriate conceptual and behavioral models—though such interpretative undergirding is clearly essential—but rather with marshaling the appropriate data sources and methodology for valid description, inference, and prediction.

Consequently, an important adjunct to this volume is an Inventory of Data Sources for Estimating Health Care Costs in the United States,24 which includes detailed descriptive information on public and private sources of data for constructing measures of health care costs. For each data source, information is provided on the sponsor (public agency, university, or private organization), population covered, lowest level of data aggregation available for analysis, type of data source (eg, survey, administrative, linked data), availability of diagnostic information, and the data source website for more detail. Also reported for each data source is the avail-

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ability of the following cost elements: inpatient care, physician and other outpatient services, outpatient pharmacy, out-of-pocket medical expenditures, patient time, and nonmedical expenditures.

In sum, it is hoped this volume will serve as a useful reference for those conducting health cost analyses, while laying a foundation for future work to improve the scientific soundness and usefulness of these analyses.

REFERENCES