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# LIFETIME COSTS FOR MEDICAL SERVICES: A METHODOLOGICAL REVIEW

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Abstract

**Objectives:** Guidelines for economic evaluation studies recommend that modeling be undertaken to estimate long-term, downstream costs. In this study, we conduct a review of a sample of studies that estimated the lifetime medical care costs for a variety of conditions.
**Methods:** We developed a categorization of the elements for a lifetime-costing study and based on these elements, we abstracted information from a sample of 33 papers in the following areas: study subject, purpose, scope, methods (including time profile, utilization, and cost), and results.
**Results:** We analyzed papers that were observational, models or that combined the two approaches. The time profiles were estimated from registry and published data. Utilization data were obtained from administrative data, chart reviews, and professional opinion. Costs were obtained from administrative and financial records and were estimated using all charges, allocated costs, and provider payments. We noted wide variations in methods and reporting practices.
**Conclusions:** Following current guidelines (CCOHTA), lifetime models can be more easily interpreted and applied if investigators are more clear in their study aims, if they incorporate assumptions that are based on current data, if they follow current methodological practices (such as deflation, discounting, and sensitivity analyses), and if reporting is more transparent.

**Keywords:** Lifetime costs, Costs, Incidence

For many health conditions, the use of resources can linger for many years. Investigators have demonstrated that the inclusion of long-term resource-use patterns influences the cost-effectiveness ratio (8;31) and guidelines for economic evaluations in health care recommend that all important downstream effects of interventions should be captured (10;16;24). The authors of these guidelines acknowledge that there are considerable difficulties in directly capturing such information, and they recommend that people who conduct economic evaluations use models as sources of estimates to replace missing data, despite the poor quality of data that are created with modeled estimates (10).

Long-term costing is one area where modeling has been used in a variety of applications. However, none of the guidelines have provided any insight as to what constitutes a "high

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quality" guess against which models can be judged. In a recent paper, Buxton et al. (9) indicate that models should exhibit simplicity and transparency; should distinguish between data and opinion; should provide sensitivity analyses; and efforts should be made to validate the model by examining levels of agreement between actual values and model estimates. In an attempt to formalize this advice, we have developed a framework for the analysis of long-term costs, and with the use of this framework, we have conducted a review of the methods currently being used to forecast lifetime health care costs for persons with specific conditions. In this paper, we report on our review.

## METHODS

A long-term costing analysis consists of two components measured over time. A periodic cost of services for a surviving person, denoted as $K_t$; and a probability (denoted by $P_t$) that the subject is alive in a given period t, starting with the incidence (21) or first diagnosis of the condition. The costs over the entire lifetime for a given subject are expressed as $\Sigma P_t \times K_t$, where the annual or periodic costs are summed over the subject's remaining lifetime. If there is a control group then the costs for this group are deducted for each period. In this way, attributable or *excess* costs are quantified. All guidelines recommend discounting future costs (24).

A listing of the characteristics of a modeled study of long-term costs includes the following: the identification of the subjects, scope of the study, the method, and the reporting of results. The method includes the type of analysis, the specification of a time profile which incorporates starting and finishing events and disease stages or resource-using events within the time span, the measurement of services used throughout the time span, and the estimation of the costs of services. These elements are summarized in Table 1.

We conducted a methods review of published articles that estimate lifetime costs. Our aim was to capture a representative sample of articles that used a variety of methods, rather than to obtain an exhaustive account of the results themselves. Our starting point was a literature search in PUBMED for all titles that contained the term "lifetime cost" and "lifetime costs." We reviewed the abstracts and retained those that actually included estimates of lifetime costs. We hand searched the bibliographies of these articles for additional references, and to these, we added any other articles that we could find, including additional literature searched in the chronic disease and transplant literatures. We excluded certain studies such as those in palliative care which, although of a lifetime span, were of short-term duration. We also excluded aggregate studies, that is, those that only reported results for an entire sample or population without providing estimates on a per person basis. As well, we omitted several studies that did not specify methods.

## RESULTS

Our initial PUBMED search revealed 33 references of which we retained 20 for review. An additional 13 references were obtained from bibliographies and other sources. We based our review on the complete articles. Of the 33 articles that we reviewed, 19 were from the United States; 4 from the United Kingdom; 3 from Canada; 2 each from Italy, Australia, and the Netherlands; and 1 from Finland. Three of the papers were published in the 1980s, 3 were published from 1990 to 1994, 20 from 1995 to 1999, and 7 between 2000 and 2002. In 28 of the articles, a study purpose was specified. Of those articles in which a purpose was specified, 11 indicated that the results could be used in economic evaluation studies such as those for screening and prevention, 4 indicated a use for government budgeting, 1 for insurance reimbursement, and 1 for all three purposes. The other studies did not give specific uses for the results, indicating only that there were "potential economic benefits,"

**Table 1.** Components of Studies Reviewed

| |
|---|
| Topic (subjects, study purpose) |
| Scope of costs (Overall or attributable, perspective) |
| *Methods* |
| • Type of analysis |
| *Time profile* |
| • Starting point |
| • Final end point |
| • Disease stages or specific events |
| *Measurement of utilization* |
| • Observational components |
| • Modeling components |
| Unit costs |
| Statistical analysis |
| Discounting |
| Sensitivity analysis |
| Reporting of results |
| Period of observation |
| Presentation by separate services |
| Reporting of physical units |
| Reporting of unit costs |
| Costs by stage of disease |
| Costs by year |
| *Statistical reporting* |
| • Mean |
| • Variance |
| • Skewness |

or that the results could be used to "inform public choices," and to "analyze the impact on policy recommendations."

For analytical purposes, we divided the sample into three groups: primarily observational studies (the O-group), primarily models (the M-group), and studies with a combination of the two (the C-group). Observational studies are those that are mostly based on databases and surveys. There were 10 such studies (1;14;22;23;26;30;35;39;47;49). Modeling studies were mostly built on assumptions and were designed for situations where there was an absence of data, although some of the M-group studies have used primary data elements; there were 16 M-group studies (3;5;11;17;19;27–29;32,33;38;40–43;48). Finally, there were seven studies that comprised combined elements (7;12;13;15;25;36;37). Most modeling studies were simple projections, but several Monte Carlo (11;41) and Markov (29;37) models were included.

## Subjects and Controls

Nine of the studies focused on subjects with cancer; four were focused on HIV, three on rheumatoid arthritis, two on diabetes, and the remainder on a variety of other, mostly chronic, conditions. The time horizon for the studies was not consistently reported, but it tended to be higher for modeling than observational studies.

With regard to the scope of the analysis, three studies focused on total costs incurred by the subjects, whether or not they were related to the specific condition being studied (5;22;26). Of the remaining 30 studies that focused on attributable or disease-specific costs, 22 directly estimated these costs and 8 used controls, subtracting the controls' costs from the subjects' costs. All of the studies that used controls were observational. Of these, 5 used

age and sex as matching variables (7;14;15;25;39); 2 used just age (1;13); and one used age, sex, and geography (36).

## Time Profiles

Time profiles have two components: the total survival time, and the stages of disease throughout this survival period. The starting point for the studies was generally diagnosis or first presentation to the observing unit. In observational studies using longitudinal databases, the first diagnosis could be verified by the absence of similar diagnosis codes in the prior year (14;39). One study that was based on longitudinal data used the period six months before diagnosis as the starting point (14).

Mortality for studies in the O- and C-groups was obtained from a variety of disease-specific databases such as the National Cancer Institute's Surveillance Epidemiology and End Results (SEER) (1;7;13;14;22;36;39), the San Francisco Men's Health Study (23), the Australian National AIDS Registry (25), a lung transplant registry (35), and a Dutch Cystic Fibrosis Registry (46;47). Some studies reported survival time by tracking the age of subject (12;13); in other cases Kaplan-Meier estimates (22;25;46) were used. Survival projections were made with nonlinear functions such as DEALE (declining exponential expectations of life expectancy) (35) and Weibull or double log functions (13). In the M-group, a variety of sources was used to obtain survival information. This included reference to the literature, published national life tables and professional opinion; only a few investigators indicated that they used statistical curves such as Gompertz or linear log functions (34) and Weibull functions (43). In one M-group study, a logistic equation was used on observational data (19).

To obtain attributable costs, several investigators deducted the lifetime costs of the control group from those of the study group. In some instances, the mortality rates of the study group were also used for the control group (14;15;25;32;34;39;41). In other instances, investigators used a separate profile to estimate the mortality experience of the control group (1;13;35;36;42–44). The data sources used to estimate control group survival when separate profiles were used, included United States Life Tables (13;36), and data from wait lists (35;43). We should note that a cohort from the general population may have a longer life span than that of a particular study group.

In addition to the length of survival, a time profile might include disease stages or resource-using events, either of which can drive costs. Staging, which is a modeling tool, has been widely used in observational and modeling studies. During each stage, monthly or per period costs are assumed to be constant, but these monthly costs will vary between stages. In cancer, investigators have incorporated three stages into their analyses: the initial, continuing, and terminal stages (1;7;13;39). Fireman added a six-month prediagnosis stage. The initial and terminal stages generally last for a fixed term, but the continuing stage, which is in-between, can be adjusted in length to incorporate various survival times. In most cancer studies, lifetime costs have been estimated with the use of observational databases; the length of time and, hence, the cost is modeled even in these studies. The same is true for HIV (22;23;25). The use of stages is very common in modeling studies of cancer (48) and diabetes (41). Instead of stages, some analysts use clinical events to drive estimates of utilization over time (11).

## Utilization

Most lifetime utilization studies have included hospitalization, outpatient services, and physician services as key components. Other studies include medications, radiation oncology, blood services, and assistive technologies. Studies in the O- and C-groups have obtained their utilization data from a variety of sources, including administrative databases

(1;7;12–14;35;39), population health surveys (15), surveys of the diseased populations (23;30;45;46;49), and chart reviews (5;37;46). In some instances (23;46), data are collected using a cross-sectional database, and these data are inserted into a model, depending on patient age, stage, or time since diagnosis (23;46). In one instance, the time of the initial event (an injury) was self-reported in a cross-sectional survey (30) and a profile based on time since that event was developed. Sources of data that were used in observational components of studies included Medicare databases, Health Maintenance Organization finance records, and insurance claims. Authors of modeling studies used a variety of sources to obtain estimates of utilization, including published literature (11;19;27–29;32), clinical practice guidelines (11;27), and professional opinion (5;11;19;27–29;41;42;44;48). When published literature was used, search and summarizing strategies (http://www.york.ac.uk/inst/crd/report4.htm) were rarely documented. Modeling studies also used disease registry data (48), chart review (43;44;48), and other observational sources.

Investigators who used administrative or personal survey data were able to measure utilization on a per month basis; this approach was appropriate for cancer and HIV, for which subjects had shorter expected survival times. In other instances, for which data could not be obtained on a per month basis or for which the survival period was longer, resource use was expressed on an annual basis.

## Costs

Investigators used a variety of methods to estimate unit costs. These methods included payments to providers (7;12;13;36;40), provider charges (1;15;22;23;49), allocated costs (14;3;19;28;29;39;44;48), microcosting (43), and discounted charges (35). The authors of 9 of the 33 studies did not state the methods used to obtain unit costs.

Twenty studies calculated costs for all years in terms of the unit costs of a base year. In 10 instances, current costs for each of the years were calculated. In 8 of these 10 studies, costs were deflated to a base year. Among the deflators used were the general Consumer Price Index (CPI) (40), the CPI for medical care (1;17;39), the Statistics Canada implicit price index for hospitals (Grover), and Health Care Finance Administration cost adjustment factors (15;36).

A present value was obtained through discounting in 23 studies; the most common discount rates were 3 and 5%. In eight studies, two or more discount rates were used. In four studies, the discount rate was 0 (although discounting was addressed), and in six studies, the issue of discounting was not mentioned.

## Statistical Methods for per Person Costs

In the O- and C-group studies, the principle method of analyzing total per person costs was monthly costs by stage multiplied by months within each stage (13;14;23;25;36;39). In most of these studies, the survival time was allowed to vary in the continuing stage. In one study (46), a five-year moving average cost was used, and the data were analyzed by age. In several cases, the authors used Kaplan-Meier estimators (13;36), and in one case (36), costs were projected using a Weibull function. In one study, the investigators used a two-part regression analysis applied to survey data to adjust for bias in estimates created by persons with zero costs (30).

## Sensitivity Analysis

In the 17 C- and O-group studies, 3 reported sensitivity analyses. In the 16 modeling studies, 9 reported sensitivity analyses.

**Table 2.** Frequency of Reporting Practices in the Studies

| | Observational and combined group studies | Modeling studies |
|---|---|---|
| Services reported separately | 8 | 4 |
| Physical units reported | 7 | 3 |
| Unit costs reported | 4 | 8 |
| Costs reported by stage of disease | 11 | 6 |
| Costs reported by year | 12 | 7 |
| Statistical mean reported | 17 | 16 |
| Variances reported | 9 | 1 |
| Skewness/outliers reported | 2 | 0 |
| Total possible | 17 | 16 |

### Reporting

The items that were reported in each study are summarized in Table 2. The O- and C-group studies' results were combined. In the observational (O- and C-) combined groups, physical units are reported in seven studies and unit costs are reported in four. In statistical reporting, means are always reported as estimates and variances are reported in half the studies; however, skewness of the data and outlier information are rarely reported (35;49).

## DISCUSSION

We developed a set of methodological criteria for conducting economic analyses of lifetime costs for chronic conditions, and in light of these criteria, we reviewed a sample of 33 studies of various diseases and analytical approaches. Our results indicate that, even at the most general level, there is a considerable variation in methods and reporting of results, even in areas where guidelines are clearly outlined.

Forecasting is a risky business, and the prediction of long-term health care events is fraught with difficulties (2;6;9). Nevertheless, for results to be usable and comparable, they need to be derived in a systematic way, in conjunction with good methodological practice. In what follows, we evaluate our results in several categories and provide suggestions as to how we can improve the practice of forecasting lifetime health care costs.

Our first category follows from the criteria that assumptions and methods should be consistent with the *purpose of the study*. Investigators in the studies that we reviewed did not always state the purpose of the study clearly, and methods did not always suit the study aims. For example, several investigators gave budgeting as a rationale for their studies, but in their analyses they measured attributable (net) costs. A spending unit would be more interested in the total amount spent, rather than in a net cost. Additionally, the selection of survival measures for the control groups was not always appropriate. Several investigators used the same survival times for subjects and controls, although the purposes of the studies were to measure the attributable costs of prevention. In these cases, the prevention of a case of cancer will result in a noncancer case. This individual will likely live longer than a person with cancer; thus, their costs should be accumulated over their cancer-free lifetimes.

A second criteria is that studies should incorporate assumptions that are consistent with *current information*. For example, it is well documented from observational studies that the last few months of life for persons with chronic conditions are very costly. There were studies of all types, especially observational studies, which have failed to incorporate these findings. Some observational studies have been based on population health or disease surveys, which may omit the costly end of life components.



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A related point is that the studies should search for high quality information. It is now widely held in outcomes studies that professional opinion, the cornerstone of many lifetime cost models, does not provide a high grade of information (www.cebm.net). It is true that, at times, professional opinion provides the only source of information. However, as stated by Buxton et al. (9), when professional opinion is used, attempts should be made to verify it.

A third criteria is that methods should be consistent with *current methodological practice*. There were numerous instances where this did not happen. Seldom did investigators follow best practice in their literature searches and reviews. There were instances when current dollar estimates were not deflated to yield constant dollar estimates. Methods to estimate unit costs varied widely; it has been shown in other areas (20) that in the absence of the use of standardized costing methods, it is very difficult to make generalizations. Many studies did not uniformly follow discounting guidelines, nor was sensitivity analysis uniformly conducted.

In many instances, the methods and assumptions of the analyses were not uniformly transparent. Often one could not assess whether good practices were followed, because methods and assumptions were not mentioned.

Finally, results were not always presented thoroughly. Unit prices and physical units should be presented separately, but often they were not. As well, the results were not as useful as they might be. There are possibly some very high cost cases in chronic disease populations and the variation in costs might be very highly skewed. Yet there were very few instances when skewness measures were presented in the observational studies, and there was very little mention of high cost drivers in the models.

The economic analysis of lifetime costs is recognized as a necessary task in economic evaluation studies which often requires modeling and forecasting. At its best, an economic projection model contains many uncertainties. When models do not incorporate the most realistic assumptions, when they do not follow standard practice, and when assumptions are not made transparent, the results are very difficult to assess and interpret. Given current practice in this area, there is a great deal that can be done to narrow the gap between current and best available practice.

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