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Overview of Methods to Estimate the Medical Costs of Cancer

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Abstract

Background—Methods to estimate the direct medical costs of cancer care have evolved into several commonly used methods.

Objectives—We describe the different estimation techniques briefly to contrast these approaches and provide a framewok for other papers in this monograph.

Measures and results—One can estimate costs for all individuals with a specific cancer in a fixed calendar period (prevalent costs) or describe costs starting at the point of diagnosis and estimate immediate and long-term costs (incident costs). A variant of the incidence approach is to divide cancer care into initial, continuing, and terminal care phases and apply these phase specific cost estimates to survival probabilities. The additional burden due to cancer may be computed using cancer services (attributable costs) or by subtracting costs of healthy matched individuals (net costs).

Conculsions—The strengths and weaknesses of these approaches are illustrated to show that the most appropriate choice will depend on whether the goal is to plan for health care costs, set public policy, or assess impact of potential interventions.

Introduction

Cancer is estimated to have cost the United States 219 billion dollars in 2007 (1). One hundred thirty billion dollars were due to indirect morbidity or mortality costs from lost productivity or early mortality. However, 89 billion dollars were estimated to be attributable directly to medical care. More specific medical care cost estimates by demographic group, cancer site, or treatment type can be useful for healthcare budgeting, comparing different treatment approaches, assessing equity of care, or as inputs to cost-effectiveness models. We focus in this brief review on how one estimates the direct medical costs of cancer. We distinguish between prevalence and incidence views of costs and between costs attributable to cancer and the net costs of cancer care.

Overview of Prevalence and Incidence Approaches to Estimating Costs

Prevalence costs represent the costs for a population with a specific cancer diagnosis over a fixed calendar time period (2). For example, we might consider the medical costs of care for all women with breast cancer during the year 2007. This would include newly diagnosed women, breast cancer survivors, and women who may die of breast cancer during the designated time period. As treatment effectiveness improves leading to improved survival, the absolute numbers of breast cancer survivors will increase and the number of deaths attributable to breast cancer will decrease. While there is some evidence that incidence rates of breast cancer are decreasing in some age groups (3–4), the absolute number of new incident cases could

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increase as the population ages. Therefore, for any specific cancer the proportion in each phase (newly diagnosed, survivor, or terminally ill) may change due to treatment effectiveness and the population at risk. Estimates of the prevalent costs may of greatest interest to policy makers and health care payers, e.g. Medicare or large insurers since they need to plan expenditures. However, using prevalent costs may make it difficult to judge the potential effect of a cancer prevention or treatment strategy since the strategy may only impact the incidence of cancer or immediate treatment costs. Therefore, costs for cancer survivors or individuals with prevalent cancer would not be affected by the reduction in cancer incidence or likely benefit from improved treatment. Starting the analysis of costs of care from the point of diagnosis may be more useful for assessing the effect of such interventions.

Incidence cancer costs are computed from the time of diagnosis and represent the costs of cancer from an individual perspective which may be aggregated over individuals to provide estimates of the costs of newly diagnosed disease (5). It may be necessary to consider demographic and tumor characteristics that can directly influence the costs of care. Costs may extend for several years thereby requiring adjusting for changes in purchasing power and possibly censorship if cost information is incomplete. Incidence cancer costs are sometimes classified by time from diagnosis into phases (6–8). One can determine the possible cost effectiveness of a cancer control strategy given incidence cancer costs and the efficacy of the intervention. For this reason incidence cancer costs may be most useful from both a public policy perspective and the patient's perspective. Below we provide a more detailed description of two variants for estimating incidence costs, the cohort and phase of care approaches, with some introduction to analytical and statistical issues which are elaborated further in other papers in this supplement.

Incidence Cancer Costs

Incidence cancer costs can be computed for a fixed duration from the point of diagnosis. Particularly for longer durations, it is necessary to discount costs as they extend forward from the point of diagnosis (9). When combining data from several years of incident cancer cases, it is also necessary to adjust costs to a common time frame. Both of these adjustments can be straightforward, but the discount rate and inflation factors need to be specified.

More difficult is the accommodation for data that may become progressively missing as time proceeds. For example, suppose we want to estimate the mean cost over 5 years based on monthly mean costs. A simple expression would be the following:

$$\text{Total cost}\,(60) = \sum_{t=1}^{60} \overline{C}_t$$

This expression assumes that the patient is alive for the entire period so it should appropriately be described as the five year costs conditional on survival to five years. To estimate expected five year costs for all patients allowing for deaths we could use the estimate proposed by Lin and colleagues (10)

$$\text{Total cost}\,(60) = \sum_{t=1}^{60} \widehat{S}(t)\,\overline{C}_t$$

where $\hat{S}(t)$ is the Kaplan-Meier survivor estimate at month t, i.e. the probability of being alive in that month

Both estimators assume that there is complete follow-up of surviving patients with respect to costs or at least there is no bias in the estimated mean monthly cost. If patients with low costs are more likely to be censored (i.e. lost to follow-up), then costs could be overestimated since the cost estimate would be biased toward high cost individuals, possibly those with shorter survival.. On the other hand, if we want to describe lifetime costs we could underestimate costs since the high costs of terminal care might be excluded for those with long survival. This consideration has led to other estimators of total costs that allow for informative censoring (11–12). These methods allow estimation of the expected costs of cancer. Thorough discussion of these methods is beyond the scope of this introduction so will not be done here, but is addressed elsewhere in this issue and the literature (13).

Both expressions above assume that the purpose is to estimate the mean cost over a fixed time period. This is reasonable if a payer is responsible for the costs of all patients. It may not be reasonable from a patient perspective where the median cost may be a better guide to the cost of care for a “typical” individual since the mean can be heavily influenced by high cost outliers while the median would be unaffected. Consequently, if using costs as inputs for cost effectiveness comparisons, one might prefer median costs if the treatments or strategies being compared did not alter the likelihood of an extremely high cost, but did address the costs for individuals with more typical cancer care. This leads to methods directly estimating the median cost, rather than the mean cost allowing for censoring (14).

One might also want to give an estimate of variability of the total costs. The monthly means may be highly correlated so the sum of variances of the monthly means may not be an adequate estimate of the total variance. Furthermore, one may want to differentiate costs by cancer stage and demographic characteristics. A possible model for individual monthly costs is a linear model allowing main effects of time from diagnosis, main effects such as age and cancer stage, and the interactions of time and the demographic and tumor characteristics variables (15). One also has to assume a reasonable correlation structure for the residual errors within an individual over time. Given the model, a linear combination over all time points (e.g. 60 months) can then be estimated for specific demographic characteristics and cancer stage along with a standard error for the estimate. Consequently, a confidence interval for total costs over this period can be provided.

Net and Attributable Costs

While cancer care can be very expensive, it is in addition to medical care for non-cancer related services. It is important to identify the additional burden and costs of care due to cancer. The terms “net costs” and “attributable costs” are sometimes used interchangeably and address the same underlying concept of additional care, but we distinguish between them here. Net costs are computed as the difference between the mean costs for cancer patients and for patients without cancer who are otherwise comparable (6). Attributable costs are based on a classification of medical costs for a cancer patient as being related to cancer or not (16). Calculations of prevalence costs may be based on the sum of attributable costs over a fixed calendar period.

The statistical models above discussed “costs” nonspecifically. Costs could be the direct medical costs for cancer care or they could be adjusted costs after accounting for other care typically received. Direct cancer costs would be the medical care costs that appear to be directly related to cancer care, i.e. for services attributable to cancer. These could include chemotherapy, biologic, or hormonal agents, as well as surgery, radiation therapy, and oncological services. Attributable costs could be computed strictly from cancer patients if one is able to distinguish cancer-related services from non-cancer services, though in practice this is both time-consuming and difficult. For survivors, it may become less apparent over time

which services are cancer-related and which services are for routine medical care. Nonetheless, it is apparent that this method can only result in increased costs if we define costs as additional costs attributable to cancer.

Net costs are defined as the difference in caring for a cancer patient versus caring for a similar patient who does not have cancer. This differs from attributable costs since a patient with cancer may not seek or may not be offered some medical procedures that a similar patient without cancer would ordinarily receive. Therefore, net costs can even be negative for some cancer patients if they did not receive expensive treatments for other conditions that their "matched" controls might receive (8). Furthermore, one may also want to consider competing risks for death in a similar control population. Therefore, it is reasonable to construct net costs by subtracting medical care costs for a similar population of cancer-free individuals from the total medical care costs of cancer patients in order to estimate the additional burden of cancer. The expectation is that net costs may be less than attributable costs because they account for diminishing medical options for non-cancer treatments in patients with cancer.

Both attributable and net costs can be computed for prevalence and incidence samples. As a simple example we can use Medicare claims to estimate the prevalent costs of care for a defined population of individuals with existing cancer over a fixed calendar period. If claims are allocated as being for cancer care or non-cancer care, we are adopting an attributable costs approach. If we compare total costs of care for individuals with prevalent cancer to a matched similar group without cancer, we are computing net costs of care. Incidence costs computation is similar, but uses diagnosis date as the individual-specific starting reference point (or a few months earlier to allow for diagnostic procedures), rather than a fixed calendar starting point for all individuals. Both prevalent and incident cancer costs can be further classified by demographic or tumor characteristics. Since complete cost streams are often unavailable, microsimulation models can be very useful in estimating costs and the effects of different decision strategies. For example, Canada's Population Health Model (POHEM) utilizes a synthetic population model with attributable costs to determine the likely economic effect of cancer control interventions (17–20). Both prevalent and incidence approaches combined with empirical data or microsimulation models, may be useful for public policy decisions depending on the goal (21–22).

Phase of care approach

A variant on the incident cancer costs approach is to define time periods of interest following a diagnosis of cancer where costs may differ dramatically across periods. The number of periods and their duration can be determined empirically or theoretically. The most common model may the Phases of Care model with three periods: Initial treatment phase, continuing care, and terminal care (6–8). Initial care can be the first six months, but one year may be better to fully capture the intensity of care that occurs such as surgery and chemotherapy. Costs of treatment can be very high in this period. Terminal care is end-of life care that can be defined retrospectively as the last six or twelve months of life conditional on the death date being observed. Costs of treatment and palliative care are also extremely high in this phase. Continuing care is all time between initial and terminal care, but is usually calibrated as an average cost on a 12 month scale. Costs for the continuing care period are much lower than the treatment and terminal phases, and the costs of specific events such as treatment for recurrence would be averaged out over the period. It is possible that the treatment and terminal care periods could overlap for a patient with a very poor prognosis so special adjudication may be required. The actual lengths of the treatment and terminal phases may depend on the disease in question.

Means and confidence intervals may be computed separately by phase. Total costs for a fixed period post-diagnosis can be constructed by summing the costs over the treatment and terminal periods plus a cost for continuing care using a disease-specific estimate of the duration of that period. This approach creates a "synthetic" patient who has complete costs, thus avoiding the difficulty with censored costs. Variance estimation is difficult without making assumptions about the independence of estimates across phases of care (23). Nonetheless, the phase cost estimates can also be utilized in survival models that weight the probability of survival in each month by the phase cost associated with that month so that an estimate of survival-adjusted total costs can be constructed (23). This provides an alternative to an incidence approach for estimation of total costs. Furthermore, it can utilize elements from prevalent costs by including in a phase cost estimate, patient costs that may not have been included in an earlier phase. For example, a patient not included in the computation of initial care costs could still contribute to continuing care or terminal care costs. Therefore, the method uses existing data efficiently.

When computing net costs the average cost for similar patients may be subtracted from both initial care and continuing care. For initial care comparisons this is often a trivial adjustment due to the high costs of initial treatment (8). While initial therapy is considered to be one year, this may be too short or too long depending on the cancer site and available treatment.. In breast cancer hormonal therapy is typically given for 5 years and some clinical trials are exploring longer durations. The costs of hormonal therapy are dwarfed by new biological therapies such as trastuzumab for HER2 positive breast cancer. Currently, one year of therapy is recommended, but longer durations are being tested in clinical trials. At the current time the annual cost of trastuzumab is $36,000 (24). That is more than three times the mean cost of initial treatment for breast cancer computed recently by Yabroff and colleagues (23).

However, for most continuing care the net costs can be small (8) since most therapy is completed and cancer follow-up visits may be combined with routine primary care. There is some evidence that terminal care costs may be higher for cancer patients than patients without cancer. Furthermore, given shorter life expectancy for cancer patients discounting will further increase the differential between cancer patients and non-cancer patients.

While the treatment phase approach has some drawbacks, it is readily understood and estimation is straightforward. The recent summary of Medicare costs for many cancer sites by Yabroff et al. can be extremely useful in planning the impact of new treatments and prevention strategies (23). With estimates of the population census, cancer incidence by age and calendar year, survival, and phase costs, one can estimate prevalence costs of care in any calendar year for planning purposes. This has great advantage as policy makers may want to know the costs of investing in cancer care now to forestall severe effects on Medicare or other payers in the future. The restriction to those over age 65 is a limitation and may miss some younger patients who would receive more aggressive care at a younger age. Similar analyses may be possible using the data from managed care organizations and large insurers that would cover this gap. The papers included in this monograph provide a strong methodology for how these medical costs studies can be conducted.

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