# The Costs of Cancer to a Major Employer in the United States: A Case-Control Analysis

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***Abstract***

***Background:*** **Detailed data will be increasingly important in determining the cost of cancer care in the managed care setting.**

***Objectives:*** **To estimate the full cost of cancer to a major employer in the United States and to determine the nature of the expenditures.**

***Study Design:*** **Analysis of medical, pharmaceutical, and disability claims data from 1995 to 1997 for a major employer with more than 100,000 employees.**

***Methods:*** **The cost of cancer is determined on a per-patient and per-employee basis. Based on a case-control method, cancer patients are matched to individuals with no record of cancer diagnosis or treatment. The incremental cost per employee and the percentage of total healthcare expenditures for cancer are quantified.**

***Results:*** **Approximately $224 per active employee, or 6.5% of the corporation's total healthcare costs, was spent on incremental care for cancer patients in 1997. Medical conditions not directly related to cancer account for approximately half the total excess expenditures for patients with cancer. On average, annual healthcare and disability costs for persons with cancer were approximately 5 times higher than for their counterparts without cancer.**

***Conclusions:*** **The costs of cancer care are a substantial proportion of healthcare costs for employers. When the full cost of cancer is included in a cost-benefit analysis, expenditures for programs to reduce the risk of cancer in the working population may be justified. Expenditures to reduce the incidence and severity of conditions indirectly associated with cancer may also reduce overall employer healthcare expenses.**

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Reliable data on the costs and outcomes of different healthcare interventions are essential for efficient distribution of healthcare resources[1] and evaluation of quality of healthcare.[2] The National Institutes of Health estimates total annual costs for cancer in the United States at $107 billion annually. These cancer costs represented roughly 5% of all healthcare expenditures in 1995.[3] These high healthcare costs translate into significant expenses for US employers. As cancer treatment improves and the number of patients in remission or recovery increases, the management of cancer care is becoming increasingly important. This trend has led managed care organizations to focus on assessing the likely costs of cancer care and outcomes for different types of cancer.[3]

This study, using a case-control analysis, is among the first to estimate the full cost of cancer care to a major employer in the United States, taking into account not only those treatment costs directly tied

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to cancer (eg, chemotherapy) but also others not unique to cancer patients but disproportionately common among them. It also provides some information on work-loss costs from cancer and related medical conditions. These findings provide information about employer healthcare expenditures and the impact of interventions, including prevention and early detection.[4] The cancer cost estimates provided here could allow a more comprehensive evaluation of the cost effectiveness of such interventions by more fully accounting for disease costs.[3]

## ··· METHODS ···

### Study Population

We relied on unusually rich original data spanning 1995 through 1997 that contained healthcare and disability information for employees of a national Fortune 100 American corporation with more than 100,000 employees as well as for their spouses and dependents covered by the corporation's health plan. There is no evidence that working in this industry increases the risk of cancer. For each person in the file, the records showed year of birth, sex, job classification (if an active employee), zip code of residence, and type of health plan. Expenditures for each person's healthcare claims paid by the employer during the period of enrollment were recorded by date of service and nature of the ailment. Approximately 87% of active employees were enrolled for the entire period. The remaining 13% were included in the analysis for the period during which they were enrolled. Employee expenditures were grouped into 4 categories: inpatient, outpatient, office services, and prescription drugs. For active workers, periods of disability and payments received from the corporation were recorded, as were dates of medical care, which could be associated with regular workdays to proxy absenteeism.

To be included in this analysis as a cancer patient required 2 or more cancer-related principal diagnoses on claims at least 30 days apart and no more than 1 year apart. Because patients with malignant nonmelanoma skin cancer are traditionally excluded from cancer epidemiology statistics,[5] they were not included in our results. For patients to be included in the pool from which noncancer controls were drawn they had to have no recorded diagnoses or history of malignant or benign tumors during 1995 through 1997. As a result, a few patients with nonmelanoma skin cancer or benign tumors were excluded from both the cancer and the noncancer groups.

Because people diagnosed as having cancer in 1997 are a key element of our analysis, we identified them by searching the claims records for *International Classification of Diseases, Ninth Edition* (ICD-9), codes related to malignancy (ie, ICD-9 codes 140-208, excluding 173). If there were costs under these codes in 1997 but no record of treatment during 1995 and 1996 and no record of previous treatment for cancer, we assumed that the initial diagnoses were in 1997.

In estimating the costs of cancer to an employer, it is conceptually easiest to focus on active employees, who must be replaced by presumably similar individuals when they are temporarily incapacitated or permanently removed from a workforce of stable size. In that setting, one cannot easily argue that cancer might bring higher costs in the short run but longer-term savings because of fewer person-years of coverage. Furthermore, because employed workers (as opposed to retirees older than 65 years) are ineligible for Medicare, and because the employer's health benefits are so comprehensive, coverage from outside sources is unlikely. For these reasons, we concentrate on active employees. We do, however, present some corresponding data about retirees, spouses, and dependents.

### The Case-Control Design

Estimating the incremental healthcare/work-loss costs to the corporation required that we match individuals with principal ICD-9 codes for each cancer diagnosis during 1995 through 1997 with individuals without cancer. Ideally, these pairs would be of the same age, sex, job classification, health plan, and residential zip code. Presumably—absent the cancer—these healthy individuals, on average, would have been similar to their matched cancer patients in overall health condition, lifestyle, attitude toward seeking medical care, and treatment by healthcare providers. Thus, these matched individuals constitute an approximate control group, suggesting the appropriate baseline levels of healthcare/disability costs unrelated to cancer. Furthermore, cancer patients not observed for the full period were matched with controls over the same time interval.

We matched 89% of cancer patients with controls on 5 dimensions—age, sex, job classification, health plan, and residential zip code—by allowing slight variations in both age and zip code (Table 1). Indeed, about 55% of all patients could be matched exactly on all 5 dimensions. In searching for controls for the other patients, we continued to insist on

exact correspondence on 3 dimensions—sex, job classification, and healthcare plan—but allowed modest variation on the other 2 dimensions.

To obtain additional controls, we initially held zip code constant and searched in increments of 1 year for controls born up to 3 years before or after the patient. If no matches were found within the 7-year span centered at the patient's birth year, we proceeded to vary the zip code. Returning to the year of the patient's birth, we searched for controls among the zip codes that were in the same metropolitan area as the patient and had per-capita income in 1990 within 10% of that of the patient's zip code (as recorded in the 1990 Census). The assumption was that any zip code meeting the criteria was similar to that of the patient (eg, affluent suburb or inner city) and thus likely reflected similar lifestyles and attitudes (especially for employees with the same job classifications). If this effort was unsuccessful, we once again varied year of birth up to 3 years as described previously.

As noted, allowing such variations yielded an 89% matching rate. Further relaxing the matching criteria could yield controls not directly comparable with patients and thus could compromise rather than advance the analysis. We therefore, in effect, deleted 11% of patients from the matched comparisons. For retirees and spouses, the successful matching rate was slightly lower, with a deletion rate of 16%.

In a case-control environment, the full incremental costs of cancer are the excess costs incurred by cancer patients over their controls. For cancer patients, we subtract the direct costs of treating cancer (eg, procedures such as chemotherapy recorded under ICD-9 codes 140-208, excluding 173) from these excess costs. The remaining amount reflects net incremental costs not uniquely identified with cancer. Any average observed increase in costs, whether from conditions often identified with cancer (eg, neutropenic fever) or from other conditions, can be attributed to cancer because that is the only systematic factor distinguishing the patient with cancer from the matched control.

## Data Analysis

We start by examining the incremental costs of cancer, ie, the increase in the corporation's healthcare/work-loss costs over the full course of the disease. Cancer costs can begin before formal diagnosis because of treatment for symptoms (eg, pneumonia) not yet recognized as caused by cancer. Similarly, the costs can extend beyond the end of direct treatment. An advantage of the case-control method is that it allows estimation of such early and late expenses: if cancer was diagnosed in the middle of 1997, eg, comparison with the matched worker can indicate prediagnosis excess costs earlier in 1997 and in all of 1996. The term "costs" refers to payments expended by the employer to healthcare providers for medical care and prescriptions or to employees for missed workdays that were covered by their disability benefits.

We divide incremental cost increases due to cancer into several categories. Direct costs (eg, radiation, antineoplastics, and cancer-related disability) reflect the actual cost of treatment or work loss directly related to cancer. The other excess costs (ie, those tied to medical conditions not inevitably linked to cancer) reflect differences between patients and controls after direct costs are subtracted. Empirically, direct cancer costs were determined from claims with cancer diagnoses, ie, with ICD-9 codes 140 through 208, excluding 173. For patients who experienced more than 1 cancer type, costs were assigned to the cancer type first treated. A more comprehensive taxonomy of divergent expenditures between patients and controls could list the most frequent principal diagnoses on which the groups differ and distinguish medical conditions strongly related to cancer from those moderately related to cancer and those further removed. Such a

**Table 1.** Selection Criteria for Identification of a Control Population for Active Employees

| Selection Criteria* | Cancer Patients Matched to Controls, % |
|---|---|
| Same zip code | |
| Equivalent age | 54.6 |
| ± 1 y | 15.0 |
| ± 2 y | 5.6 |
| ± 3 y | 3.4 |
| *Subtotal* | *78.6* |
| Similar zip code | |
| Equivalent age | 5.0 |
| ± 1 y | 3.1 |
| ± 2 y | 1.5 |
| ± 3 y | 1.2 |
| *Subtotal* | *10.8* |
| **Total** | **89.4** |

*Sex, job classification, and health plan are the same for all patients and controls.

taxonomy, however, is beyond the scope of this analysis.

For a particular type of cancer, an important calculation was the employer's total reported excess costs for healthcare and disability in 1996 ($TC_{96}$). This "snapshot" measure considers different patients at various phases of the disease in that year, ranging from prediagnosis through posttreatment. The estimate arises from case-control comparisons. $TC_{97}$ is the corresponding total cost for 1997, adjusted slightly to include prediagnosis costs in 1997 for some individuals diagnosed in 1998 (beyond the end of our data span). We show in the Appendix that $\Delta C$, the total excess cost to the employer per case of a given type of cancer diagnosed in 1997, can be estimated using the following formula:

$$\Delta C \approx (TC_{96} + TC_{97})/(2N_{97})$$

where $TC_{96}$ is the observed excess spending for healthcare and disability in 1996 associated with a certain cancer, $TC_{97}$ is the adjusted excess cost for 1997, and $N_{97}$ is the number of new cases of that cancer in 1997. Although $\Delta C$ focuses on cases diagnosed in 1997, it approximates not only excess costs borne in 1997 itself, but the full stream of costs over the longer period during which they occur.

## ··· RESULTS ···

The proportion of the corporation's active workforce diagnosed as having various cancers in 1997 and the corporation's estimated incremental cost per case arising from these cancers are shown in Table 2. For example, these results suggest that during 1997 an employee chosen at random among those working that year would have a probability of 1 in 4470 of being diagnosed as having colorectal cancer and 1 in 370 of being diagnosed as having any cancer (excluding nonmelanoma skin cancer). Associated incremental cost to the corporation during the full course of the colorectal cancer would be $78,567. Thus, the average excess cost to the corporation associated with colorectal cancers diagnosed in 1997 would be (1/4470) x $78,567 = $18 per employee (ie, the excess cost is weighted by the

**Table 2.** Incidence and Incremental Cost of Cancer Over the Entire Treatment Period for Active Employees Diagnosed as Having Cancer—1997*

| Type of Cancer | New Cases, % | Fraction of Employees Diagnosed as Having Cancer | Mean Incremental Cost per Case, $ | Mean Incremental Cost per Employee, $ |
|---|---|---|---|---|
| Lung | 20 | 1 in 1850 | 72,465 | 39 |
| Prostate | 16 | 1 in 2300 | 49,475 | 22 |
| Colorectal | 8 | 1 in 4470 | 78,567 | 18 |
| Breast | 5 | 1 in 6900 | 85,842 | 12 |
| Bladder | 5 | 1 in 6900 | 62,940 | 9 |
| Lymphoma | 4 | 1 in 9500 | 136,083 | 14 |
| All others† | 42 | 1 in 900 | 99,614 | 111 |
| *All cancers** | *100* | *1 in 370* | *83,084* | *225* |

*Figures do not include nonmelanoma skin cancers.
†Includes lymphoid leukemia (4%), esophagus (4%), larynx (3%), thyroid gland (3%), brain (3%), kidney and other unspecified urinary organs (3%), multiple myeloma and immunoproliferative neoplasms (2%), pancreas (2%), stomach (2%), and other less frequently observed tumors (15%).

probability of having to assume it). Continuing in this way, we find that in 1997 cancer cost the corporation approximately $225 (ie, 1/370 x $83,084) per active employee per year in excess costs. Of this excess cost, $172 resulted from excess healthcare costs and $53 from excess work loss.

In this corporation, overall healthcare and disability costs per employee were approximately $3500 in 1997. Cancer, therefore, accounted for approximately 6.5% (ie, 225/3500) of these costs. Table 3 presents similar data for retirees, spouses, and dependents with cancer in 1997.

As shown in Table 4, total annual healthcare costs incurred by patients with cancer were 5 times higher than those incurred by controls, averaging $16,246 ($6786 + $9460) for cancer patients vs $3264 for controls. The average incremental cost of $12,982 per year ($16,246 minus $3264) is only a fraction of the total incremental cost for a cancer patient because treatment costs, as well as other excess healthcare costs and disability, are often spread out over several years. It is difficult to readily distinguish costs incurred at the onset of cancer from those resulting from follow-up care because the data only start in 1995 and observed cancers might have begun much earlier. For patients whose initial diagnosis was in 1996, however, excess costs in the first year of treatment, when care is most intensive, averaged $22,269. That amount is nearly twice the average annual excess cost cited previously ($12,982). If an employer were to set aside a "reserve" to cover the full expected incremental cost of an employee newly diagnosed as having cancer, the amount would be $83,084 (Appendix).

We observe from Table 4 that total excess costs for cancer patients substantially exceeded direct cancer costs. The full excess was nearly twice as large as the cost of directly related treatment: $9948 as opposed to $5412. Stated somewhat differently, the obvious costs of cancer are only about half the total incremental costs attributable to this disease. Thus, the economic impact of cancer is much larger than first appears.

The preceding analysis applies to the cost of cancer excluding nonmelanoma skin cancer. To test the sensitivity of the results, we performed a similar

**Table 3.** Incidence and Incremental Cost of Cancer Over the Entire Treatment Period for Retirees, Spouses, and Dependents Diagnosed as Having Cancer—1997*

| Type of Cancer | New Cases, % | Fraction of Retirees, Spouses, and Dependents Diagnosed as Having Cancer† | Mean Incremental Cost per Case, $ | Mean Incremental Cost per Employee, $ |
|---|---|---|---|---|
| Lung | 12 | 1 in 5850 | 66,493 | 11 |
| Prostate | 11 | 1 in 6650 | 42,661 | 6 |
| Colorectal | 3 | 1 in 20,500 | 186,082 | 9 |
| Breast | 32 | 1 in 2200 | 43,190 | 20 |
| Bladder | 3 | 1 in 22,300 | 40,172 | 2 |
| Lymphoma | 4 | 1 in 18,900 | 45,953 | 2 |
| All others‡ | 35 | 1 in 1980 | 79,751 | 40 |
| *All cancers§* | *100* | *1 in 700* | *63,673* | *90* |

*Eighty-four percent of retirees, spouses, and dependents were successfully matched with a noncancer patient; the remaining 16% were dropped from the analysis.
†Some retirees and other dependents are covered by Medicare and incur no costs to the employer except for prescription drugs.
‡Includes thyroid gland (4%), brain (3%), ovary and other uterine adnexa (3%), pancreas (3%), body of uterus (2%), multiple myeloma and immunoproliferative neoplasms (2%), and other less frequently observed tumors (19%).
§Figures do not include nonmelanoma skin cancers.

analysis including all cancer patients. This led to similar results. The overall cost of all cancers was $228 per employee instead of $225. The relatively inexpensive skin cancers reduced the average incremental cost for all cancers to $11,464 from $12,982, whereas the total costs associated with cancers remained twice as large as the costs of directly related treatment.

Excess healthcare costs for workers with cancer arose from many causes. By observing diagnosis-specific average costs, we found that although many of these "high"-cost diagnoses were traditionally associated with cancer and its treatment, there were some notable exceptions. For example, infections, asthma, and dental procedures, although not immediately thought of as associated with cancer, in fact cost considerably more among cancer patients than controls. Compared with controls, claims for infection were twice as costly and twice as likely for patients with cancer. Workers with cancer experienced a 5-fold increase in disability claims for asthma, with twice the mean duration of disability, and a 9-fold cost increase in disability claims for dental procedures. Future research might systematically analyze which diagnoses most frequently account for complications and comorbidity.

Absenteeism, disability, and healthcare costs are also likely to be related to adverse effects of cancer and its treatment that affect quality of life, including anemia/fatigue[6-8] and nausea.[9-11] Employees with cancer who experienced both anemia/fatigue and nausea incurred total excess costs of $184,868. Employees with only one of these conditions experienced excess costs about half as high: $106,982 for anemia/fatigue and $80,550 for nausea. Employees with cancer but neither of these conditions incurred

**Table 4.** Active Employees' Cancer Treatment and Other Costs per Year Compared with Controls, Excluding Nonmelanoma Skin Cancer

| | Cancer Patients | | Controls | |
|---|---|---|---|---|
| | Direct Cancer Care Costs, $ (ICD-9 Codes 140-208) [1] | Other Care Costs, $ (All Other Claims) [2] | (All Claims) [3] | Annual Incremental Costs During the Observation Period, $ [4] = [1] + [2] - [3] |
| **Healthcare Costs (per Patient)** | | | | |
| Medical | | | | |
| Office | 1054 | 641 | 249 | 1446 |
| Inpatient | 2395 | 3072 | 649 | 4818 |
| Outpatient | 1763 | 1778 | 497 | 3043 |
| Total medical | 5212 | 5491 | 1395 | 9307 |
| Pharmacy* | 200 | 917 | 476 | 641 |
| *Subtotal* | *5412* | *6408*† | *1871*† | *9948* |
| **Work Absence Costs (per Patient)** | | | | |
| Absenteeism | 538 | 1105 | 520 | 1124 |
| Disability | 836 | 1948 | 873 | 1910 |
| *Subtotal* | *1374* | *3053*† | *1393*† | *3034* |
| **Total costs** | **6786** | **9460** | **3264** | **12,982** |

*Direct cancer costs for pharmacy are limited to claims made for antineoplastics.
†If the observed case/control differences as a random sample of those that would arise at the corporation over the long run, these differences-of-mean are highly significant ($P<.001$).

lesser excess costs of $68,621.* This downward sequence suggests that anemia/fatigue and/or nausea might be associated with a greater "propensity" for nonmalignant conditions that raise costs among cancer patients. Additional research is needed to determine whether a cause-and-effect relationship exists.

## ··· DISCUSSION ···

Using an unusually rich source of employee data and healthcare information, we determined the incidence of various types of cancer diagnosed among active workers, retirees, and dependents of one of America's largest corporations between 1995 and 1997. Because this study relied on insurance claims data, the findings are subject to the usual limitations of analyses of administrative datasets regarding the accuracy of medical diagnoses and possibly incomplete assembly of claims (eg, missing bills and multiple plan coverage).[12] The overall probability of an active worker in this corporation being diagnosed as having any type of cancer in 1997 was approximately 1 in 370. The corresponding probabilities for lung, prostate, colorectal, and breast cancer were 1 in 1850, 1 in 2300, 1 in 4470, and 1 in 6900, respectively. These probabilities are consistent with those relied on by the American Cancer Society to estimate the number of new cases of cancer diagnosed in a community population given differences in the study population.[13]

Based on a case-control study design, we estimated the corporation's excess healthcare costs in 1996 and 1997 due to cancer and used these data to estimate the average incremental cost per case for each type of cancer. Direct cancer treatment and other healthcare costs due to cancer were approximately $225 per employee, or 6.5% of the $3500 in total healthcare and disability costs.

Although control group members in our study essentially matched patients with cancer for age, sex, job classification, zip code, and health plan, relevant differences between the 2 study populations may remain. For example, cigarette smoking not only increases the risk of cancer (especially lung cancer) but also that of other ailments. Thus, some of the increased healthcare costs observed in a particular cancer group may be unrelated to cancer. In this study, this effect seems limited because conspicuously large cost differences were not apparent for cancers associated with specific behaviors (eg, lung cancer and smoking), as shown in Table 2. Future research could explore lifestyle or comorbidity variables that we could not explicitly consider.

A previous study[14] attempted an analysis somewhat similar to ours by matching each cancer patient with a composite noncancer "patient" whose characteristics were the average of those of all noncancer patients of the same sex and within the same 5-year age cohort. Costs were imputed from utilization records beginning 1 month before diagnosis. The estimated incremental cost of cancer was measured as the difference in total expenditures between cancer patients and their corresponding noncancer cohorts. Our study refines and improves on this previous research. It uses a one-on-one patient match based on a broader set of criteria (which include occupation and income as well as age and sex) and distinguishes between direct costs for cancer treatment and other costs that arise among both cancer patients and controls but are more common among the former. Our study also relies on actual payment data and considers disability payments and work absence as part of the cost of cancer.

Most studies estimating healthcare costs due to cancer are based solely on direct costs related to diagnosis and treatment of the disease.[15,16] In contrast, a striking observation in this study was that direct healthcare costs for the treatment of cancer, such as surgery, chemotherapy, and radiation, accounted for only about half of the incremental costs of cancer to the employer. Disability and absenteeism added somewhat to the total cost. Medical expenditures beyond the direct costs contributed the most, however, suggesting that effective prevention or treatment of "secondary" medical conditions might result in substantial reductions in cancer-associated healthcare costs.

In view of our evidence about the economic burden that cancer imposes on employers, increased expenditures for screening and prevention may be warranted. (In fact, our results may understate the true cost of cancer because we did not systematically include caregiver costs or medical/work-loss costs associated with screening tests.) Screening programs conducted on a regular basis can detect breast, colorectal, and prostate cancers at earlier stages, when optimal benefit can be derived from treatment.[17] Whereas implementation of screening programs may increase short-term costs to employers, long-term

*All the costs in this paragraph exclude nonmelanoma skin cancer.

costs of cancer may be reduced by treating cancer at an earlier stage.[1] From a worker's perspective, "the most important benefits apply primarily to people who are healthy today but may develop cancer in the future."[18] Alternatively, for patients who develop cancer and require aggressive treatment, efforts to address medical conditions that affect ability to work might be cost effective. For example, anemia/fatigue and nausea, common conditions concurrent with cancer, were associated with markedly higher incremental costs in the present study. Expenditures for antiemetic therapy effective at reducing hospitalization and improving the functional status of cancer patients[19] might therefore be justified.[20] Similarly, treating anemia in cancer patients might be cost effective because it has been associated with improvements in overall well-being and physical, social, and psychological function.[21,22]

Overall, the results of the present study demonstrate a substantial impact of cancer on the healthcare costs of a major employer in the United States and suggest that reducing the risk of cancer and secondary ailments among cancer patients might be effective in reducing healthcare expenditures. Of course, this corporation's incremental cancer costs reflect the age distribution and behavior patterns of its workforce and healthcare costs and treatments in those parts of the United States where its activities are concentrated. Furthermore, although some analyses were performed for retirees, spouses, and dependents, the estimates about cost increases pertain to active employees only.

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## APPENDIX

### Estimating the Average Excess Cost During the Course of a Malignancy ΔC

$(TC_{96} + TC_{97})/2$ is the total observed excess cost for a specific cancer averaged over 1996 and 1997. As noted, we define ΔC as the average excess cost that each case of a specific cancer diagnosed in 1997 will generate over the course of the disease. These excess costs often extend into 1998 and beyond and cannot be determined from the data at hand. We can, however, estimate these costs from the 1996 and 1997 data if we make the steady-state approximations that (1) the number of new cases per year was fairly constant in the middle to late 1990s and (2) the duration and magnitude of mean excess cancer costs per case—from prediagnosis to posttreatment—will be stable over several years starting in 1996.*

Under this approximation, the future excess costs for patients diagnosed in 1997 are, in effect, already included in the 1996 and 1997 data. If $EX_{97}$ is the total excess cost for those diagnosed as having a particular cancer in 1997, then $EX_{97}$ follows:

$$EX_{97} = EX_{97}(96) + EX_{97}(97) + EX_{97}(98) + EX_{97}(99) + EX_{97}(00) + \ldots$$

where $EX_{97}(z)$ = total excess cost in year z for those diagnosed as having the cancer in 1997.

The quantity $TC_{96}$—total excess cost for that particular cancer in 1996— is given by:

$$TC_{96} = EX_{97}(96) + EX_{96}(96) + EX_{95}(96) + EX_{94}(96) + EX_{93}(96) + \ldots$$

where $EX_k(96)$ = total excess cost in 1996 for those diagnosed as having the cancer in year k.

Under the steady-state approximation, $EX_{97}(97) \approx EX_{96}(96)$ because the number of new cancer cases and mean excess cost per case in year of diagnosis should be roughly the same for 1997 and 1996. Similarly, $EX_{97}(98) \approx EX_{95}(96)$, and $EX_{97}(99) \approx EX_{94}(96)$. Extending this logic, we reach the approximation:

$$EX_{97} \approx TC_{96}$$

Thus, $TC_{96}/N_{97}$ becomes an estimate of the per-capita excess cost over the full course of the cancer (which is actually given by $EX_{97}/N_{97}$), where $N_{97}$ is the number of new cases diagnosed in 1997. An equally good estimate is $TC_{97}/N_{97}$, where $TC_{97}$ is the corporation's estimated total excess costs for cancer in 1997. The formula for ΔC takes the 2 estimates and averages them together:

$$\Delta C = (TC_{96} + TC_{97})/2N_{97}$$

*We are ignoring inflation and time discounting in this approximation.