The Value of Medical Advances for Lung Cancer: 1980-1997

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ABSTRACT

Context: Lung cancer, the leading source of cancer mortality, takes a large toll in the United States, both expenditures and lost lives. However, the value of spending on the treatment of lung cancer has not been conclusively demonstrated.

Objective: To better elucidate the relationship between use of resources and improvements in survival, we evaluated the direct costs and benefits of medical care for non-small cell lung cancer for the elderly U.S. population.

Design: Direct costs for non-small cell lung cancer detection and treatment were determined using Part A and Part B reimbursements from the Continuous Medicare History Sample File (CMHS) data. The CMHS data were linked with Surveillance, Epidemiology, and End Results (SEER) data from the National Cancer Institute to calculate the average reimbursements and lifetime costs for those diagnosed in 1980 and 1995. Benefits were measured as changes in life expectancy after a diagnosis with lung cancer in the years 1980 and 1997.

Results: Life expectancy after diagnosis with lung cancer improved only minimally, with an increase of approximately .17 years (2.04 months). Total spending on lung cancer rose by approximately $19,000 per patient in real 2000 dollars from 1980 to the mid-1990s.

Conclusions: The cost-effectiveness ratio found for lung cancer is close to the traditional thresholds used to define cost-effective care, $50,000 - $100,000 per life year. We therefore conclude that the investments in lung cancer treatment for the elderly have resulted in a marginally positive, if not overwhelming, rate of return. However, these modestly favorable results are entirely accounted for by improved survival for people with local stage lung cancer.

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INTRODUCTION AND BACKGROUND

Cancer has surpassed heart disease and is now the top killer for those under age 85 in the United States.[1] Lung cancer is the largest source of cancer deaths and accounts for a substantial share of costs.[2,3] It has been estimated that 163,510 people will die of lung cancer in 2005, and treatment costs are estimated to be $5 billion a year.[4,5] Further, relative to the economy as a whole, spending on lung cancer has increased rapidly.[6]

The increase in lung cancer spending reflects changes in treatments occurring in the past decades. While there is no widely employed effective screening for lung cancer as the debate about the cost effectiveness of low-dose helical computed tomographic (CT) scans continues, the treatment of existing cases has changed; new staging and surgical techniques are used and there has been an increase in the utilization of chemotherapy.[7,8,9,10,11]

The value of spending on lung cancer treatment is not clear, however. While survival rates for these cancer patients are low, some authors argue that survival may be increasing.[12]

In this paper, we evaluate the costs and benefits of changes in lung cancer care for the elderly over the 1980s and 1990s. Nearly 50% of lung cancer deaths are in the elderly population, making this a relevant population to study.[13] (The literature suggests, however, that performance status, rather than age, has the most important independent effect on survival.[14]) Further, Surveillance, Epidemiology, and End Results (SEER)

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Program data of the National Cancer Institute matched to Medicare records allow us to determine costs and benefits for equivalently staged lung cancer patients over time.

METHODS

Life expectancy calculations

We estimated the costs and benefits of changes in lung cancer care from the early 1980s to the mid-1990s. Data from SEER were used to calculate incidence and survival trends. When we began our analysis, the SEER Program collected and published cancer incidence and survival data covering approximately 10 percent of the US population.[15] Life expectancy calculations were made using the SEER survival data and life tables from the *Human Mortality Database* University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany).

First, we calculated interval probabilities of death from cancer for up to three years after detection. The SEER-Stat mortality data extended reliably through 1999, so our late sample was based on cases diagnosed in 1997. Our earlier sample was cases diagnosed in 1980. We divided the cancer population into groups based on SEER historical stage at diagnosis (localized, regional, and distant). For each stage, we calculated the interval probabilities of death, holding the percentage of deaths from causes other than cancer constant at 1980 levels:

$$M_{tysi} = \frac{\left((\frac{O_{t1980si}}{A_{t1980si}}) * A_{tysi} \right) + C_{tysi}}{A_{tysi} - 1/2 L_{tysi}},$$

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where M_{tysi} = interval mortality rate for cancer site t, year y, stage s, and during interval i, A_{tysi} = number of cancer patients alive for cancer site t, year y, stage s, and during interval i, L_{tysi}= number of cancer patients lost to follow-up for cancer site t, year y, stage s, and during interval i, $O_{t1980si}$ = number of deaths due to other causes for cancer site t, stage s, and during interval i, in 1980, $A_{t1980si}$ = number of cancer patients alive for cancer site t, stage s, and during interval i, in 1980, and C_{ytsi} = number of cancer deaths for cancer site t, year y, stage s, and during interval i.

Next we calculated probabilities of death for the general population using population life tables. We determined mortality rates by year, sex, and age group (65-69; 70-74; 75-79; 80-84; 85+). Using the 1980 distribution of sex and age groups within stage at diagnosis as weights, we calculated a weighted average national mortality rate to match with the cancer interval mortality rates. We denote $L_{t^*ys^*i}$, where t^* and s^* indicate that weights are used to create a national population sample proxy matching with cancer site t and stage s. Using data from three years after diagnosis, we formed the excess mortality rate for cancer patients relative to the general population:

$$F_{tysi} = \frac{M_{tysi}}{L_{t^*ys^*i}}.$$

We extrapolated beyond year three using the excess mortality rates, F_{tysi}, with the assumption that the excess mortality rate declines to 1 by the start of the seventh year after diagnosis with cancer. This assumption is appropriate if over time interval probabilities of death of cancer patients converge to those of non-cancer patients as the cancer has not recurred. We used these mortality rates to estimate life expectancy by year and stage and use the same methodology for the 1980 sample, even though long-term follow-up data are available, to minimize the role of methodological differences in our results.

We believe stage migration, i.e. the shifting of cases across stages due to improvements in staging modalities rather than due to an inherent shift of severity within stage, to be true.[16] The change in the distribution of stage at diagnosis is therefore endogenous to the treatment effects we are trying to capture. Therefore, we did not adjust for stage. We discounted years using a 3% discount rate as recommended by the United States panel on Cost-Effectiveness in Health and Medicine.[17] As a specification test, we calculated the life expectancies using a multiple decrement life table approach as well.[18] The multiple decrement results were very similar to those presented.

Cost calculations

Lung cancer costs were calculated using the linked SEER-Continuous Medicare History Sample File (CMHSF) data. CMHSF includes 5% of the Medicare population and has data on medical expenses for inpatient hospital stays, outpatient services, skilled nursing facility stays, home health agency charges, and physician services. More details about the CMHSF and SEER data can be found elsewhere.[19]

Patients were excluded from the analysis if: their primary cancer was not non-small cell lung cancer; they were younger than age 65 or older than 100 at time of diagnosis

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(according to both SEER and Medicare); their reporting source was autopsy or death certificate; their month of diagnosis was unknown. Additionally, SEER patients were excluded if they did not match to the CMHSF file, if their costs did not have continuous Part A/B, or if they were enrolled in an HMO. Individuals were also excluded if their costs did not fit into an initial, continuous or terminal phase, as defined below.

To increase the cell sizes for cost averaging, we created clusters using the years surrounding our year of interest; the years 1976-1984 were used to estimate 1980 costs and the years 1992-1998 were used to estimate 1995 costs. We would have preferred more contemporary costs, but none were available at the time the study was conducted. The GDP Deflator was used to adjust for general price inflation. All cost results are presented in 2000 dollars.

Cancer lifetime costs tend to be U-shaped with time after diagnosis.[20] Costs are high initially after diagnosis, lower during the maintenance phase, and then climb again at the end of life. An approach was developed to get an approximately unbiased estimate of the phase-specific costs from the annualized totals available in the CMHSF file. For the initial phase cost we selected only patients who were diagnosed during the first six months of the calendar year; we counted their entire annual spending as initial phase costs.

To calculate terminal costs, we select people who died in the second half of the year and use their total annual spending as terminal costs. For patients diagnosed in the first half of the year and dying in the second half of the same year, all costs are counted as terminal costs. Continuing phase costs are those between the initial and terminal phase.

We similarly estimated costs for a control group of Medicare beneficiaries matched by age, gender, and SEER registry, but without lung cancer. All phases/observation periods were a 5 to 1 match (controls to cases).

Lifetime Cost Methods

Two different approaches were used to estimate the lifetime costs of lung cancer patients diagnosed in 1980 and 1995. In the first approach, our concern was how total spending is changing for people with lung cancer relative to the overall changes in the economy. We divided these costs into two parts: the spending due to lung cancer (often termed attributable costs), and the spending people would have incurred in those years had they not had lung cancer. In the second approach, we compared lifetime spending of patients with lung cancer to lifetime spending of people of a similar age and gender, but without lung cancer. The difference between these is the total lifetime spending costs of lung cancer relative to not having cancer. All costs are discounted using a 3% interest rate.

RESULTS

Life expectancy results

The SEER data represent primarily male and white lung cancer patients, as shown in Table 1, although a greater percentage of lung cancer patients were female in 1997.

There was a shift over time towards older age at diagnosis and away from localized stage at diagnosis, as well.

Table 1: Description of Lung Cancer Survival Data

Descriptive Category	**% in 1980**	**% in 1997**
Age at Diagnosis		
65-69	33.27%	23.69%
70-74	27.54%	28.31%
75-79	20.57%	23.74%
80-84	11.35%	15.32%
85+	7.27%	8.95%
Stage at Diagnosis		
Localized	29.62%	19.43%
Regional	27.31%	34.83%
Distant	33.61%	29.71%
Unknown	9.45%	16.03%
Gender		
Male	73.02%	56.47%
Race		
White	87.72%	85.67%
Black	8.62%	8.35%
Other	3.60%	5.91%

Life expectancy results by year and stage are shown in Table 2. Lung cancer patients diagnosed in the localized stage saw the greatest improvement; those diagnosed in 1997 lived 1 year longer than did those who were diagnosed with lung cancer in 1980. As would be expected, those diagnosed in the distant stage saw the least improvement with essentially 0 years gained. Cases diagnosed in the regional stage also saw only small improvement in survival.

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On average, across stages, the change in life expectancy from 1980 to 1997 was .17 years, or approximately 2 months. Because the average age at diagnosis became older over time, this estimate is slightly lower than an age-adjusted estimate. Holding constant the age distribution would add another .05 years to survival gains.

Table 2: Life Expectancy after Diagnosis by Year and Stage

Stage at Diagnosis	**1980 Life Expectancy after Diagnosis**	**1997 Life Expectancy after Diagnosis**	**Change in Life Expectancy**
Localized	2.14	3.14	1.00
Regional	1.56	1.65	0.09
Distant	0.63	0.61	-.018
Unknown	1.09	1.12	0.04
Weighted Average	16 months (1.37 years)	18 months (1.55 years)	2 months (.17 years)

Cost results

Table 3 presents the cancer and control phase costs for those diagnosed in 1980 and in 1995. We present only the localized stage, distant stage and mean stage results because they are the more stable categorizations over time than are the others.[21] Cancer patients' initial phase spending rose more substantially than did control costs. There has also been a marked increase in terminal costs for lung cancer patients, but it is somewhat smaller than the rise in terminal phase costs for the non-cancer population.

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Table 3: Cancer and Control Phase Costs, 1980 and 1995, in 2000 dollars

Historic Stage	Phase	1980		1995		Change	
		Cancer Costs	Control Costs	Cancer Costs	Control Costs	Cancer Costs	Control Costs
Localized	**Initial**	$17,220	$1,747	$27,770	$6,577	$10,550	$4,830
	Continuous	$3,535	$1,747	$6,548	$6,577	$3,013	$4,830
	Terminal	$16,794	$12,091	$29,781	$27,130	$12,987	$15,039
Distant	**Initial**	$16,163	$1,098	$35,612	$7,743	$19,449	$6,645
	Continuous	$2,811	$1,098	$10,675	$7,743	$7,864	$6,645
	Terminal	$17,485	$12,038	$27,309	$25,738	$9,824	$13,700
Mean	**Initial**	$16,628	$1,690	$30,316	$6,690	$13,688	$5,000
	Continuous	$3,301	$1,690	$7,683	$6,690	$4,382	$5,000
	Terminal	$17,295	$11,555	$28,544	$25,402	$11,249	$13,847

Table 4 shows our estimates of lifetime costs. On average, nearly $19,000 more was spent on lung cancer patients in 1995 than was spent in 1980. However, costs for other diseases rose by even more than costs for lung cancer patients. By 1995, treatment costs were substantially less for lung cancer cases compared to costs for all other disease categories, with the exception of local stage lung cancer.

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Table 4: Lifetime Spending on Medical Treatment for Lung Cancer

	Diagnosed in 1980	Diagnosed in 1995	Difference
Total Spending on Lung Cancer Patients			
Localized	$14,262	$44,775	$30,514
Regional	$23,781	$40,730	$16,949
Distant	$19,080	$30,613	$11,532
Unstaged	$16,827	$35,096	$18,268
Weighted Average	$18,722	$37,607	$18,885
Excess Lifetime Spending			
Localized	$4,901	$16,706	$11,804
Regional	$8,483	-$18,293	-$26,776
Distant	$4,007	-$36,350	-$40,357
Unstaged	-$5,009	-$46,660	-$41,651
Weighted Average	$4,642	-$21,403	-$26,045

.03% In Situ dropped b/c not enough SEER observations; distribution recalculated without them

Cost Effectiveness

Taking the weighted average of costs and life expectancy across stages, costs increased by $18,885 per 0.17 life years added. Because the change towards diagnosis at later ages is mostly due to changes in smoking trends, exogenous from the changes in lung cancer detection and treatment, adjusting for age is justified. Doing so would result in a life expectancy gain of .22 years, changing the cost effectiveness ratio to $86,000 per life year gained.[22]

Table 5 shows our cost effectiveness calculations. Other than the marginally positive rate of return for treatment of localized lung cancer, the cost effectiveness ratios indicate that there was very little if any life expectancy gained per dollar spent.

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Table 5: Cost Effectiveness Results by Stage, using Total Spending on Lung Cancer Patients

Stage	Change in Lifetime Costs	Change in Life Expectancy	Costs per Life-Year
Localized	$30,514	1.00	$30,545
Regional	$16,949	0.09	$180,309
Distant	$11,532	0.00	NA
Unknown	$18,268	0.04	$480,737
Weighted Average	$18,885	0.17	$111,088

DISCUSSION

There are three important conclusions to make based on these results. First, we spend a lot more on lung cancer relative to the economy, but not more so than for other diseases. Compared to the economy as a whole, lung cancer costs increased by $19K per patient, but lifetime costs increased by far more for non-cancer patients. It is now less expensive to have lung cancer than to die of another disease.

Second, the additional money spent on lung cancer in the mid-1990s compared to in the early 1980s resulted in a less than overwhelming rate of return. Conclusions based on other studies reinforce our conclusion that survival has increased only by a matter of months.[23] In comparison with similar studies done examining the value of our spending on the overall treatment for other diseases, lung cancer stands out as having one of the least attractive cost-effectiveness ratios to date.

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Third, almost all gains have been in localized cases. Some of this may be due to treatment advances such as better surgical technique in general resulting in lower short term mortality or high quality of lung cancer surgery related to better imaging and pretreatment planning, but these are speculations requiring further research. It seems clear that the best chance lung cancer patients have for survival is to qualify for resection, but the majority of lung cancer patients are currently diagnosed with cancer that is too advanced for them to have this option.

The benefit to cost ratio for lung cancer could change markedly post-1997 as some promising new treatments begin to emerge, such as angiogenesis inhibitors and targeting drugs like tyrosine kinase inhibitor, but with associated incremental costs that are large by historical standards.[24] In addition, modestly effective chemotherapy for advanced stage lung cancer began to be disseminated after 1994 and it is only very recently that evidence on the benefit of adjuvant chemotherapy for local lung cancer has emerged.[25,26,27] Also, some experts in the field believe that the increased use of positron emission tomography (PET) scans may lead to improved surgical outcome; the PET scan has an improved ability to evaluate mediastinal lymph nodes.[28]

Similarly, the use of effective widespread screening for lung cancer could change the balance between lung cancer spending and benefits. Although lung cancer screening by conventional chest x-ray has been shown to be ineffective, screening using CT has shown some promise.[29] The effectiveness of CT screening will be known in a few years when results of the current NCI-sponsored National Lung Cancer Screening Trial (NLST) become available.[30]

Limitations

The lack of a life expectancy benefit for patients diagnosed with distant stage lung cancer may indicate that stage migration has in fact not taken place. We address this by calculating the unweighted life expectancy average. If the underlying nature of disease was unchanging but diagnosis differed because of stage migration, the unweighted average of survival changes would be more accurate than the stage-weighted average. We found the two calculations to be similar.

Additional limitations of our research follow. Not adjusting for age potentially underestimates impact of care, although the effect on life expectancy of adjusting for age is not big, .05 years. The use of yearly data in forming costs was not ideal, but the CMHSF does not report monthly costs. Lung cancer patients enrolled in HMOs were not included in our cost analysis, but yet are included in our survival analysis. Conditional on having lung cancer however, the distribution of illness severity is unlikely to differ between HMO and fee-for-service enrollees.

We have not included indirect costs, prevention costs, or adjustment for quality of life in our analysis. Given lung cancer patients' short survival, indirect costs such as lost productivity are likely to be less of an issue than for other cancers. We plan to include these costs, and adjust for quality of life, as we proceed with our research.

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