The Value of Medical Interventions for Lung Cancer in the Elderly

Results from SEER-CMHSF

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BACKGROUND. Lung cancer is the leading source of cancer mortality and spending. However, the value of spending on the treatment of lung cancer has not been conclusively demonstrated. The authors evaluated the value of medical care between 1983 and 1997 for nonsmall cell lung cancer in the elderly US population.

METHODS. The authors used Surveillance, Epidemiology, and End Results (SEER) data to calculate life expectancy after diagnosis over the period 1983 to 1997. Direct costs for nonsmall cell lung cancer detection and treatment were determined by using Part A and Part B reimbursements from the Continuous Medicare History Sample File (CMHSF) data. The CMHSF and SEER data were linked to calculate lifetime treatment costs over the time period of interest.

RESULTS. Life expectancy improved minimally, with an average increase of approximately 0.60 months. Total lifetime lung cancer spending rose by approximately $20,157 per patient in real, ie, adjusted for inflation, 2000 dollars from the early 1980s to the mid-1990s, for a cost-effectiveness ratio of $403,142 per life year (LY). The cost-effectiveness ratio was $143,614 for localized cancer, $145,861 for regional cancer, and $1,190,322 for metastatic cancer.

CONCLUSIONS. The cost-effectiveness ratio for nonsmall cell lung cancer was higher than traditional thresholds used to define cost-effective care. The most favorable results were for persons diagnosed with early stage cancer. These results suggested caution when encouraging more intensive care for lung cancer patients without first considering the tradeoffs with the costs of this therapy and its potential effects on mortality and/or quality of life. ***Cancer*** **2007;110:2511–8.** *© 2007 American Cancer Society.*

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Lung cancer, with 60% of cases diagnosed in those older than 65 years of age, is the largest source of cancer deaths, accounting for approximately 160,000 deaths annually.[1] Spending on medical treatment for lung cancer accounts for nearly 5 billion dollars in annual costs[2–4] and, like medical spending in general, has increased rapidly relative to the US Gross Domestic Product (GDP), the value of all goods and services created within the US economy.

The increase in lung cancer spending reflects changes in detection and treatment that have occurred during the past few decades. Although there has been an increase in use of computed tomography (CT) examination for early detection of lung cancer, the effectiveness of CT screening has not been conclusively determined.

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Meanwhile, the management of existing cases has changed markedly. Staging techniques such as chest computed tomography, which has improved ability to detect small tumors, and magnetic resonance imaging (MRI), which allows for advanced soft tissue contrast, are used more frequently.[5]

Also, there has been an increase in the use of chemotherapy;[6,7] up to 21.5% of the elderly with metastatic disease receive this form of treatment.[8] In the 1990s, a greater share of the elderly received taxane-based combinations, which were associated with higher costs, even though these combinations have little or no benefit when compared with platinum plus nontaxane regimens.[7]

Despite this large increase in spending, one of the central questions about lung cancer remains: Has it been worth it? Results from clinical trials, often used in lung cancer cost-effectiveness studies, have been mixed.[9–12] In addition, care in the community may differ substantially from care in clinical trials, especially for a disease with complex medication regimens. Most clinical trials also exclude the elderly, who account for >50% of lung cancer cases. In this study, we focus on changes over time in costs and benefits of lung cancer care for the elderly in the community and include those diagnosed with localized disease, thus helping us to understand what has actually transpired overall.

Data from the Surveillance, Epidemiology, and End Results (SEER) Program of the National Cancer Institute matched to Medicare records allow us to determine costs and benefits of treatment changes for lung cancer patients, as equivalently staged as possible, over time. (Because of differences in survival and treatment between small cell lung cancer and nonsmall cell lung cancer, we include only the latter in this analysis. From here on, we use "lung cancer" and "nonsmall cell lung cancer" [NSCLC] interchangeably.) We examine changes in medical costs and outcomes from the early 1980s to the mid-1990s.

MATERIALS AND METHODS

Life Expectancy

Five-year mortality is 85% for persons with lung cancer. Data to calculate survival trends were obtained from the SEER Program.[13] Life expectancy, defined as expected remaining years of life after diagnosis with lung cancer, was calculated for those aged 65 years and older by using the SEER survival data and life tables from the *Human Mortality Database*.[14]

When selecting SEER-Stat's survival data, we used net cause-specific survival because we were examining cancer survival at different points in time and did not want cancer survival to be affected by other (noncancer) causes of death. To avoid confusing improvements in lung cancer treatment with improvements affecting death from other causes among lung cancer patients when calculating the overall interval rate, we held the probability of death from causes other than lung cancer constant at 1983 levels matched to the 1997 cohort on age and sex. In addition, to account for any NSCLC cases with misidentified cause of death due to cancer spread to other organs, we attributed death from any cancer to lung cancer among people diagnosed with lung cancer.

First, we divided the cancer population into groups based on stage at diagnosis by using the SEER Historical Stage variable (localized, regional, distant, unstaged). For each stage, we calculated interval probabilities of death from cancer and other causes for each year. We denote these as c_{tysi} and o_{tysi} for an observation in cancer site t, year y, stage s, and during interval i. The sum is stage-specific interval mortality overall, ie,

$$mr_{tysi} = c_{tysi} + o_{tysi} - c_{tysi} \cdot o_{tysi} \qquad (1)$$

where $o_{ysi} \cdot c_{ysi}$, is a correction term reflecting the overestimate of the numbers of deaths when going from net probabilities to the overall or crude number of deaths, a step required to allow for other causes of death to affect cancer survival.

These mortalities were used to forecast expected remaining years of life, which we term *life expectancy* for shorthand, by using standard life-table methods. To project past the 5 years of SEER data available for those diagnosed in 1997, we first determined the percentage change between these additional intervals (ie, post-5th year after diagnosis) in the 1983 data. We then multiplied the interval survival in 1997 by the percentage change based on the post-5th year 1983 survival to estimate the interval survival for 1997 for Year 6 and greater. Algebraically, life expectancy is given by:

$$LE_{tys} = \sum_{i=1}^{\infty} mr_{tysi} \cdot (i - 0.5) \qquad (2)$$

Following standard life-table assumptions, persons who die during an interval are assumed to die halfway through the interval (thus, $i-0.5$ is life expectancy for a person who dies i intervals after diagnosis). Note that with quality values to attach to these years, we can form quality-adjusted life expectancy in a straightforward fashion by multiplying the share of persons who are alive in an interval by quality of life in that interval. Life expectancy for patients as a whole is the weighted average of the stage-specific survival across stages:

$$LE_{ty} = \sum_{s} \omega_{tys} \cdot LE_{tys} \tag{3}$$

where ω_{tys} is the share of patients with cancer t in year y who are diagnosed in stage s. Equations (1) through (3) are estimates for the years of interest.

Next, we calculated probabilities of death for the general population by using standard US life tables. We determined mortality rates, allowing for death by any cause, by sex and age group (65–69 years; 70–74 years; 75–79 years; 80–84 years; 85+ years). By using the 1983 and the 1997 distributions of sex and age groups within the lung cancer population as weights, we calculated the expected mortality for a cohort of individuals from the general population matched to the cancer cohorts on the variables listed. This gave us an estimate of the mortality that would have been experienced by the cohort of cancer patients diagnosed in 1983 and 1997 if they had not been diagnosed with cancer. All life-expectancy calculations, both for lung cancer patients and for the general population, were discounted by using a 3% discount rate.[15]

Life expectancy will change over time because of changes in both cancer and noncancer mortality. To simulate life expectancy improvements from cancer alone, we considered mortality risks and held rates of death due to other causes constant at levels from the earlier time period. These rates of death due to other causes were then adjusted to match on age and sex to the later time period's cohort. Consider an example that compares life expectancy for those diagnosed in 1983 to life expectancy for those diagnosed in 1997. Holding other mortality constant at 1983 levels leads to a simulated mortality of:

$$mr'_{tysi} = c_{tysi} + o_{t1983si} - c_{tysi} \cdot o_{t1983si} \tag{4}$$

The simulated mortality can then be used to form a simulated life expectancy, LE'_{ty}, which varies only with changes in cancer mortality:

$$LE'_{ty} = \sum_{s} \omega_{tys} \cdot LE'_{tys} = \sum_{s} \omega_{tys} \cdot \left(\sum_{i=1}^{\infty} mr'_{tysi} \cdot (i - 0.5) \right) \tag{5}$$

The change in life expectancy between years y and y', $LE'_{ty'} - LE_{ty}$, reflects changes in screening and treatment. Results were stratified by stage at diagnosis by using the SEER Historical Stage variable (localized, regional, distant, unstaged).

An important issue in aggregate totals is whether to adjust average survival for stage at diagnosis, which has been shown to affect both survival and costs. Prior literature suggests that changes in stage distribution over time are largely a result of detecting smaller tumors that have mestastized rather than true changes in stage.[16–18] As a result, our primary analysis is not stage-weighted, although we report the stage-weighted estimates by using the stage distributions in 1983 as weights for both the 1983 and 1997 calculations for comparison.

In addition, we held the stage distribution constant at 1983 levels in both the 1983 and 1997 weighted-average calculations to try to filter out the change in life expectancy due *only* to stage shifts, ie, not to any intervention effect. Given that the percentage of unstaged cases actually dropped over this time period and the poor diagnosis for people diagnosed with unstaged NSCLC, the weighted average presents an overall average that appears somewhat worse than what actually transpired, which is essentially biased by the stage-shift effect. We adjusted for this bias by holding the stage distribution constant across years.

Costs

Costs of treating lung cancer were calculated by using the linked SEER-Continuous Medicare History Sample File (CMHSF) data, chosen largely because of our interest in looking at comparable cost data beginning in the early 1980s. These data include 5% of the Medicare population and provide information on medical expenses for inpatient hospital stays, outpatient services, skilled nursing facility stays, home health agency usage, and physician services. SEER-CMHSF contains roughly 70,000 cancer patients per year and 400,000 noncancer control individuals per year. More details about the CMHSF and SEER data are reported elsewhere.[19,20]

Measurement of indirect costs, such as time costs and costs due to lost productivity, are beyond the scope of this article. Unlike case direct-treatment costs, multiple data sources would be required to obtain estimates of indirect costs. We know of no reliable data sources for comparing lung cancer-specific indirect costs over the time period studied.

Cancer lifetime costs tend to be U-shaped with time after diagnosis.[3,21,22] 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 obtain the most accurate 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 6 months of the calendar year. We counted their entire annual spending as initial-phase costs. To calculate last-year-of-life costs, we selected persons who died in the second half of the year and used their total annual spending as last-year-of-life costs. For patients who were diagnosed in the first half of the year and died in the second half of the same year, all costs are counted as last-year-of-life costs. Continuing-phase costs are those between the initial phase and the last year of life.

There were 1858 patients in the final cohort. Individuals were selected from SEER into the sample if they were diagnosed with NSCLC between 1973 and 1998 and could be matched to the CMHSF file (N = 10,456). Patients were excluded from the analysis if they were younger than age 65 years or older than 100 years at time of diagnosis (n = 1313); their reporting source was autopsy or death certificate (n = 257); this was not their first cancer diagnosis (n = 1611); or their month of diagnosis was unknown (n = 39). In addition, patients were excluded if their costs did not have continuous Medicare Part A/B records, or if they were enrolled in a health maintenance organization (HMO) (combined exclusion, n = 456). Individuals were also excluded if their costs did not fit into an initial, continuous, or last year of life, as defined below (n = 3846). The continuous phases of patients diagnosed more than 3 years before the start of the observation period were excluded as well (n = 523).

Because of inconsistencies in SEER historical staging data (personal E-mail correspondence with Lynn Ries, SEER statistician), initial-phase costs for patients diagnosed between 1978 and 1982 were dropped (N = 553). To help keep our sample sizes as high as possible, all continuous and last-year-of-life phase costs were used if the year of diagnosis was not in the 1978 to 1982 range but still within 1976 to 1984.

To increase the statistical spread-sheet cell sizes for cost averaging, we created clusters by using the years surrounding our year of interest. The years 1976, 1977, 1983, and 1984 were used to estimate 1983 costs. We would have preferred more contemporary CMHSF costs for the use with our 1997 survival data, but none were available. However, for the purposes of this analysis, we assume that costs estimated with 1992 through 1998 data represent the costs for patients diagnosed in 1997.

To calculate lifetime costs, we used yearly mortality data after cancer diagnosis. We matched these mortality data to initial, continuing, and end-of-life costs. For example, the probability of dying in the first year is multiplied by end-of-life phase costs for persons in that year. We similarly estimated initial-phase costs for those who survived at least 1 year, and subsequent continuous-phase costs for those who survived additional years. Denote l as the number of years the cancer patient survives. Ignoring time and stage subscripts, the present value of lifetime spending is given by:

$$\mathit{Cancer\ Spending} = (l > 1) \cdot \Bigg[C_{initial} + \sum_{a=2}^{l-1} (1+r)^{-(a-1)} C_{cont}\Bigg] + (1+r)^{-(l-1)} C_{end} \tag{6}$$

The first term is the initial-phase and continuing-phase costs for patients who do not die within 1 year of cancer diagnosis. (In which case, all costs are considered end-of-life costs.) The second term is the end-of-life cost. The term r is the discount rate, which we assume is 3%, as recommended by the Panel on Cost Effectiveness in Health and Medicine, a nonfederal panel convened by the U.S. Public Health Service.

The lifetime cost estimate takes into account the actual survival experience of lung cancer patients, so this measure corrects for any overstimation of the yearly phase-specific costs. The GDP Deflator was used to adjust for general price inflation,[23] and all cost results are presented in Year 2000 dollars. We similarly estimated costs for a control group of Medicare beneficiaries, who did not have lung cancer, matched by age, sex, and SEER registry.

We used only direct medical costs to calculate lifetime costs. In our first approach, we included all costs for persons after their diagnosis with lung cancer. Because costs are adjusted for inflation, this approach reveals changes in the costs of lung cancer patients over time relative to other goods and services in the economy. In the second approach, we compared lifetime spending of lung cancer patients with lifetime spending of similar age and sex persons who did not have lung cancer. The difference between these is the total increment in lifetime costs from lung cancer. We term this "additional lung cancer costs." However, this number is negative when the costs of those without lung cancer exceed the costs of those with lung cancer. All costs are discounted by using a 3% rate.

Lung cancer patients enrolled in HMOs, a form of managed care, were not included in our cost analysis because these data were not available, but yet they were 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. There is no effective screening program in place in either setting, and

TABLE 1
Description of Lung Cancer Survival Data

Descriptive category	% in 1983	% in 1997
Age at diagnosis, y		
65–69	33.56	23.69
70–74	27.45	28.31
75–79	20.69	23.74
80–84	11.79	15.32
85+	6.52	8.95
Stage at diagnosis		
Localized	19.23	19.43
Regional	33.16	34.83
Distant	27.89	29.71
Unstaged	19.72	16.03
Sex		
Men	70.50	56.47
Race		
White	88.35	85.67
Black	8.38	8.35
Other	3.28	5.91

TABLE 2
Discounted Life Expectancy After Diagnosis by Year and Stage

	Life expectancy, y		
	1983	1997	Change, mo
Localized	3.29	3.50	0.21 (2.52)
Regional	1.49	1.65	0.15 (1.80)
Distant	0.66	0.68	0.01 (0.12)
Unstaged	1.31	1.21	−0.10 (−1.20)
Unweighted average*	1.52	1.57	0.05 (0.60)
Weighted average†	1.57	1.65	0.08 (0.96)

* Unweighted averages were based on SEER data, all stages combined.

† Weighted averages were calculated by using distributions of stage at diagnosis as weights; distribution was held constant at 1983 levels.

patients are generally asymptomatic until they reach advanced cancer stages.

RESULTS

The SEER data represent primarily men and white lung cancer patients, as shown in Table 1, although a greater percentage of lung cancer patients were women in 1997. This is consistent with the finding that female smoking prevalence rates rose compared with male smoking prevalence rates over past decades[24] becoming equal at initiation in the mid-1970s.[25] Lung cancer patients were substantially older at diagnosis in 1997 than they were in 1983.

Discounted life expectancy results by year and stage are shown in Table 2. Lung cancer patients diagnosed in the localized stage saw the greatest improvement, with those diagnosed in 1997 living 0.21 discounted years (almost 3 months) longer than those diagnosed in 1983. Cases diagnosed in the regional stage also saw a modest improvement in survival (about 2 months). Those diagnosed in the distant stage saw the least improvement, with less than 1 month improvement in survival. The average of these results across stages was an increase of 0.08 years. The unweighted average over this time period yielded a similar increase in life expectancy, 0.05 years, or approximately 3/5 of a month.

Table 3 presents some cancer and control phase costs for those diagnosed in 1983 and in 1997. The costs for lung cancer patients were higher than for nonlung cancer patients in most phases and years. Looking at the mean results across stages (last 3 rows of Table 3), lung cancer patients' initial-phase spending rose more substantially than did the control costs in each year. There was also a marked increase in last-year-of-life costs for lung cancer patients, but it was somewhat smaller than the rise in last-year-of-life costs for the noncancer population.

Table 4 shows our estimates of lifetime costs. Adjusted for inflation, an average of $20,157 more was spent on lung cancer patients in 1997 than was spent in 1983. Lifetime costs for other diseases, captured by the controls, rose by even more than lifetime costs for lung cancer patients, such that additional lung cancer costs, as defined in Table 4, were negative in most cases. By 1997, treatment costs were substantially lower for lung cancer cases compared with average costs for a category that included all other diseases.

Table 5 shows cost-effectiveness calculations. Across stages, costs increased by $20,157 per 0.05 life years added or $403,142 per year of life. Costs per life year were $143,614 for patients with localized cancer, $145,861 for regional cancer, and $1190,322 for distant cancer.

It was beyond the scope of this article to determine quality-of-life weights for lung cancer patients, although we knew that they reported experiencing more mental distress from their symptoms than patients who had other cancers.[26] Some disease-related symptoms, such as cough, coughing up blood, and difficult painful breathing, may diminish with treatment, whereas others may increase, ie, nausea, vomiting and hair loss (due to chemotherapy), and difficulty swallowing and sore throat (due to radiation). We did not have data necessary to determine whether quality of life had worsened or improved over our time period, and so we present only results unadjusted for quality of life at this time.

DISCUSSION

Evaluating the return on medical spending is essential to assessing the performance of the health sys-

TABLE 3
Cancer and Control Phase Costs, 1983 and 1997, in 2000 Dollars

		1983		1997		Change	
Historic stage	Phase	Cancer costs	Control costs	Cancer costs	Control costs	Cancer costs (% increase)	Control costs (% increase)
Localized	Initial	$18,448	$1873	$27,770	$6700	$9322 (51)	$4827 (258)
	Continuous	$3820	$1873	$6548	$6700	$2728 (71)	$4827 (258)
	Last year of life	$14,543	$12,042	$30,011	$25,677	$15,468 (106)	$13,635 (113)
Distant	Initial	$19,669	$1935	$35,612	$7179	$15,943 (81)	$5244 (271)
	Continuous	$970	$1935	$10,675	$7179	$9705 (100)	$5244 (271)
	Last year of life	$18,107	$11,149	$27,309	$26,034	$9202 (51)	$14,885 (134)
Mean	Initial	$17,522	$1812	$30,316	$6833	$12,794 (73)	$5,021 (277)
	Continuous	$3356	$1812	$7683	$6833	$4327 (129)	$5021 (277)
	Last year of life	$16,833	$11,356	$28,575	$25,368	$11,742 (70)	$14,012 (123)

TABLE 4
Lifetime Spending on Medical Treatment for Lung Cancer

Costs	Diagnosed in 1983	Diagnosed in 1997	Difference
Total spending on lung cancer patients			
Localized	$35,534	$65,693	$30,159
Regional	$27,300	$49,179	$21,879
Distant	$20,541	$32,445	$11,903
Unstaged	$19,787	$40,343	$20,557
Unweighted average*	$25,221	$45,378	$20,157
Weighted average†	$25,516	$45,944	$20,428
Additional lung cancer costs‡			
Localized	$10,974	−$9,913	−$20,887
Regional	$9,571	−$21,969	−$31,540
Distant	−$2,412	−$46,301	−$43,889
Unstaged	−$5,259	−$35,419	−$30,160
Unweighted average*	$2,602	−$28,599	−$31,201
Weighted average†	$3,574	−$29,090	−$32,664

* Unweighted average based on mean (across stages) CMHSF costs.

† Weighted averages calculated by using distributions of stage at diagnosis as weights; distribution held constant at 1983 levels.

‡ Average costs for cases minus average costs for controls. A negative number indicates that less was spent on average for lung cancer patients.

TABLE 5
Cost Effectiveness Results by Stage, Using Total Spending on Lung Cancer Patients, Not Adjusted for Quality

Stage	Change in lifetime costs	Change in life expectancy	Costs per life-year
Localized	$30,159	0.21	$143,614
Regional	$21,879	0.15	$145,861
Distant	$11,903	0.01	$1,190,322
Unstaged	$20,557	−0.10	NA
Unweighted average	$20,157	0.05	$403,142
Weighted average	$20,428	0.08	$255,346

tem. Whereas some cost-effectiveness studies of particular treatments have shown promise,[9,27–29] our study is the first to consider cost increases and health gains across time in the elderly lung cancer population.

Our results yield 3 important conclusions. First, our spending on lung cancer has increased greatly relative to the economy, but not more so than spending on other diseases, partly as a result of the typically rapid progression and lethality of lung cancer. Compared with the economy as a whole, lung cancer costs increased by nearly $20,200 per patient. But lifetime costs increased by far more for noncancer patients, largely because of their more substantial long-term continuing-care costs. It is now less expensive to have lung cancer than to not have lung cancer and die of another disease. Part of the explanation for this is that end-of-life costs for the general population more than doubled over this time period, whereas there was a less dramatic increase in end-of-life costs for lung cancer patients (as seen in Table 3). Continuing-care costs also rose for the general population.

Second, almost all gains in survival have been in localized-cancer cases. Life expectancy has improved by 1/5 of a year for localized-cancer cases and has not increased appreciably for distant-cancer cases. Our results are quite similar to those found in a French analysis of NSCLC survival changes from 1982 to 1997.[30] Some of the improvement in localized-cancer cases may be because of treatment advances such as better surgical technique in general, resulting in lower short-term mortality, or higher quality of lung-cancer surgery related to better imaging and pretreatment planning. There have also been improvements in perioperative care and selection into surgery.[31]

Conclusions based on randomized clinical trials offer construct validity to our distant-stage results; 2.6 weeks was the median survival improvement of

33 phase 3 trials initiated between 1973 and 1994 for patients with advanced NSCLC, comparing results from 1973 to 1983 to those from 1984 to 1994.[12] The average lung cancer patient is diagnosed in advanced stages of lung cancer. Our result for this group, 0.05 years, is the same as the 2.6 weeks found in the trials.

A third conclusion is that the costs per additional year of life were generally high. There is no single agreed-upon cutoff for cost effectiveness. Many studies suggest a value of $100,000 per year of quality-adjusted life, although values of up to $200,000 have been used.[32] Our best estimate is that in the case of nonsmall cell lung cancer, the cost was $403,142 when the additional time is spent in perfect health. The cost-effectiveness ratios are more favorable for early stage disease, but even in this case, the suggested value of medical advance for lung cancer is quite limited.

Several promising new therapies have been developed since 1997 that could affect future cost-effectiveness criteria, but uncertainties remain about these treatments. Phase 3 trials of angiogenesis inhibitors have not yet demonstrated significant improvements in mortality, and toxicity is a serious side effect.[33] Tyrosine kinase inhibitors have shown potential by improving disease-related symptoms and inducing radiographic tumor regressions in patients with NSCLCs that persist after chemotherapy,[34] but ongoing studies are needed to better assess which patient characteristics are associated with a positive response.

There have been some developments in chemotherapy for advanced stage lung cancer and adjuvant chemotherapy for local lung cancer.[35–37] A few previous studies have reported favorable cost-effectiveness results for some of the newer chemotherapy agents, eg, gemcitabine.[10,11] One of the main differences between our analysis and theirs is that we evaluate treatment effectiveness in the community for the elderly population, whereas their clinical trials demonstrate treatment effectiveness for a younger population under strictly controlled circumstances. We also recognize that some imaging, such as positron emission tomography (PET), and treatment advances have been shown to be ‘‘locally’’ cost effective and may result in some improvements in the quality of life, but the overall effect has still not been very favorable.

Our study has some limitations. The use of yearly data in forming costs was not ideal, but the CMHSF does not report monthly costs. An additional limitation in the cost analyses is the omission of nonmedical direct costs such as travel, lodging, home services, other out-of-pocket expenses, outpatient drugs, and research costs (eg, NIH). However, including these additional costs would only have made the cost-effectiveness ratio that much more unattractive. Also, we are unable to say which treatment changes have led to specific changes in survival over that period. We were also unable to adjust for quality of life in this study. Although some chemotherapy advances have indicated quality-of-life improvements,[10,11] it seems unlikely that the quality of life has improved for lung cancer patients overall. Finally, ours is not a natural history model.[38] However, we saw relative advantages, including simplicity and efficiency, of relying on existing data to assess survival and treatment effects.

In sum, the additional money spent on lung cancer treatment in the mid-1990s compared with that spent in the early 1980s did not result in a favorable economic rate of return by conventional benchmarks. Survival has increased by less than 1 month, while costs per patient have increased by $20,157.

It may be possible that the future will differ from the past,[12] but marked improvement has not occurred to date. Meanwhile, given that tobacco smoking is the etiological carcinogen accounting for 80% to 90% of lung cancer cases in men and 70% to 80% of lung cancer cases in women,[39] smoking prevention and cessation programs are perhaps more promising. For example, the decline in lung cancer incidence in men reflects decreases in smoking rates in men. Our lung cancer analysis could be duplicated for the other major cancers, breast, prostate, and colorectal, to allow for cross-site comparison of the costs and benefits of treatment changes.

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