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An analysis of whether higher health care spending in the United States versus Europe is ‘worth it’ in the case of cancer

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Abstract

Some observers argue that the US spends more on health care than other developed countries, but does not get enough in return. We study whether higher US cancer costs, compared to the EU, are “worth it” based on differences in the survival of cancer patients. We find that the US has achieved greater survival gains for cancer patients, and that – even net of higher US cost growth – this generated \$556bn of additional value for US patients diagnosed between 1983 and 1999, compared to their European counterparts. This corresponds to 78 percent of overall cancer spending or \$57,000 per patient.

The United States spends substantially more on health care per capita than any European country, and the relative growth in US health care costs has exceeded that of most countries in the European Union as well.¹ The value of this additional spending is frequently debated, in spite of little hard evidence on either side of the controversy.

In this paper, we assess the value generated by higher US spending, for the important case of oncology. Cancer is the leading cause of death in developed countries² and an important component of overall health care costs. Mirroring overall trends in US health care costs, US spending on cancer care has risen substantially over time, from \$13.1 billion in 1980 to \$72.1 billion in 2004, exceeding costs and cost growth observed in Europe.³

Previous epidemiological studies have suggested that survival prospects for US cancer patients are better than those for European patients. US population mortality rates for cancer are lower

than those in Europe despite higher cancer incidence rates.⁴ Five-year relative survival rates from cancer diagnosis appear to be higher in the US for most solid tumors.⁵ These studies, however, have left open the central policy question of whether higher US survival gains are sufficient to justify the higher US costs. To address this question, we examine survival differences, assess their incremental social value, and compare this to differences in the costs of care.

Methods

We use survival data from cancer registries in the US and Europe to quantify the additional survival gains that US patients have experienced, and then compare these to the corresponding gains for European patients. We then estimate the incremental social value generated by higher survival in the US, using conventional approaches to valuing statistical lives. Finally, we assess whether or not this incremental social value exceeds or falls short of the additional cost of treating US patients, which we recover from OECD health expenditure data. To confirm that survival differences reflect real patient outcomes and not merely changes in the time of diagnosis (for example, due to increased screening in one location compared with the other), we also examine changes in population mortality rates in the US and in Europe using population mortality data from the WHO.

Cancer Survival

Data on survival among diagnosed cancer patients were obtained from the SEER database for the United States and from the EUROCARE databases for countries in Europe. Beginning in 1973, the SEER database has been recording survival time, tumor characteristics, and demographics for individual cancer patients followed by cancer registries across the United States, representing approximately 14% of the US population. The EUROCARE databases record aggregate counts of deaths and patients lost to follow-up at one-year intervals for cancer patients diagnosed between years 1983 and 1999 followed through registries in 23 European countries.⁶ EUROCARE data provide separate counts of patients by country, cancer site, age group, gender, and period of diagnosis. We restricted analysis to 10 countries that reported consistently over the analysis period 1983-1999: Finland, France, Germany, Iceland, Norway, Scotland, Slovakia, Slovenia, Sweden, and Wales. We examined survival data over this period for 13 cancer sites for which data were consistently available from both European and US survival databases: breast, prostate, colorectal, testis, soft tissues, thyroid gland, stomach, corpus uteri, melanoma, Hodgkin disease, non-Hodgkin lymphoma, acute myeloid leukemia, and chronic myeloid leukemia

We examined survival differences between the US and Europe using two approaches. First, we examined differences in survival levels in the most recent period available for analysis across US and European datasets, which consisted of cancer patients diagnosed in years 1995 through 1999. Second, we examined differences in survival gains over time, using the set of years common to the SEER database and the EUROCARE databases, covering patients diagnosed in 1983 through 1999. We focused on this latter approach examining survival gains over time, as it provides insight into the progress countries have made relative to their own baseline levels of survival. An analysis focused on levels of survival is more likely to be influenced by intrinsic population characteristics, such as genetic predisposition, and may not reflect outcomes of different health care delivery systems.

Our main analysis of survival was based on Cox proportional hazards models for each site, including as covariates patient age groups, gender, location, period of diagnosis, and interactions between location and period of diagnosis.⁷ We also estimated a combined model that examined average survival across all cancer sites, including as covariates age, gender, site, location, period of diagnosis, and interactions between location and period. We chose the Cox

model because it allows for estimation of full survival curves over patient lifetimes, as opposed to estimation of survival after a limited duration of time, such as at 5 years after diagnosis. To test the sensitivity of our results to our model choice, we compared estimates of survival differences at 5 years obtained using the Cox proportional hazards model to estimates of differences in relative survival at 5 years, a method frequently published in the peer-reviewed oncology literature.⁸

Kip Viscusi and Joseph Aldy reviewed the literature and concluded that the value of a statistical life ranges primarily from \$5 million to \$12 million for prime-aged workers.⁹ Assuming a real rate of interest of 3 percent and a constant flow of value implies figures of between \$150,000 and \$360,000 for each statistical life-year.¹⁰ We conservatively chose a value of \$150,000 for our survival calculations which were estimated in terms of discounted life-years.¹¹

Costs of Cancer Care

Data on total health expenditures in individual European countries and the United States over the period 1983 through 1999 were collected from the OECD. Costs were calculated only for the set of countries included in the survival analysis for comparability.¹² Costs were expressed in US dollars by purchasing power parity. These estimates were then multiplied by estimates of the fraction of health expenditures devoted to cancer in each country to obtain total costs of cancer care.¹³ These costs include expenses associated with treatment, as well as prevention. To approximate average lifetime patient-level costs in each year, we divided aggregate costs of cancer care by the total number of cancer patients in each year.¹⁴

Net Value Calculations

To calculate the net value of survival gains in the US relative to the value experienced in the European countries included in the analysis, we calculated the difference between the value of excess survival gains in the US and the excess costs of cancer care in the US. The aggregate value to US cancer patients was then calculated using published estimates of the number of new cancer patients in each year by site.¹⁵

Country-Level Correlations

Using results on life expectancy from cancer diagnosis and cancer expenditures in each country from the previous steps, we examined country-level associations between cancer survival and spending. First, we compared survival among patients diagnosed during the period 1995-1999 with country-level cancer spending during this period. Second, we compared gains in cancer survival over the period 1983-1999 by country with changes in each country's cancer expenditures.

Sensitivity Analysis: Population Mortality Rates

We also examined changes in cancer-specific population mortality rates in the US and Europe to address the question of whether our conclusions are produced artificially by changes in the reference time of diagnosis. When greater efforts are placed on detection of cancer cases, more cases may be diagnosed at an earlier stage, which could create the false impression of increased survival. Consider as an example a completely untreatable cancer that is typically detected 24 months before patient death. A new technology that detects this cancer 36 months until death would appear to increase survival by 12 months, even though the actual prognosis is unchanged for these patients. This is a phenomenon often referred to as “lead-time bias” in the epidemiological literature. Note that this new detection technology would not change the rate at which people die from this cancer. As a result, population mortality rates are not sensitive to lead time bias or its sources.¹⁶

A limitation of examining population mortality rates alone is that these rates will be affected if cancer incidence changes for reasons other than improved detection, including changes in prevention or risk factors for disease. Taken together, however, analyses of mortality rates and survival produce more robust conclusions. If US data show both survival gains and mortality reductions, this is likely to reflect real improvements in health; the alternative interpretation requires a scenario in which the diagnosis rate is rising in the US while the actual number of cancer cases is falling.

We examined trends in cancer mortality rates over time by cancer site, age group, gender, and country over a similar period to that examined in the analysis of cancer survival – 1982 through 2005 – using the WHO Cancer Mortality Database. We examined the same set of countries included in the analysis of survival, excluding Wales, because data were not available for Wales independent of England in the WHO Cancer Mortality Database. We estimated negative binomial regressions with number of deaths as the explanatory variable controlling for age, gender, location, period of death, and the interaction between location and period of death.¹⁷ The population corresponding to each age group in each country was used as the exposure.

To value differences in population mortality, which were estimated in terms of number of deaths prevented, we used a value of statistical life-year of \$5 million.¹⁸

Results

Cancer Survival

For cancer patients diagnosed during the period 1995-1999, adjusted average survival was 11.1 years from diagnosis in the US, compared with 9.3 years among the European countries, a difference of 1.8 years or 16% of US life expectancy (Exhibit 1).¹⁹ This difference reflected higher US survival levels during the period 1995-1999 for most cancer sites, with the exception of chronic myeloid leukemia, acute myeloid leukemia, Hodgkin disease, and testicular cancer, for which the European countries experienced improved survival.²⁰

Examining changes in cancer survival over the period 1983 through 1999, US gains in survival from cancer diagnosis exceeded gains experienced in the European countries for most cancer sites. The greatest US excess survival gains were observed for prostate cancer, chronic myeloid leukemia, and acute myeloid leukemia, for which US patients gained over two additional years of survival over 1983-1999 in excess of EU gains over this period. The EU experienced greater gains in colorectal cancer survival (an additional 0.6 year), corpus uteri survival (an additional 1.3 years), and Hodgkin's disease survival (an additional 0.2 year).

Exhibit 2 shows the aggregate value of survival gains over the period 1983-1999 by individual cancer site, which was highest for prostate cancer (\$627 billion in excess US gains) and breast cancer (\$173 billion in excess US gains). These US gains were offset in part by European gains in survival for several cancer sites: Hodgkin disease (\$70 billion in excess European gains over 1983-1999), corpus uteri (\$67 billion in excess European gains), and colorectal cancer (\$46 billion in excess European gains over 1983-1999).

Costs of Cancer Care

US spending on cancer care in 2010 US dollars increased from \$47,000 per cancer case to \$70,000 (49%) over the period 1983 through 1999. European spending on cancer care in 2010 US dollars increased from \$38,000 to \$44,000 (16%). The aggregate value of additional spending among patients with cancers included in the analysis totaled \$158 billion over the period 1983-1999.

Net Social Value

The net value of US survival gains in excess of European survival gains over the period 1983 through 1999 is shown in Figure 3. Net value of survival gains for the average individual patient with cancer was \$57,000 on average, ranging between \$37,000 and \$73,000 over the analysis period. The aggregate net value to all US patients with cancer at sites included in the analysis was \$556 billion or approximately \$40 billion annually.²¹ This corresponded to 78% of the total value of survival benefits over the analysis period.

Country-Level Correlations

Exhibit 4 documents correlations between cancer survival and country expenditures on cancer treatment. First, the correlation between cancer expenditures per capita over the period 1995-1999 and average survival from cancer diagnosis over the same period was analyzed. A linear trend suggests that each \$100 increase in spending per capita on cancer care (approximately a \$20,000 increase in spending per cancer patient) corresponded to an increase of 2.3 years in life expectancy for the average cancer patient from cancer diagnosis. This correlation was significant at the 5% level ($P=.016$). Approximately 47% of the variation in survival from cancer diagnosis was explained by variation in cancer spending.

Second, country-level correlations between changes in cancer expenditures per capita over the period 1983-1999 and gains in survival over the same period were analyzed. A linear trend suggests that each additional \$100 in cancer spending per capita (approximately an additional \$20,000 increase in spending per cancer patient) over the period 1983-1999 led to an additional survival gain of 1.0 year of life expectancy from cancer diagnosis. The correlation was significant at the 10% level ($P=.092$). Approximately 28% of the variation in gains in cancer survival over the period was explained by variation in changes in spending over the period.

Sensitivity Analysis: Population Mortality Rates

Because the aggregate value of excess survival gains could be affected by changes in the reference time of cancer diagnosis due to changes in detection of cancer over time, we also examined population mortality rates for cancer over time in the US and in Europe, which are not sensitive to changes in the reference time of cancer diagnosis.

Exhibit 5 shows changes in mortality rates in the US over 1982-2005 in excess of changes observed in European countries by cancer site. Additionally, the corresponding number of deaths and economic value of these changes are shown. For prostate cancer, the US experienced an additional reduction of 15.8 deaths per 100,000 male population relative to Europe over the period 1982-2005, which corresponded to 222,000 deaths averted or \$1.28 trillion. For breast cancer, US trends in population mortality corresponded to 87,000 deaths averted or \$502 billion. In contrast with the survival analysis, the US exhibited more rapid improvement in colorectal cancer mortality rates than European countries; valuing these gains produces over \$1.88 trillion in US benefits. Stomach cancer mortality rates exhibited substantially more rapid declines in the European countries examined; however this result was not statistically significant, and US mortality rates for stomach cancer remained lower than rates for any European country included in the analysis.

Discussion

The high costs of cancer care in the US are frequently cited as evidence of a poorly functioning health care system, compared to other developed countries.²² Using conservative market estimates of the value of a statistical life, this study presented evidence that US cancer survival gains are worth more than the corresponding growth in the cost of US cancer care, during the 1980s and 1990s.²³

A majority of the aggregate value of survival gains in the US was due to gains in prostate and breast cancer survival. As we noted, the observed survival of patients with prostate or breast cancer could be influenced by changes in the stage at which they are diagnosed due to changes in screening rates for these cancers.²⁴ To assess this hypothesis, we examined population mortality rates for both prostate and breast cancer and found they declined significantly more rapidly in the US than in European countries. Valuing excess US declines in mortality from prostate and breast cancer (as opposed to survival) produced even larger estimates of the aggregate economic benefit associated with US improvements totaling \$1.8 trillion. Unlike survival calculations, population mortality rate calculations are not sensitive to the reference time of cancer diagnosis. On the other hand, mortality rates are sensitive to underlying changes in cancer incidence, for example, due to increased cancer prevention; however, previous studies have indicated that declines in mortality associated with these two cancer sites are unlikely to be driven by changes in prevention or changes in patient risk factors.²⁵ Thus, these results support the conclusion that survival improved substantially for prostate and breast cancer in the US relative to improvements experienced in Europe.

A key question is whether the US survival gains are actually produced by higher US spending. On face, this seems plausible, since we are analyzing survival for patients that have already been diagnosed. Non-health investments by patients – in healthy behavior and other types of preventive activities – are likely to have a smaller impact. There are also reasons to believe that differences in US cost reflect – at least in part – more rapid take-up of new technologies that could plausibly explain differences in survival.

New cancer drugs often reach US patients sooner than their European counterparts,²⁶ in part due to delays or denials associated with reimbursement decisions. For example, trastuzumab, a major breakthrough in the treatment of breast cancer,²⁷ was approved by the US FDA in 1998 and was quickly incorporated into clinical guidelines.²⁸ By contrast, the UK governmental organization NICE, which evaluates cost-effectiveness, did not recommend reimbursement and use of trastuzumab for breast cancer until 2002,²⁹ and uptake of the drug was slow in several major European countries.³⁰ Several major changes in prostate cancer treatment in the US were implemented in the 1980s and 1990s, including higher rates of radical prostatectomy, use of luteinizing hormone-releasing hormone agonists, and improvements in radiation therapy.³¹ Compared with the US, European countries have typically treated prostate cancer less aggressively.³² Finally, earlier detection and management associated with increased screening for breast and prostate cancer in the US relative to Europe could also have improved US patient outcomes.³³

Country-level correlations between costs of cancer care and cancer survival provide additional evidence consistent with a causal mechanism between spending and survival. We found that those countries within Europe with higher cancer expenditures per capita demonstrated longer average survival from diagnosis. Furthermore, countries that demonstrated greater increases in cancer spending in the 1980s and 1990s were generally those that experienced greater gains in cancer survival.

This study has several limitations worth noting. First, we do not examine the cost-effectiveness of individual cancer treatments; although our results suggest that survival gains associated with US cancer treatments have been worth the costs overall, this does not imply that all treatments are cost-effective. Second, we restricted our analysis to the set of European countries that reported survival data consistently over time. We note that it is possible that trends observed among the set of countries analyzed may not represent all European countries. Third, the costs data approximate the costs of cancer care in each year by dividing the aggregate costs by the number of patients diagnosed in each year, but these estimates cannot exactly match the lifetime costs of care associated with patients diagnosed in a particular year. Fourth, we focus on

differences in improvements in cancer survival and population mortality, rather than crude differences in survival or mortality levels across countries. This approach is less likely to be influenced by intrinsic population characteristics that could affect patient outcomes, but comparing gains relative to different baselines assumes survival improvements are independent of baseline levels, which may not always be true. Finally, this study did not examine differences in morbidity or productivity associated with cancer, and thus these outcomes were not valued. Given the observed survival benefits associated with the United States, these omissions are likely to attenuate estimates of the net value of cancer care in the United States.

In summary, the results of this study indicate that the US has experienced greater cancer survival gains compared with those experienced in Europe and that the value of these additional gains has exceeded the additional costs of care in the US during the 1980s and 1990s. Our findings bear on the larger question of whether higher US health care spending is worth it. We believe similar studies targeted towards other disease areas are needed to shed further light on this broad and timely question.

Notes

1. Reinhardt UE, Hussey PS, Anderson GF. U.S. health care spending in an international context. *Health Affairs*. 2004; 23(3):10–25. [PubMed: 15160799]
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3. Estimates for the EU were calculated from data on health expenditures from OECD and the percent of health spending on cancer from the Karolinska Institute. See also: Wiling N, Jonsson B, Hogberg D, Justo N. *Comparator report on patient access to cancer drugs in Europe*. 2009 Stockholm, Sweden
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6. Data for years 1983–1999 were publicly available through the EURO CARE web site. The EURO CARE steering committee was contacted regarding sharing more recent data but refused to provide additional data.
7. Age groupings were those available in the EURO CARE databases: 15–44 years, 45–54, 55–64, 65–74, and 75–99. Periods of diagnosis were those available in the EURO CARE databases: 1983–1985, 1986–1988, 1989–1991, 1992–1994, and 1995–1999. Location was a binary variable in the main analysis, indicating whether an observation came from the US or Europe. Aggregate EURO CARE data on number of patients who died or were lost to follow-up in each year were converted to individual-level observations using the *cttost* command using Stata statistical software.
8. Survival differences at 5 years between the US and Europe using the Cox model were similar to estimates of differences in relative survival between the US and Europe using a 5-year relative survival period analysis. The Cox model produced greater differences between US and EU survival only for melanoma, stomach cancer, and testicular cancer. For details on the period relative survival approach, see: Verdecchia A, Francisci S, et al. Recent cancer survival in Europe: a 2000–02 period analysis of EURO CARE-4 data. *Lancet Oncol*. 2007; 8(9):784–796. [PubMed: 17714993]
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11. We used a discount rate of 3% and used year 1999 as the reference year.
12. When country-level health expenditure data was not available for every year, estimates were extrapolated geometrically using the available data for that country. To account for cases when survival data from a European country's registries represented a subset of the country's cancer cases, the relative contribution of the country's registries to the survival analysis was used to weight average European costs.

13. Estimates of the proportion of health expenditures on cancer care were obtained from the Karolinska Institute. The proportion of health expenditures spent on cancer care over time in the US has been demonstrated to be fairly constant over time at approximately 5%. See: Bosanquet N, Sikora K. The economics of cancer care in the UK. *Lancet Oncol.* 2004; 5(9):568–574. [PubMed: 15337487] See also: Mariotto AB, Yabroff KR, Shao Y, Feuer EJ, Brown ML. Projections of the cost of cancer care in the United States: 2010–2020. *J Natl Cancer Inst.* 2011; 103:117–128. [PubMed: 21228314]
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17. Age groups were 0-49 years, 50-54 years, 55-59 years, 60-64 years, 65-69 years, 70-74 years, 75-79 years, 80-84 years, and 85+ years.
18. For these calculations an annual discount rate of 3% was used and 2005 was used as the reference year.
19. In a sensitivity analysis we examined the extent to which including all 23 European countries available in the EURO CARE-4 database for the period 1995-1999 would change these results. We found that the difference in life expectancy between the US and Europe was 1.2 years using this approach, compared with 1.8 years in the main analysis.
20. Survival differences ranged between a 2.1 year survival advantage for the US for prostate cancer to a 0.5 year survival advantage for the European countries. All differences were significant at the 5% level except for those for Hodgkin disease and thyroid cancer.
21. In a sensitivity analysis we calculated the net value of the survival benefits in the US by comparing levels of survival for patients diagnosed in 1995-1999 with costs per patient for this same period. By this approach, the net value of survival benefits was \$115,000 for the average US cancer patient, and the aggregate annual value to the US population with cancer was \$175 billion.
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Exhibit 1. Trends in Average Survival from Cancer Diagnosis in the United States and 10 European Countries

Source: Authors' calculations using data from SEER, EUROCARE-3, and EUROCARE-4 databases.

Note: Results are standardized by age, gender, and cancer site. Includes EU countries for which survival data were consistently available over the analysis period: Finland, France, Germany, Iceland, Norway, Slovakia, Slovenia, Scotland, Sweden, and Wales.

	1983-1985	1986-1988	1989-1991	1992-1994	1995-1999
US	8.45899	9.18165	9.70518	10.2336	11.0568
EU	7.10271	7.5839	7.93917	8.37374	9.25581

Exhibit 2. Aggregate Value of US Survival Gains in Excess of European Survival Gains for US Patients Diagnosed in 1983-1999, by Site

Source: Authors' calculations using data from SEER, EURO CARE-3, and EURO CARE-4 databases.

Note: Abbreviations: AML, acute myeloid leukemia; CML chronic myeloid leukemia, NHL, non-Hodgkin lymphoma. Results are standardized by age and gender. Includes EU countries for which survival data were consistently available over the analysis period: Finland, France, Germany, Iceland, Norway, Slovakia, Slovenia, Scotland, Sweden, and Wales.

Cancer Type	Billions of U.S. Dollars (2010)
Corpus uteri	-66.91817655
Colorectal	-45.53241235
Melanoma	-2.501591049
Chronic myeloid leukemia	15.31767163
Acute myeloid leukemia	29.66885236
Breast	173.1234132
Prostate	626.7031053

Exhibit 3. US Survival Benefits, Costs, and Surplus to Average Cancer Patients in Excess of European Countries

Source: Authors' calculations based on data from SEER, EURO CARE-3, EURO CARE-4, OECD, and the Karolinska Institute.

Note: Results are standardized by age, gender, and cancer site. Estimates are expressed in 2010 US dollars. The value of a life-year was set at \$150,000. Survival gains and costs are discounted at 3% per year to 1999. Costs are converted to 2010\$ using the Consumer Price Index. Includes EU countries for which survival data were consistently available over the analysis period: Finland, France, Germany, Iceland, Norway, Slovakia, Slovenia, Scotland, Sweden, and Wales. Data on health expenditures by country from the OECD were geometrically extrapolated for some years when unavailable.

	1983-1985	1986-1988	1989-1991	1992-1994	1995-1999
Benefits	0	64923.8189	102718.63	111766.46	111766.46
Costs	0	14213.05	19188.28	17507.45	14660.57
Surplus	0	50710.7738	83530.347	94259.011	68850.608

Exhibit 4. Country-Level Correlations between Cancer Spending and Average Cancer Survival

Source: Authors' calculations based on data from SEER, EUROCARE-3, EUROCARE-4, OECD, and the Karolinska Institute.

Note: Results are standardized by age, gender, and cancer site. Includes EU countries for which survival data were consistently available over the analysis period: Finland, France, Germany, Iceland, Norway, Slovakia, Slovenia, Scotland, Sweden, and Wales. Estimates of the average gain in cancer survival against the change in cancer expenditures were calculated for the period 1995-1999 relative to the period 1983-1985. Data on health expenditures by country from the OECD were geometrically extrapolated for some years when unavailable.

Exhibit 5
Value Associated with US Changes in Population Cancer Mortality Rates Relative to European Changes

Cancer site	Change in US death rate in excess of EU change, 1982-2005 males (/100,000)	Change in US death rate in excess of EU change, 1982-2005, females (/100,000)	Additional deaths avoided (incurred) in US, 1982-2005	Aggregate excess value of US trend to US patients (US \$, billions)
Breast	0.1	6.1	86,913	501.6
Colorectal	4.0	2.6	281,932	1,884.5
Hodgkin	-0.3	-0.2	-8,025	-48.5
Leukemia	3.8	2.4	23,347	98.1
Melanoma	0.8	0.5	15,050	86.6
NHL	3.1	2.0	67,826	405.0
Prostate	15.8	0.0	221,749	1,279.9
Stomach	-10.2	-4.6	-224,212	-1,313.9
Testis	-0.2	0.0	-4,175	-24.9
Thyroid	-0.4	-0.4	-11,556	-66.8
Uterus	0.0	0.0	14,990	115.9

Source: Authors' calculations based on data from the WHO Cancer Mortality Database.

Note: Results are standardized by age and gender and predicted based on negative binomial regression analysis. Includes EU countries examined in the main analysis for which mortality data were available: Finland, France, Germany, Iceland, Norway, Slovakia, Slovenia, Sweden, and Scotland. The value of statistical life was set at \$5 million. The value of mortality benefits was discounted at 3% to 2005. Differences in changes in mortality rates in the US relative to Europe were significant at the .05 level except for leukemia, stomach, testis, and uterus, which were not statistically significant.