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Cancer Mortality Reductions Were Greatest Among Countries Where Cancer Care Spending Rose The Most, 1995–2007

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ABSTRACT Health care spending and health outcomes vary markedly across countries, but the association between spending and outcomes remains unclear. This inevitably raises questions as to whether continuing growth in spending is justified, especially relative to the rising cost of cancer care. We compared cancer care across sixteen countries over time, examining changes in cancer spending and two measures of cancer mortality (amenable and excess mortality). We found that compared to low-spending health systems, high-spending systems had consistently lower cancer mortality in the period 1995–2007. Similarly, we found that the countries that increased spending the most had a 17 percent decrease in amenable mortality, compared to 8 percent in the countries with the lowest growth in cancer spending. For excess mortality, the corresponding decreases were 13 percent and 9 percent. Additionally, the rate of decrease for the countries with the highest spending growth was faster than the all-country trend. These findings are consistent with the existence of a link between higher cancer spending and lower cancer mortality. However, further work is needed to investigate the mechanisms that underlie this correlation.

Spending on health care in the United States is generally much higher than in other countries in the Organization for Economic Cooperation and Development (OECD), and the difference has persisted for a number of years.[1,2] Higher US spending levels have been variously attributed to higher prices,[3,4] greater utilization,[5] or both.[6] More recently, this difference has fueled research attempting to assess whether the higher spending can be justified by additional health gains in the United States.[7,8] Results from these studies have been mixed. However, they consistently point to a great deal of variation in health gains across different therapeutic areas.[7] This makes it difficult to compare countries with differing patient mixes, health systems, and levels of development.

Some observers have suggested that the United States spends too much on health care in comparison to other countries.[1,2] However, the important question is whether health systems are delivering good value for money spent. Put another way, does additional health spending provide the appropriate amount of improved health outcomes that would be expected, given the stage of development of a given health system? In recent years cancer care has been a flash point in the debate about appropriate health care spending. The launch of a number of new anticancer drugs has been accompanied by debates about their prices[9] and a range of reimbursement decisions by different health care systems.[10,11]

The United States spends more on cancer care

than any other country, but most studies also place the United States at or very near the top of most international rankings for cancer outcomes.[3,12] To what degree are spending and outcomes related?

Previous work has compared cancer spending and survival across countries, but possible biases related to the use of particular survival measures may have imposed limitations on study results.[13–17] Using a different approach, we explored the association between cancer spending and survival across countries both in absolute terms and in terms of rate of progress.

Study Data And Methods

We estimated the association between cancer spending—both aggregate levels and aggregate changes—and cancer mortality. Heterogeneity across countries always poses challenges for cross-national analyses of spending and outcomes. One concern is that aggregate health outcomes may depend on factors other than health care, such as patient behavior.

Focusing on cancer in particular helps mitigate this concern to some extent, because cancer outcomes are arguably more tightly linked to health care spending than is the case with other diseases. Nonetheless, even for cancer patients, outcomes may depend on factors other than cancer spending.

To mitigate this problem further, we focused on mortality rates instead of survival times. Comparing mortality rates avoids common limitations in international comparisons of survival outcomes, including lead-time bias, overdiagnosis, and stage migration.[13–17] Stage migration happens when methods of diagnostic imaging and staging of tumors differ across nonhomogeneous countries or eras.[18] Survival times may also be improved mechanically if patients are simply diagnosed with disease earlier, even if no improvements in care occur.

A problem even with mortality rates is the possibility of mortality from causes that are unaffected by cancer treatment spending. To address this problem, we used two alternative measures of mortality (both age-adjusted) that are present in the literature: amenable mortality and excess mortality. Amenable mortality measures mortality in a set of conditions in which mortality can be avoided in the presence of timely and effective treatment.[19–21] In this application we followed exactly the classification in previous studies that used amenable mortality for the same time period.[19] The list of amenable cancers is available in the online Appendix.[22]

Our other adjustment for excess mortality controlled for differences across countries in noncancer mortality. This reduced biases stemming from variation in population characteristics, such as age distribution, and competing death risk factors such as cardiovascular disease. In other words, excess mortality measures cancer mortality corrected for the risk of noncancer causes of death, or background mortality.[12]

We analyzed both of these mortality measures in sixteen OECD countries—Australia, Denmark, Finland, France, Germany, Iceland, Italy, Japan, the Netherlands, Norway, Slovakia, Slovenia, Spain, Sweden, the United Kingdom, and the United States—for the time period 1995–2007. We divided the countries into three groups (high, middle, and low) for both spending level and spending growth; further details are provided below.

These countries represent the full set of countries for which all necessary variables were available in the three data sets of interest for all thirteen years. Despite a high degree of heterogeneity, we chose to include all of the countries, to be as inclusive and objective as possible. We also conducted sensitivity analyses (described below) to test the influence of particular outliers on our results.

DATA We used data from several sources. The World Health Organization Mortality Database provided death counts by sex and age band, which were used to age-adjust the final mortality measures.[23] Data on the incidence of cancer were extracted from the European Cancer Observatory's national and regional cancer registries and from individual country registries for non-European countries.[24] Our health care expenditure data came from the World Health Organization Global Health Expenditure database.[25]

The spending data were first converted into cancer-specific expenditures using reported estimates from recent studies of the proportion of total health care spending that went toward cancer.[26–29] Expenditure data were then divided by cancer incidence data to create estimates of mean per patient spending.

We used US dollar prices instead of purchasing power parity prices, which many international comparison studies use.[3,30] A general price index weighting such as purchasing power parity prices might not be an effective tool for comparing prices within a particular market, such as health care. Purchasing power parity price indices tend to reflect the fact that most consumer goods and services elsewhere are more expensive, relative to the United States.

In contrast to this, almost all studies assessing the price of health care and of health care inputs suggest that prices are significantly higher in the United States than in other OECD countries.[1,2] Therefore, the use of purchasing power parity

prices in international health comparisons risks artificially widening the gap between the United States and other OECD countries.

ANALYSIS Spending on cancer per incident case was calculated for each country in each year. The sixteen OECD countries were then ranked by both the level of cancer spending per patient in 2007 and growth in this spending between 1995 and 2007. Alternative approaches to ranking, such as ranking by per case spending in the base year instead of the final year, had minimal effects on the ranking of countries. Thus, we chose to rank countries based on 2007 spending levels to better reflect current spending trends.

The ranked countries were then categorized into groups of four low-, eight medium-, and four high-spending countries. For level of cancer spending in 2007, the high-spending countries were Japan, Iceland, Norway, and the United States. The medium-spending countries were Australia, Denmark, Finland, France, Germany, the Netherlands, Sweden, and the United Kingdom. The low-spending countries were Italy, Slovakia, Slovenia, and Spain.

The countries in the three categories were somewhat different when we ranked them based on growth in cancer spending. In that case, Australia, Finland, Iceland, and the United States were in the high category. Denmark, Germany, Italy, Japan, the Netherlands, Spain, Sweden, and the United Kingdom were in the medium category; and France, Norway, Slovakia, and Slovenia were in the low category.

We calculated age-adjusted amenable and excess mortality rates per 100,000 people using the 2000 US Standard Population[31] (Exhibit 1). We then examined both the absolute levels of cancer-specific mortality and the trends in cancer mortality between 1995 and 2007, and we compared these outcomes across cancer spending categories.

LIMITATIONS Our analysis had several important limitations. We faced a number of challenges related to the use of data on amenable mortality.[21,30,32] For example, identifying conditions amenable to health care is difficult, since death from any given cause may merely represent the end of a complex chain of processes that result from various underlying social, economic, and health-related factors.

Similarly, there are multiple ways to calculate excess mortality, and our method was limited by the quantity and quality of the available data. For example, we did not observe cancer mortality among cancer patients, only population cancer incidence and population cancer mortality for a

EXHIBIT 1

Mortality Rates And Per Patient Cancer Spending In Sixteen Countries In The Organization For Economic Cooperation And Development, 1995 And 2007

	Age-adjusted cancer mortality (per 100,000 population)						
	Amenable cancers		Excess cancers		Per patient spending		Growth in per patient spending
Country	1995	2007	1995	2007	1995	2007	1995–2007
Australia	65.7	50.5	197.0	166.1	$28,406	$37,643	$ 9,237[a]
Denmark	76.7	51.9	249.3	219.6	27,577	32,902	5,324
Finland	45.7	38.8	172.6	146.9	25,040	34,034	8,994[a]
France	55.5	48.0	209.6	179.4	22,962	22,819	–143[b]
Germany	69.0	49.8	201.9	174.5	28,743	32,860	4,116
Iceland	51.4	45.6	190.3	179.7	31,878	43,739[a]	11,861[a]
Italy	54.5	47.9	204.5	177.3	16,715	20,114[b]	3,399
Japan	44.2	40.6	179.1	160.2	55,213	59,077[a]	3,864
Netherlands	59.5	55.2	221.3	196.0	19,441	26,286	6,846
Norway	67.1	61.5	196.8	175.7	42,200	41,162[a]	–1,038[b]
Slovakia	74.2	75.8	224.1	204.6	5,201	8,231[b]	3,029[b]
Slovenia	77.6	69.5	221.7	215.4	10,664	11,394[b]	730[b]
Spain	52.6	49.5	191.9	168.9	13,515	19,159[b]	5,644
Sweden	51.3	50.7	176.4	162.9	24,423	33,359	8,936
UK	56.7	48.5	220.8	192.7	13,093	20,741	7,648
US	55.1	45.2	198.1	163.8	49,537	67,737[a]	18,200[a]

SOURCE Authors' analysis of data from the World Health Organization (WHO) Mortality Database (Note 23 in text) and the WHO Global Health Expenditure Database (Note 25 in text). **NOTES** For country-level cancer incidence, see the online Appendix (see Note 22 in text). Spending is in 2007 US dollars. "Amenable" and "excess" cancers are defined in the text. [a]High spending or high spending growth. [b]Low spending or low spending growth.

given country and year.[13] Also, changes in the *International Classification of Diseases* (ICD) coding system over time, and differences in the quality of death registry data across countries and times, limit analyses such as ours. Mortality rates reflect the efficacy of treatment and incidence of disease in previous years. Therefore, any analysis of cancer mortality alone, excluding information on survival and incidence, will be less than perfect.[12,33]

The available international data also have limitations. Both incidence and mortality data are subject to slight variations in definitions over time and across national boundaries, despite the enormous effort that goes into formalizing definitions in global health information systems.

Finally, the estimated proportion of health care spending devoted to cancer care is often available at a single point of time, instead of over many years. Thus, we had to infer the growth over time in spending on cancer using a single year's estimate of the proportion, combined with overall growth in health care spending. Clearly, if the proportion of spending devoted to cancer care changed over time, this method might suffer from inaccuracy.

Alternative data sources (for example, country-level data services such as those provided by the US Bureau of Labor Statistics, which provides detailed data for only one country) are available. However, our selected data sources provide the best balance of completeness and detail currently possible. Because of the nature of many of the variables used, a more detailed analysis of the data that controlled for variance over time was not feasible.

Study Results

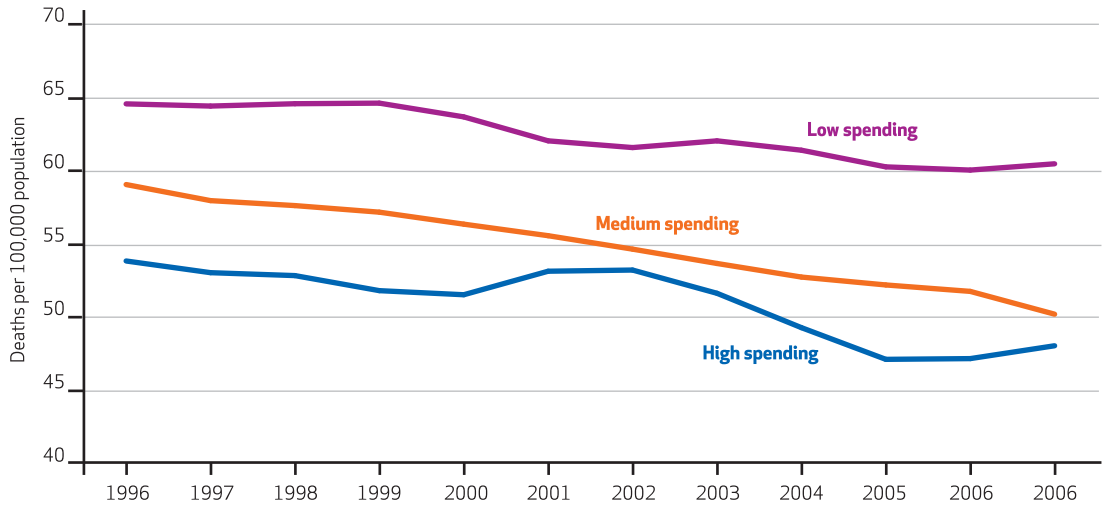
AMENABLE AND EXCESS MORTALITY Exhibits 2 and 3 show smoothed cancer mortality curves by cancer spending category for age-adjusted amenable cancer mortality and age-adjusted excess mortality, respectively.[34] These exhibits illustrate that there is a clear separation of cancer mortality levels across spending categories, with high- and medium-spending countries tending to have better cancer outcomes than low-spending countries in both cases.

Even after smoothing by taking two-year moving averages of mortality rates, we still observed some volatility over time. In the case of amenable mortality (Exhibit 2), for example, a monotonic decrease in mortality rates is seen only in medium-spending countries. Nonetheless, all categories demonstrate overall downward trends in mortality, with mortality rates in low-spending countries decreasing from sixty-five to sixty-one deaths per 100,000 population, those in medium-spending countries decreasing from fifty-nine to fifty deaths, and those in high-spending countries decreasing from fifty-four to forty-eight deaths.

In the case of excess mortality, this downward

EXHIBIT 2

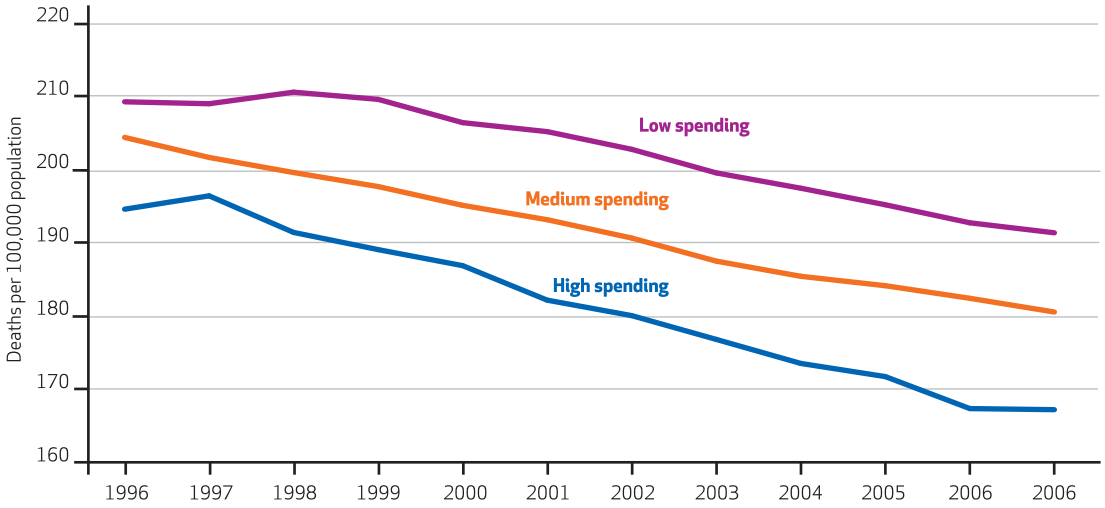
Amenable Cancer Mortality Rates, By Cancer Spending Category, 1995–2007



SOURCE Authors' analysis of data from the World Health Organization Mortality Database (Note 23 in text). **NOTES** "Amenable" cancer is defined in the text. The analyses used age-standardized amenable cancer mortality rates and present two-year moving averages (for example, the data labeled 1996 represent the two-year average of 1995–96). Countries were ranked and categorized based on mean per case cancer spending in 2007. The high-spending countries were Japan, Iceland, Norway, and the United States. The medium-spending countries were Australia, Denmark, Finland, France, Germany, the Netherlands, Sweden, and the United Kingdom. The low-spending countries were Italy, Slovakia, Slovenia, and Spain.

EXHIBIT 3

Excess Cancer Mortality Rates, By Cancer Spending Category, 1995–2007



SOURCE Authors' analysis of data from the World Health Organization Mortality Database (Note 23 in text). **NOTES** "Excess" cancer is defined in the text. The analyses used age-standardized excess cancer mortality rates and present two-year moving averages (for example, the data labeled 1996 represent the two-year average of 1995–96). Countries were ranked and categorized based on mean per case cancer spending in 2007. The countries in each category are listed in Exhibit 2 notes.

sloping trend is also apparent, with clear separations between the three spending groups (Exhibit 3). This is consistent with the hypothesis that better cancer outcomes are achieved in health systems that invest more heavily in cancer care.

The association between increased spending and improved outcomes is also demonstrated in Exhibit 4. When we compared the rate at which progress was achieved in reducing cancer mortality and the rate at which cancer spending per case rose by spending category, we found that the countries whose spending increased the most showed the largest decrease in cancer mortality. Interestingly, the rate of progress in improving cancer outcomes in the countries with high spending growth has happened in spite of the fact that, collectively, they had lower levels of cancer mortality in 1995, compared to countries in the other two categories of spending growth.

EXHIBIT 4

Mean Changes In Per Patient Cancer Spending And Cancer Mortality, By Category Of Spending Growth, 1995–2007

	Countries whose growth in spending was:		
	Low	**Medium**	**High**
SPENDING			
Mean (SD)	$645 ($1,746)	$5,722 ($1,960)	$12,073 ($4,544)
Percent change	16	29	36
AMENABLE CANCER MORTALITY			
Mean change (SD)	–4.9 (4.5)	–8.8 (8.6)	–9.5 (4.2)
Percent change	–8	–14	–17
EXCESS CANCER MORTALITY			
Mean change (SD)	–19.3 (9.9)	–24.1 (5.5)	–25.4 (10.5)
Percent change	–9	–12	–13

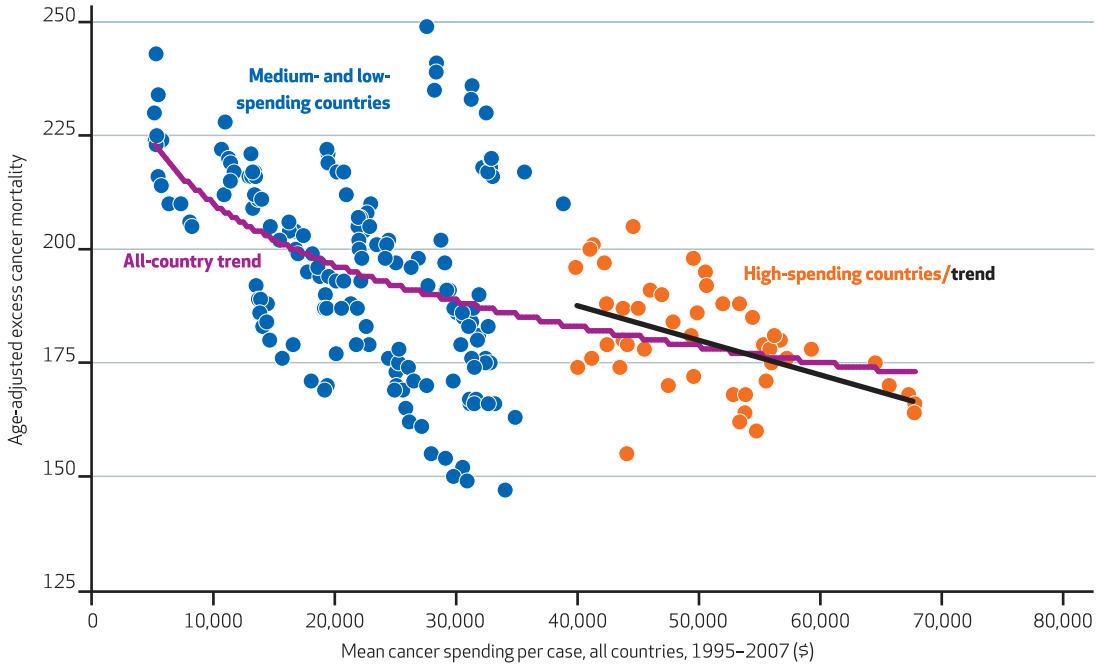
SOURCE Authors' analysis of data from the World Health Organization (WHO) Mortality Database (Note 23 in text) and the WHO Global Health Expenditure Database (Note 25 in text). **NOTES** Countries were ranked and categorized based on growth in mean annual per patient cancer spending from 1995 to 2007. The countries with low spending growth were France, Norway, Slovakia, and Slovenia. Those with medium spending growth were Denmark, Germany, Italy, Japan, the Netherlands, Spain, Sweden, and the United Kingdom. Those with high spending growth were Australia, Finland, Iceland, and the United States. "Amenable" and "excess" cancer are defined in the text. Analyses used age-standardized amenable and excess cancer mortality rates. Spending is in 2007 US dollars. Mortality is deaths per 100,000 population. SD is standard deviation.

RETURNS ON INVESTMENT We hypothesized that there are decreasing returns on cancer innovation. In other words, as cancer care programs develop, the pace of progress as measured by improved outcomes gradually slows over time, with each unit of progress coming at an increased cost. Early in the development of cancer care, health technologies are able to generate huge gains in health outcomes by taking advantage of low-hanging fruit, and these technologies spread rapidly around the world. Over time, however, new technologies and their advances become more marginal, and the cost of each additional unit of improved health increases.

To test this hypothesis, we ran a regression of cancer mortality on changes in cancer spending from 1995–2007 (Exhibit 5), which compared relative progress by measuring the expected change in mortality for a given change in cancer spending. Analysis of the resulting semilog mod-

EXHIBIT 5

Excess Cancer Mortality And Cancer Spending Per Capita, By Country And Year



SOURCE Authors' analysis of data from the World Health Organization (WHO) Mortality Database (Note 23 in text) and the WHO Global Health Expenditure Database (Note 25 in text). **NOTES** "Excess" cancer is defined in the text. Each point represents excess mortality (deaths per 100,000 population) for a given country in a given year, with all years pooled for analysis. The points corresponding to high-spending countries are signified by orange circles. High-spending countries were determined based on per patient cancer spending in 2007. The countries in each spending category are listed in the Exhibit 2 Notes. The all-country trend line (in purple) represents a semilog regression model, whereas the high-spending country trend line (in black) represents a linear model.

el confirmed that the rate of return slows as spending rises, as illustrated by the flattening slope of the OECD all-country mortality-spending trend line as spending levels rise (Exhibit 5), which can be interpreted as the rate of progress.

When we looked at the high-spending countries alone, they showed a rate of progress of 1.65 fewer deaths per 100,000 for every $1,000 spent on cancer. This rate of progress in cancer mortality is notably greater than the all-country trend of 0.39 fewer deaths per 100,000 for every $1,000 dollars spent, measured at the mean spending level of high-spending countries ($50,026).

We additionally estimated the same outcomes using a semilog model that included an interaction term and a fixed effect for the high-spending countries (not shown), to test whether the slope and position of the curve differed for high-spending countries across all levels of spending. In this model the slope of the all-country trend (measured at a mid-range spending level of $30,000) suggested a decline in mortality rate of 0.64 deaths per 100,000 for every $1,000 spent on cancer, compared to the decline for high-spending countries alone at the same point of 2.45 deaths per 100,000 per $1,000 spent. This confirmed our original finding that high-spending countries made faster progress than would be expected from the all-country trend.

SENSITIVITY ANALYSIS We tested the sensitivity of our results to the inclusion of potential outliers, such as the two former Warsaw Pact countries (Slovenia and Slovakia) and the United States. The relationship between spending growth and amenable cancer mortality was entirely insensitive to the inclusion of these three countries.

The relationship between spending growth and excess cancer mortality was largely insensitive, with one exception. When we excluded Slovenia, the pattern of mortality decreasing with increasing spending categories failed to hold in the case of low- and medium-spending growth categories. However, the countries with high spending growth continued to exhibit the largest declines in excess cancer mortality. The full results of the sensitivity analysis are provided in the online Appendix.[22]

Discussion

International differences in health care spending—in particular, spending on cancer care and anticancer drugs—has been a subject of considerable interest around the world in recent years. This study explored whether the rate at which spending on cancer care rises over time is associated with a similar pattern of improvement in health outcomes. The results suggest both that it is and that the rate of improvement in health outcomes has risen more quickly in high-spending countries, compared to the overall trend across all countries.

More work is needed to interpret the second finding. One hypothesis is that high-spending countries are more efficient users of health care resources than medium-spending countries. Indeed, this could explain why high-spending countries spend more overall than other countries do. It could also be that high-spending countries adopt more effective technologies more quickly, compared to other countries, and thus derive more years of overall benefit from the technologies. Other hypotheses may emerge as well, with more careful and systematic analysis of this intriguing and suggestive result.

This study was an evaluation of health systems from an economic perspective. Nonetheless, we chose to avoid a simple comparison of cost levels with levels of mortality, a method that takes a backward-looking view of health technology. The role of health care systems, unlike that of individual technologies, is to translate individual advancements in health care technology and delivery into constant improvements in population health over time. Thus, what matters most is how marginal investments in new technology translate, or fail to translate, into marginal improvements in life expectancy.

As we stated in the "Study Data And Methods" section, our analysis does have limitations. There are likely considerable areas of heterogeneity across countries that may be masked by an analysis that considers only average spending and health outcomes in aggregate international comparisons. For example, France experiences higher cancer rates than many other countries do.[35] Heterogeneity across countries may be due to factors outside the health care system, yet it may influence the estimated relationship across countries between spending growth and mortality reductions.

More generally, heterogeneity across countries could contaminate our results if countries with higher-than-average levels of spending also systematically have the cases of cancer that are easiest to treat. Individual-level data within each country and a method for estimating health production functions for individual patients with cancer would be required to rule out this possibility.

Our findings suggest that a distinct difference in high-spending health systems allows for greater progress in outcomes.

In addition, we were unable to distinguish between the effects of spending on care and those of spending on cancer prevention. Our aim was ultimately to show the marginal effect of changes in expenditure on cancer care and proxy outcomes of performance. Cross-country heterogeneity led us to compare different populations with different levels of underlying risk and different health systems relying on different allocations of resources to prevention and treatment. The outcomes represent the relative effectiveness of these allocations. Thus, our inability to explicitly incorporate prevention spending may lead us to understate the relationship between spending and cancer mortality.

The results of our analysis, which indicate that high-spending health systems experience more rapid progress than other health systems in reducing mortality, must be considered exploratory at this stage. Nonetheless, our findings suggest that a distinct difference in high-spending health systems allows for greater progress in outcomes. The nature and cause of any difference remain unclear, however.

One hypothesis is that countries that invest more in research and development are "lead markets" that tend to adopt new technologies earlier. Other countries then follow their example. This tendency to use innovations earlier would explain the faster pace of improvement in health outcomes that we observed for the high-spending countries. In comparison, low-spending countries may be more conservative in their approach to adopting new technologies.[36–38]

A number of studies have suggested that the value of new technologies often rises rapidly beyond initial estimates of their cost-effectiveness, which are often based on trial data and utilization for a limited number of indications.[39,40] It

could be that high-spending health systems are benefiting from this technology "dividend" both earlier and to a greater degree, compared to low-spending health systems, where access to innovative treatments is often delayed.[10]

Another hypothesis is that high-spending health care systems tend to have a wider choice of potential therapeutic options for each condition, and this variation is more likely to generate better outcomes in a highly heterogeneous patient population, compared to a limited choice of options for treating each condition.[41,42]

These hypotheses will need to be tested more vigorously when the quality and availability of data allow.

Conclusion

Our findings are consistent with a higher rate of return on cancer care spending in high-spending countries, compared to medium- and low-spending countries. We found that cancer mortality rates tend to be lower in countries that spend more on cancer care, and that progress in reducing cancer mortality between 1995 and 2007 was greatest in countries where spending on cancer had risen the most. In fact, high-spending countries saw cancer mortality fall at faster rates than the underlying mortality-spending trend would lead us to expect in that period. These results should be considered exploratory. Nonetheless, they indicate that discussions about whether health care systems spend too much or not enough on cancer care are often oversimplified. ■

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22 To access the Appendix, click on the Appendix link in the box to the right of the article online.
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