Association Between Spending and Outcomes for Patients With Cancer

Meng Li, ScM, PhD^{1,2}; Darius N. Lakdawalla, PhD^{1,2,3}; and Dana P. Goldman, PhD^{1,2,3}

INTRODUCTION

Health care spending and health outcomes vary markedly across countries and even across regions within the United States.^{1,2} This inevitably raises questions about whether higher spending is “worth it” in terms of better health outcomes.³⁻⁶ Regional comparisons within the United States suggest that higher health care spending—especially at the end of life (EOL)—is not associated with better health outcomes. Medicare enrollees in higher spending regions receive more care but do not seem to live longer or otherwise experience better health outcomes,⁷ although the Medicare data suggest more waste than what is seen in younger, privately insured populations.⁸

Internationally, higher total and per capita health care spending in the United States is well documented and has persisted for many years.^{9,10} This has fueled research attempts to assess whether additional health gains exist in the United States to justify this higher spending.^{11,12} Results from these studies generally attribute the higher spending to higher prices,^{13,14} greater utilization,¹⁵ or both,¹⁶ but these broad comparisons mask important heterogeneity by disease.¹¹

Perhaps nowhere is this issue more acute than in cancer. The United States spends more on cancer care than any other country and places at the top, or very near the top, of most international league tables for cancer outcomes.^{11,17} Within the United States, we have seen a sizable reduction in cancer mortality in the past two decades but at significant cost. Overall cancer spending increased from \$27 billion in 1990 to \$137 billion in 2017 and is projected to increase further through 2020.¹⁸⁻²⁰

This rapid growth has motivated much scrutiny of cancer spending and its association with outcomes. It has also led to experiments with alternative payment and care delivery models in oncology.²¹ The fundamental question behind these debates and reforms is the relationship between spending and outcomes: Does spending improve outcomes in cancer, and if so, when? Existing evidence suggests that while some treatments, such as targeted cancer therapies, can improve outcomes, many others, such as chemotherapy overuse at EOL, fail to demonstrate such benefit.^{22,23} Therefore, the association between

spending and outcomes in cancer may not always be positive. For a conceptual framework of the effect of spending on health outcomes, see Martin et al.²⁴ To shed some light on this, we reviewed and synthesized the evidence both within the United States and internationally.

METHODS

We searched PubMed for articles published in English between the inception of the database and May 2, 2019. The primary search was based on the combination of three sets of key words. The first set included various terms for spending (and their variations): spending, spend, cost, expenditure, payment, reimbursement, reimburse, saving, investment, invest, dollar, and wealth. The second set included terms for health or quality outcomes: outcome, mortality, survival, life expectancy, longevity, health, death, consequence, and quality. The third set included terms for cancer: cancer, oncology, leukemia, carcinoma, lymphoma, sarcoma, neoplasm, and tumor. Articles that contained at least one term from each category were included in the screening. We performed another search specifically for articles that reported the impact of innovative care delivery or payment models on spending and outcomes in cancer. The key words for such models included care model, medical home, bundle, episode-based, accountable care, ACO, risk-sharing, value-based, pay for performance, demonstration, global budget, hospital budget, contract, financial alignment, capitation, capitated, and managed care. These key words were then combined with the key words from the spending and the outcomes categories to form the search strategy. These searches yielded 875 articles. We screened these articles on the basis of their titles; abstracts; and in some cases, full texts (Fig 1).

An article was included if it was published in a peer-reviewed journal, examined the relationship between spending and outcomes in cancer, examined the impact of innovative care delivery or payment models on spending and outcomes in cancer, or analyzed primary or secondary data (to exclude modeling studies). Among the 875 articles, 31 met the inclusion criteria. An additional 13 articles were identified through reviewing the reference lists of included

ASSOCIATED CONTENT

Appendix

Author affiliations and support information (if applicable) appear at the end of this article.

Accepted on October 2, 2019 and published at ascopubs.org/journal/jco on December 5, 2019; DOI <https://doi.org/10.1200/JCO.19.01451>

© 2019 by American Society of Clinical Oncology

FIG 1. Flowchart of the review.

articles, which resulted in a total of 44 articles in the final analysis. We extracted the study population, cancer sites, study design, expenditure measures, outcome measures, and key findings. We classified the study designs as follows:

- Longitudinal: analyzed individual-level data with repeated measures for the same patient over time
- Time series: analyzed repeatedly measured data aggregated at the area level
- Cross-sectional: analyzed individual- or area-level data at a single time point
- Repeated cross-sectional: analyzed cross-sectional data from multiple time points
- Difference in difference: compared outcomes of the intervention group at two time points, before and after the intervention, relative to a control group
- Prepost without a control group: compared outcomes of the intervention group, before and after the intervention

Furthermore, some articles examined multiple cancer types and reported findings separately for each type, and they were treated as separate studies in the analysis. We focused on overall health care and cancer spending and excluded studies that examined spending on a specific drug, procedure, or other health care service.

RESULTS

Detailed information on the 44 included articles are listed in Appendix [Tables A1, A2, A3, and A4](#) (online only).

Association Between Spending and Outcomes in the United States

We identified 13 articles comprising 24 studies that examined the relationship between spending and outcomes of patients with cancer in the United States (Appendix [Table A1](#)). Most of the evidence came from observational studies of the Medicare fee-for-service (FFS) population.²⁵⁻³⁴ Eleven studies used the EOL expenditure index (EI) in a hospital referral region as the spending measure.^{25,26,28,29,35} EOL-EI is calculated as age-, sex-, and race-adjusted and price-standardized spending on hospital and physician services provided to beneficiaries in their last 6 months of life. It is a different cohort than the cancer cohort in which the outcomes are measured. Seven studies used per-patient or per-episode cancer-specific spending in a hospital referral region or health care service area,^{30,31,32} two used per-patient total Medicare spending in an area,^{32,34} three used per capita health spending in a state,^{36,37} and one used the ratio of social to health spending in a state.³⁸ Nearly all studies (22 of 24) reported all-cause mortality

FIG 2. Empirical estimates of the association between spending and all-cause mortality of US patients with cancer. Twenty-two studies from 11 articles^{25-34,37} reported all-cause mortality. EOL, end of life.

for patients with cancer, with nine also reporting cancer-specific mortality.^{26,28,30,36-38} Most studies measured outcomes at the individual level, while four studies measured outcomes at the health care service area or state level.^{34,37,38}

Empirical evidence from these studies was mixed. Twelve of 22 studies found no significant association between spending and all-cause mortality of patients with cancer^{26,28-31,33,34} (Fig 2). Five studies found higher spending to be associated with lower all-cause mortality,^{26,33,37} while five found the opposite.^{25,27,29,32}

This distribution of spending-outcomes associations seemed to differ on the basis of whether the spending occurred at EOL (Fig 2). In the EOL setting, four of 11 studies found higher spending to be associated with higher all-cause mortality,^{25,27,29} one found the opposite,²⁶ and six found no association.^{26,28,29} In the non-EOL setting, a smaller proportion of studies (one of 11) found that higher spending is associated with worse outcomes,³² while a greater proportion (four of 11) found the opposite^{33,37} compared with the EOL setting.

For cancer-specific mortality, the majority of studies found either no association (four of nine)^{26,28,36} or higher spending to be associated with lower mortality (four of nine),^{26,37,38} with only one of nine finding higher spending to be associated with higher mortality²⁹ (Fig 3). The difference between EOL spending and non-EOL spending on cancer-specific mortality was similar to that for all-cause mortality, and in the non-EOL setting, a greater percentage (three of five studies)^{37,38} found higher spending to be associated with better outcomes compared with the EOL setting (one of four).²⁶

Key features of the best study design include longitudinal analysis of individual-level data, spending measured at the area level rather than at the individual level, spending adjusted for the price and case mix in an area, and attempts to control for patient characteristics as well as other factors

known to affect cancer outcomes. As a sensitivity analysis, we included 11 studies from five articles deemed to have a low risk of bias and found similar patterns as the entire sample^{25-27,31,33} (Fig 4).

The effect of spending on cancer outcomes can be summarized using the percentage change in mortality associated with a unit increase in spending. In a study of Medicare FFS beneficiaries with colorectal cancer, Fisher et al²⁵ found that a 10% increase in the EOL-EI in an area was associated with a 1.2% increase in the relative risk of death over 5 years. In a similar study using the same study sample, a 10% increase in EOL-EI was found to be associated with a 0.7% increase in long-term mortality rates.²⁷ In contrast, Keating et al²⁶ studied Medicare FFS and Veterans Health Administration patients with lung, prostate, or colon cancer, and found that a \$1,000 increase in EOL-EI was associated with an approximately 3% reduction in both all-cause and cancer-specific mortality at 1 year for Medicare FFS patients with lung cancer. No association was found for other cancer sites, and there was little variation in spending levels among Veterans Health Administration patients.²⁶ Similarly, Baumgardner et al³³ found that a \$10,000 increase in risk- and price-adjusted Medicare spending per oncology care episode was associated with a 7% and 13% lower hazard for lung cancer and multiple myeloma and that there was no association for advanced breast cancer, renal cell carcinoma, or chronic myeloid leukemia. Divi et al³² studied Medicare FFS beneficiaries with head and neck cancer and found that a \$10,000 increase in spending was associated with a 3% increase in hazard, although the spending measure in the study was neither price nor case mix adjusted.

Given the evidence that a significant amount of heterogeneity exists in the estimates of the spending-outcomes relationship, studies that examined the use of different types of care can provide additional insights. Landrum et al²⁸ found that in colorectal cancer, higher spending was associated with a higher likelihood of receiving both recommended and nonrecommended care. The benefits from increased use of recommended care may be offset by the increased use of nonrecommended care, and patient outcomes were similar across spending levels in that study. Similarly, Keating et al²⁶ found that higher spending was associated with higher use of both recommended care and care that was preference sensitive, such as chemotherapy for stage IV lung cancer and colorectal cancer and primary treatment of local/regional prostate cancer. These differences in use were translated into lower lung cancer mortality for the high-spending group but no difference in colorectal or prostate cancer mortality.²⁶ Other studies also found that higher spending was associated with a higher likelihood of inpatient services,^{29,39} more frequent specialist consultations,³⁹ more frequent tests and minor procedures,³⁹ and lower rates of hospice care.²⁹

FIG 3. Empirical estimates of the association between spending and cancer-specific mortality in the United States. Nine studies from six articles^{26,28,30,36-38} reported cancer-specific mortality. EOL, end of life.

Association Between Spending and Outcomes Outside the United States

Unlike studies from the United States, those conducted outside the United States have suggested that in most cases (eight of 11 studies), spending was associated with better cancer outcomes (Appendix Table A2). Three cross-sectional studies examined the effects of cancer program spending or National Health Service total spending per capita on standardized years of life lost or mortality of cancer in a primary care trust in England.^{24,40,41} These three studies attempted to address the selection bias in the spending-outcomes relationship by using instrumental variables (see Rassen et al⁴² for a description of instrumental variable analysis). Two found that higher spending was associated with better outcomes,^{24,40} while one did not find a significant association.⁴¹ A cross-sectional study from Poland found no association between per-patient spending on rectal

FIG 4. Empirical estimates of the association between spending and all-cause mortality of patients with cancer from US studies that were deemed of low risk of bias. Eleven studies from five articles^{25-27,31,33} were included. Cancer-specific mortality was not plotted because there were very few data points. EOL, end of life.

cancer and its 5-year survival in one province.⁴³ Of particular value in this group of studies is the individual-level longitudinal analyses. Chang et al⁴⁴ examined the effect of EOL-EI of a hospital on the 5-year mortality of patients with head and neck cancer, colorectal cancer, lung cancer, hepatoma, breast cancer, or prostate cancer in Taiwan. They found no association for head and neck cancer and a negative association between spending and all-cause mortality for the other five cancers. Similarly, Stukel et al⁴⁵ examined the relationship between EOL-EI of a hospital and short- and long-term mortality and readmission of patients with colon cancer in Ontario, Canada, and found higher spending to be associated with lower rates of all-cause mortality and readmission.

International Comparisons of Spending and Outcomes

Thirteen of 14 studies on country-level comparisons of spending and cancer outcomes found higher spending to be associated with better outcomes (Appendix Table A3). The expenditure measure was total national health expenditure in eight studies,⁴⁶⁻⁵³ public sector or government spending on health in three studies,⁵⁴⁻⁵⁶ per incident case cancer spending in two studies,^{3,57} and per capita cancer drug spending in one study.⁵⁸ Four studies included both developed and developing countries across five continents,⁴⁸⁻⁵¹ while the rest focused primarily on developed countries in North America and Europe.

Nine of 14 studies were cross-sectional, among which eight simply calculated the correlation between spending and cancer outcomes.^{46-50,52,53,58} Only one cross-sectional study adjusted for health, development, and economic indicators of a nation, such as gross domestic product and life expectancy, and was the only study that found higher spending to be associated with worse outcomes.⁵¹ Four studies on international comparisons used a time series design with country-level fixed effects, and all found higher spending to be associated with lower mortality.⁵⁴⁻⁵⁷

The most salient evidence on the cross-country comparisons comes from an individual-level, longitudinal analysis of cancer registries from 11 countries.³ The authors found that from 1995 to 1999, each \$20,000 increase in spending per patient with cancer was associated with an additional 2.3 years of life expectancy after diagnosis for the average patient with cancer.

Impact of Novel Care Delivery or Payment Models

We identified 11 studies that examined the impact of innovative care delivery or payment models on spending and outcomes in patients with cancer: five on care pathways,⁵⁹⁻⁶³ two on bundled payment,^{64,65} two on medical homes,^{66,67} one on accountable care organizations,⁶⁸ and one from the Physician Group Practice (PGP) Demonstration³⁵ (Appendix Table A4). The PGP was Medicare's first pay-for-performance demonstration, where PGPs earned incentive payments for providing high-quality, coordinated care that resulted in Medicare savings. Eight of 11 studies found

that these innovative models were associated with lower spending, with the reduction ranging from 4% to 57%,^{35,59,60,62,63,66,67} while the remaining three found no change or difference^{61,64,68} (Fig 5). Care pathways seemed to generate greater savings than other reforms, although this difference may be partly or entirely explained by the fact that all the care pathway studies used a prepost design without a control group and that three of five only examined short-term hospital spending.

Seven of 11 studies reported all-cause mortality for the study population, among which six found no change or difference.^{59,61-65} Colla et al³⁵ found that the PGP Demonstration was associated with a 5.6% reduction in all-cause mortality for Medicare FFS beneficiaries with cancer. A study of patients with breast cancer from Taiwan demonstrated that a bundled payment program was associated with an 18% reduction in hazard for event-free survival but no difference in overall survival.⁶⁴

One possible explanation for the fact that these reforms can lower spending without adversely affecting health outcomes is that the use of low-value care was reduced or care was shifted away from the inpatient or the emergency department (ED) settings. Borza et al⁶⁸ found that being treated by an accountable care organization–affiliated provider was associated with an 11% reduction in over-treatment among low-risk patients with prostate cancer, while the overall treatment rate among patients of all risk levels was not significantly different. Colla et al³⁵ found that savings in the PGP Demonstration were derived almost entirely from reductions in payment for inpatient stays. Similarly, both Newcomer et al⁶⁵ and Colligan et al⁶⁷ found that the rate of hospitalization in the alternative payment group was lower compared with the FFS group.

Furthermore, participation in oncology medical homes was associated with a 10% reduction in ED visits.⁶⁶

DISCUSSION

National and international differences in spending on cancer care have been a subject of considerable interest around the world in recent years. We reviewed studies that examined the relationship between spending and outcomes in cancer in the United States and internationally. The totality of evidence suggests that spending has a wide range of effects across countries and spending levels. Studies conducted within the United States, especially those that examined spending at EOL, more frequently found that higher spending was associated with worse outcomes or no association compared with similar studies from outside the United States or that examined non-EOL spending. When it comes to international comparisons of country-level spending and cancer outcomes, higher spending was almost always correlated with better outcomes.

The positive correlations from international comparisons may be due to the average patient in the United States having faster access to a greater number of innovative medicines and using more hospital and physician services compared with the average patient from other countries.^{16,69} Furthermore, some high-income European countries have explicit thresholds for willingness to pay for health that are lower than the implicit thresholds in the United States, which may limit the use of some very expensive, but marginally effective cancer therapies in those countries.⁷⁰

Within the United States, where the spending level is already high, the frequent lack of association, and in some

FIG 5. Empirical estimates of reduction in spending associated with an innovative care or payment model in cancer. Six articles examined overall spending,^{35,61,64-67} two articles examined cancer-related spending,^{59,68} and three articles examined hospital spending.^{60,62,63} ACO, accountable care organization; PGP, physician group practice.

cases the inverse association, between Medicare spending and cancer outcomes indicates that some of the spending in the highest-spending group is wasteful. A survey of physicians across the United States reported that approximately 20% of overall medical care was not needed, including 22% of prescription medications, 25% of tests, and 11% of procedures (see Lyu et al [Appendix, online only]). In cancer, the percentages are likely higher because the high mortality rate of the disease compels physicians and patients to try treatments of marginal benefit.

The existence of wasteful spending in cancer care is further illustrated by findings from studies that evaluated the financial and health impacts of alternative care delivery or payment models in cancer. The majority of studies have shown that these reforms can lower spending without adversely affecting important health outcomes, at least in the short term.^{35,59,60,62,63,66,67} Some studies even demonstrated that certain outcomes were improved, even though spending was curbed.^{35,64} Although the exact services that were wasteful were not always identified and data on the long-term effects are lacking for many, these early results suggest that in nearly all settings, opportunities exist for some cost savings.

One particularly promising practice redesign is the PGP Demonstration, where one evaluation found that cost savings were achieved with improved mortality.³⁵ The participating PGPs engaged in a wide variety of care management interventions, many of which aimed to reduce avoidable ED visits, hospital admissions, and readmissions and improve transition from inpatient to outpatient care (see Kautter et al [Appendix]). It is not surprising that the PGP Demonstration resulted in a spending reduction concentrated in acute care payments. However, the reduced hospital admissions may not be the main source for the improved mortality, and the interventions that have resulted in lower mortality remain unknown. Furthermore, the evaluation revealed that despite the overall spending reduction, cancer-specific spending on procedures and chemotherapies were not reduced, which suggests that changes were not made in treatment decisions for cancer. Therefore, the cost savings may come from more efficient management of comorbidities.

In the studies where higher spending was found to be associated with better outcomes, one might ask whether the additional survival is worth the cost. In a study of the United States and European countries, Philipson et al³ found that an approximately \$20,000 increase in spending per patient with cancer was associated with an additional 2.3 years of life expectancy after diagnosis, which equals \$8,696 per life-year gained. Even with the reduced quality of life accounted for, the incremental cost per quality-adjusted life-year (QALY) gained is likely well below the suggested range of thresholds between \$50,000 and \$200,000 per QALY for being cost effective^{7,2,5} (see also Neumann et al [Appendix]). In

Soneji and Yang (Appendix), an ecological analysis with more recent data (1999 to 2007) showed that the incremental cost per QALY gained in the United States compared with Western Europe equaled \$402,000 for breast cancer, \$110,000 for colorectal cancer, and \$1,929,000 for prostate cancer. For lung cancer, the United States had lower QALY despite additional spending (–\$19,000 per QALY gained). Baumgardner et al³³ estimated that the cost per QALY for cancer spending was between \$160,000 and \$228,000 for lung cancer and approximately \$69,000 for multiple myeloma.

One challenge of these types of analyses is the selection bias in the spending-outcomes relationship, where sicker patients have both higher spending and worse outcomes. To address this, several studies measured risk-adjusted EOL spending at the area level with the goal of capturing geographic variations in practice patterns rather than the differences in case mix or patient preferences.^{25-27,29,44,45} Furthermore, in cancers identified by screening, lead-time bias may be present. By early detection through screening, lead time can artificially inflate the perceived survival and may increase the spending because the period of treatment changes. The direction of bias depends on the relative change between survival and spending. For cross-country comparisons, most studies were fraught with methodological problems, such as omitted variables and lack of panel data. As a result, inferences about a causal relationship should be made with great caution.

Several key research issues remain unresolved. Most notably, there was a lack of data on the quality of life of patients with cancer. Research so far has focused almost exclusively on overall or cancer-specific survival. Although many studies included in this review failed to demonstrate a positive association between spending and survival, higher spending could be linked to higher quality of life in some patients. For example, psychological distress is common among patients with advanced cancer and is highly treatable, yet affected individuals have low rates of using mental health services (see Adler and Page and Kadan-Lottick et al [Appendix]). In this case, patients may benefit from the practice styles in high-spending regions by receiving an earlier diagnosis and better treatment of their mental health problems, which may in turn improve their quality of life. It is also possible, however, that increased intensity of treatment could lead to poorer quality of life when the benefit of the treatment is outweighed by its risk (Eaton et al; Appendix). This is especially important in cancer, where many of the pharmacologic therapies have significant toxicity.

In addition, more research is needed to identify wasteful care in cancer. Several studies have linked higher spending with worse survival in colorectal, breast, and prostate cancer but stopped short of identifying the marginal use that led to higher mortality.^{25,27,29} Studies on alternative care delivery or payment models in oncology have demonstrated that these reforms can lower spending without

worsening health outcomes,^{35,59,60,62,63,65-67} and most of them have pointed to reduced use of inpatient care and ED visits as the driver for reductions in overall spending.^{35,65-68} However, not all hospitalizations and ED visits are excessive, and these studies offered little insight into what type of inpatient and ED care was reduced. Similarly, for international comparisons, an area for future research is to understand the different treatment patterns for cancer across different countries, which may drive both spending and outcomes (see Benitez Majano et al [Appendix]).

In conclusion, we found a varied relationship between spending and outcomes in cancer. International comparisons and research outside the United States consistently found an association between higher spending and lower mortality. However, in the United States, higher spending did not always produce better outcomes, especially when relying on measures of EOL care. Studies of alternative care delivery or payment models indicated that lower spending is achievable without adversely affecting outcomes, with the best results coming from efforts to limit expensive hospital use.

AFFILIATIONS

¹Leonard D. Schaeffer Center for Health Policy and Economics, University of Southern California, Los Angeles, CA

²Sol Price School of Public Policy, University of Southern California, Los Angeles, CA

³School of Pharmacy, University of Southern California, Los Angeles, CA

CORRESPONDING AUTHOR

Dana P. Goldman, PhD, Schaeffer Center for Health Policy and Economics, University of Southern California, Verna & Peter Dauterive Hall, 635 Downey Way, Los Angeles, CA 90089-3333; Twitter: @SchaefferCenter; e-mail: dana.goldman@usc.edu.

SUPPORT

Supported by the National Institute on Aging of the National Institutes of Health under award numbers P30AG043073, P30AG024968, and P01AG033559. The content is solely the responsibility of the authors

and does not necessarily represent the official views of the National Institutes of Health.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST AND DATA AVAILABILITY STATEMENT

Disclosures provided by the authors and data availability statement (if applicable) are available with this article at DOI <https://doi.org/10.1200/JCO.19.01451>.

AUTHOR CONTRIBUTIONS

Conception and design: All authors

Financial support: Dana P. Goldman

Collection and assembly of data: Meng Li

Data analysis and interpretation: All authors

Manuscript writing: All authors

Final approval of manuscript: All authors

Accountable for all aspects of the work: All authors

REFERENCES

- Garber A, Goldman DP, Jena AB: The promise of health care cost containment. *Health Aff (Millwood)* 26:1545-1547, 2007
- Papanicolas I, Woskie LR, Jha AK: Health care spending in the United States and other high-income countries. *JAMA* 319:1024-1039, 2018
- Philipson T, Eber M, Lakdawalla DN, et al: An analysis of whether higher health care spending in the United States versus Europe is 'worth it' in the case of cancer. *Health Aff (Millwood)* 31:667-675, 2012
- Cutler DM, McClellan M: Is technological change in medicine worth it? *Health Aff (Millwood)* 20:11-29, 2001
- Cutler DM, Rosen AB, Vijan S: The value of medical spending in the United States, 1960-2000. *N Engl J Med* 355:920-927, 2006
- Woodward RM, Brown ML, Stewart ST, et al: The value of medical interventions for lung cancer in the elderly: Results from SEER-CMHSF. *Cancer* 110:2511-2518, 2007
- Fisher ES, Wennberg JE, Stukel TA, et al: Associations among hospital capacity, utilization, and mortality of US Medicare beneficiaries, controlling for sociodemographic factors. *Health Serv Res* 34:1351-1362, 2000
- Philipson TJ, Seabury S, Lockwood L, et al: Geographic variation in health care: The role of private markets. *Brookings Pap Econ Act* 41:325-361, 2010
- Reinhardt UE, Hussey PS, Anderson GF: U.S. health care spending in an international context. *Health Aff (Millwood)* 23:10-25, 2004
- Anderson GF, Frogner BK, Reinhardt UE: Health spending in OECD countries in 2004: An update. *Health Aff (Millwood)* 26:1481-1489, 2007
- Nolte E, McKee CM: In amenable mortality--deaths avoidable through health care--progress in the US lags that of three European countries. *Health Aff (Millwood)* 31:2114-2122, 2012
- Bezruchka S: The hurrier I go the behinder I get: The deteriorating international ranking of U.S. health status. *Annu Rev Public Health* 33:157-173, 2012
- Kanavos P, Ferrario A, Vondoros S, et al: Higher US branded drug prices and spending compared to other countries may stem partly from quick uptake of new drugs. *Health Aff (Millwood)* 32:753-761, 2013
- Laugesen MJ, Glied SA: Higher fees paid to US physicians drive higher spending for physician services compared to other countries. *Health Aff (Millwood)* 30:1647-1656, 2011
- Thorpe KE, Howard DH, Galactionova K: Differences in disease prevalence as a source of the U.S.-European health care spending gap. *Health Aff (Millwood)* 26:w678-w686, 2007
- Squires DA: Explaining high health care spending in the United States: An international comparison of supply, utilization, prices, and quality. *Issue Brief (Commonw Fund)* 10:1-14, 2012
- Coleman MP, Quaresma M, Berrino F, et al: Cancer survival in five continents: A worldwide population-based study (CONCORD). *Lancet Oncol* 9:730-756, 2008
- National Cancer Institute: Cancer Trends Progress Report: Financial Burden of Cancer Care, 2019. https://progressreport.cancer.gov/after/economic_burden
- Brown ML, Lipscomb J, Snyder C: The burden of illness of cancer: Economic cost and quality of life. *Annu Rev Public Health* 22:91-113, 2001

20. Mariotto AB, Yabroff KR, Shao Y, et al: Projections of the cost of cancer care in the United States: 2010-2020. *J Natl Cancer Inst* 103:117-128, 2011
21. Aviki EM, Schleicher SM, Mullangi S, et al: Alternative payment and care-delivery models in oncology: A systematic review. *Cancer* 124:3293-3306, 2018
22. Li P, Jahnke J, Pettit AR, et al: Comparative survival associated with use of targeted vs nontargeted therapy in Medicare patients with metastatic renal cell carcinoma. *JAMA Netw Open* 2:e195806, 2019
23. Prigerson HG, Bao Y, Shah MA, et al: Chemotherapy use, performance status, and quality of life at the end of life. *JAMA Oncol* 1:778-784, 2015
24. Martin S, Rice N, Smith PC: Does health care spending improve health outcomes? Evidence from English programme budgeting data. *J Health Econ* 27: 826-842, 2008
25. Fisher ES, Wennberg DE, Stukel TA, et al: The implications of regional variations in Medicare spending. Part 2: Health outcomes and satisfaction with care. *Ann Intern Med* 138:288-298, 2003
26. Keating NL, Landrum MB, Lamont EB, et al: Area-level variations in cancer care and outcomes. *Med Care* 50:366-373, 2012
27. Fisher ES, Wennberg DE, Stukel TA, et al: Variations in the longitudinal efficiency of academic medical centers. *Health Aff (Millwood)* 23:VAR19-32, 2004
28. Landrum MB, Meara ER, Chandra A, et al: Is spending more always wasteful? The appropriateness of care and outcomes among colorectal cancer patients. *Health Aff (Millwood)* 27:159-168, 2008
29. Brooks GA, Li L, Sharma DB, et al: Regional variation in spending and survival for older adults with advanced cancer. *J Natl Cancer Inst* 105:634-642, 2013
30. Skolarus TA, Ye Z, Zhang S, et al: Regional differences in early stage bladder cancer care and outcomes. *Urology* 76:391-396, 2010
31. Tannenbaum S, Soulos PR, Herrin J, et al: Regional Medicare expenditures and survival among older women with localized breast cancer. *Med Care* 55: 1030-1038, 2017
32. Divi V, Tao L, Whittemore A, et al: Geographic variation in Medicare treatment costs and outcomes for advanced head and neck cancer. *Oral Oncol* 61:83-88, 2016
33. Baumgardner J, Shahabi A, Linthicum M, et al: Greater spending associated with improved survival for some cancers in OCM-defined episodes. *J Manag Care Spec Pharm* 24:504-513, 2018
34. Hassett MJ, Neville BA, Weeks JC: The relationship between quality, spending and outcomes among women with breast cancer. *J Natl Cancer Inst* 106:dju242, 2014
35. Colla CH, Lewis VA, Gottlieb DJ, et al: Cancer spending and accountable care organizations: Evidence from the Physician Group Practice Demonstration. *Healthc (Amst)* 1:100-107, 2013
36. Kim D: The associations between US state and local social spending, income inequality, and individual all-cause and cause-specific mortality: The National Longitudinal Mortality Study. *Prev Med* 84:62-68, 2016
37. Chahoud J, Semaan A, Rieber A: Wealth, health expenditure, and cancer: A national perspective. *J Natl Compr Canc Netw* 14:972-978, 2016
38. Bradley EH, Canavan M, Rogan E, et al: Variation in health outcomes: The role of spending on social services, public health, and health care, 2000-09. *Health Aff (Millwood)* 35:760-768, 2016
39. Fisher ES, Wennberg DE, Stukel TA, et al: The implications of regional variations in Medicare spending. Part 1: The content, quality, and accessibility of care. *Ann Intern Med* 138:273-287, 2003
40. Martin S, Rice N, Smith PC: Comparing costs and outcomes across programmes of health care. *Health Econ* 21:316-337, 2012
41. Claxton K, Lomas J, Martin S: The impact of NHS expenditure on health outcomes in England: Alternative approaches to identification in all-cause and disease specific models of mortality. *Health Econ* 27:1017-1023, 2018
42. Rassen JA, Brookhart MA, Glynn RJ, et al: Instrumental variables I: Instrumental variables exploit natural variation in nonexperimental data to estimate causal relationships. *J Clin Epidemiol* 62:1226-1232, 2009
43. Herman KJ, Komorowski AL, Wysocki WM, et al: Variation in treatment modalities, costs and outcomes of rectal cancer patients in Poland. *Contemp Oncol (Pozn)* 19:400-409, 2015
44. Chang T-S, Huang K-Y, Chang C-M, et al: The association of hospital spending intensity and cancer outcomes: A population-based study in an Asian country. *Oncologist* 19:990-998, 2014
45. Stukel TA, Fisher ES, Alter DA, et al: Association of hospital spending intensity with mortality and readmission rates in Ontario hospitals. *JAMA* 307:1037-1045, 2012
46. Pritchard C, Hickish T: Changes in cancer incidence and mortality in England and Wales and a comparison of cancer deaths in the major developed countries by age and sex 1979-2002 in context of GDP expenditure on health. *Ecanermedicalscience* 2:80, 2008
47. Evans BT, Pritchard C: Cancer survival rates and GDP expenditure on health: A comparison of England and Wales and the USA, Denmark, Netherlands, Finland, France, Germany, Italy, Spain and Switzerland in the 1990s. *Public Health* 114:336-339, 2000
48. Wang S-C, Sung W-W, Kao Y-L, et al: The gender difference and mortality-to-incidence ratio relate to health care disparities in bladder cancer: National estimates from 33 countries. *Sci Rep* 7:4360, 2017
49. Wang C-C, Tsai M-C, Peng C-M, et al: Favorable liver cancer mortality-to-incidence ratios of countries with high health expenditure. *Eur J Gastroenterol Hepatol* 29:1397-1401, 2017
50. Chen S-L, Wang S-C, Ho C-J, et al: Prostate Cancer mortality-to-incidence ratios are associated with cancer care disparities in 35 countries. *Sci Rep* 7:40003, 2017
51. Neupane S, Bray F, Auvinen A: National economic and development indicators and international variation in prostate cancer incidence and mortality: An ecological analysis. *World J Urol* 35:851-858, 2017
52. Ades F, Senterre C, de Azambuja E, et al: Discrepancies in cancer incidence and mortality and its relationship to health expenditure in the 27 European Union member states. *Ann Oncol* 24:2897-2902, 2013
53. Gatta G, Trama A, Capocaccia R: Variations in cancer survival and patterns of care across Europe: Roles of wealth and health-care organization. *J Natl Cancer Inst Monogr* 2013:79-87, 2013
54. Maruthappu M, Watson RA, Watkins J, et al: Unemployment, public-sector healthcare expenditure and colorectal cancer mortality in the European Union: 1990-2009. *Int J Public Health* 61:119-130, 2016
55. Maruthappu M, Painter A, Watkins J, et al: Unemployment, public-sector healthcare spending and stomach cancer mortality in the European Union, 1981-2009. *Eur J Gastroenterol Hepatol* 26:1222-1227, 2014
56. Maruthappu M, Watkins JA, Waqar M, et al: Unemployment, public-sector health-care spending and breast cancer mortality in the European Union: 1990-2009. *Eur J Public Health* 25:330-335, 2015
57. Stevens W, Philipson TJ, Khan ZM, et al: Cancer mortality reductions were greatest among countries where cancer care spending rose the most, 1995-2007. *Health Aff (Millwood)* 34:562-570, 2015

58. Vrdoljak E, Bodoky G, Jassem J, et al: Expenditures on oncology drugs and cancer mortality-to-incidence ratio in central and eastern Europe. *Oncologist* 24:e30-e37, 2019
59. Jackman DM, Zhang Y, Dalby C, et al: Cost and survival analysis before and after implementation of Dana-Farber clinical pathways for patients with stage IV non-small-cell lung cancer. *J Oncol Pract* 13:e346-e352, 2017
60. Kreys ED, Koeller JM: Documenting the benefits and cost savings of a large multistate cancer pathway program from a payer's perspective. *J Oncol Pract* 9:e241-e247, 2013
61. Kobayashi ST, Diz MDPE, Campolina AG, et al: Integrated care pathway for rectal cancer treatment: Health care resource utilization, costs, and outcomes. *Int J Evid-Based Healthc* 15:53-62, 2017
62. Zhu L, Li J, Li X-K, et al: Impact of a clinical pathway on hospital costs, length of stay and early outcomes after hepatectomy for hepatocellular carcinoma. *Asian Pac J Cancer Prev* 15:5389-5393, 2014
63. So JBY, Lim ZL, Lin H-A, et al: Reduction of hospital stay and cost after the implementation of a clinical pathway for radical gastrectomy for gastric cancer. *Gastric Cancer* 11:81-85, 2008
64. Wang CJ, Cheng SH, Wu J-Y, et al: Association of a bundled-payment program with cost and outcomes in full-cycle breast cancer care. *JAMA Oncol* 3:327-334, 2017
65. Newcomer LN, Gould B, Page RD, et al: Changing physician incentives for affordable, quality cancer care: Results of an episode payment model. *J Oncol Pract* 10:322-326, 2014
66. Waters TM, Kaplan CM, Graetz I, et al: Patient-centered medical homes in community oncology practices: Changes in spending and care quality associated with the COME HOME experience. *J Oncol Pract* 15:e56-e64, 2019
67. Colligan EM, Ewald E, Ruiz S, et al: Innovative oncology care models improve end-of-life quality, reduce utilization and spending. *Health Aff (Millwood)* 36:433-440, 2017
68. Borza T, Kaufman SR, Yan P, et al: Early effect of Medicare Shared Savings Program accountable care organization participation on prostate cancer care. *Cancer* 124:563-570, 2018
69. Danzon PM, Wang YR, Wang L: The impact of price regulation on the launch delay of new drugs--evidence from twenty-five major markets in the 1990s. *Health Econ* 14:269-292, 2005
70. Braithwaite RS, Meltzer DO, King JTJ, Jr., et al: What does the value of modern medicine say about the \$50,000 per quality-adjusted life-year decision rule? *Med Care* 46:349-356, 2008

ASCO Immuno-Oncology Program

Use this eLearning program for an overview of immunobiology along with in-depth topics including treatment, efficacy, monitoring, and the management of immunobiologic agents. Composed of 6 sections that are each designed to be completed in 15 minutes, users will gain greater competence in the areas of immunobiology, predictive biomarkers, clinical activity, and more. MOC, CME, nursing, and pharmacy CE available.

Learn more at elearning.asco.org/coursecollection/immuno-oncology

This course is part of ASCO eLearning Essentials and Advanced Practitioner Certificate Programs.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Association Between Spending and Outcomes for Patients With Cancer

The following represents disclosure information provided by authors of this manuscript. All relationships are considered compensated unless otherwise noted. Relationships are self-held unless noted. I = Immediate Family Member, Inst = My Institution. Relationships may not relate to the subject matter of this manuscript. For more information about ASCO's conflict of interest policy, please refer to www.asco.org/rwc or ascopubs.org/journal/jco/site/ifc.

Open Payments is a public database containing information reported by companies about payments made to US-licensed physicians ([Open Payments](#)).

Darius N. Lakdawalla

Other Relationship: Precision Health Economics

Dana P. Goldman

Stock and Other Ownership Interests: Precision Health Economics

Honoraria: ACADIA Pharmaceuticals, Aspen Institute, Celgene

Consulting or Advisory Role: Precision Health Economics

Research Funding: Schaeffer Center for Health Policy & Economics (Inst)

No other potential conflicts of interest were reported.

APPENDIX

See also Lyu H, et al: PLoS One 12:e0181970, 2017; Kautter J, et al: Health Care Financ Rev 29:15-29, 2007; Soneji S, et al: Health Aff (Millwood) 34:390-397, 2015; Neumann PJ, et al: N Engl J Med 371: 796-797, 2014; Adler N, et al: Cancer Care for the Whole Patient: Meeting Psychosocial Health Needs, 2008; Kadan-Lottick NS, et al: Cancer 104:2872-2881, 2005; Eaton KD, et al: Oncologist 21:903-906, 2016; Benitez Majano S, et al: Lancet Oncol 20:74-87, 2019.

TABLE A1. Studies Conducted in the United States That Examined the Relationship Between Spending and Outcomes of Patients With Cancer

First Author	Cancer Type	Study Design	Study Population	Expenditure Measure	Outcome Measure	Summary Findings*
Fisher ²⁵	Colorectal	Longitudinal, individual level	195,429 Medicare FFS beneficiaries diagnosed in 1993-1995	EOL-EI of an HRR (quintile and continuous)†	All-cause mortality	A 10% increase in the EOL-EI associated with 1.2% increase in relative risk of death over 5 years
Keating ²⁶	Lung, prostate, colorectal‡	Longitudinal, individual level	Medicare FFS and VA patients diagnosed in 1993-1995	EOL-EI of an HRR (quintile and continuous)†	All-cause and cancer-specific mortality	A \$1,000 increase in spending associated with a 2.8% reduction in 1-year all-cause mortality and a 3.1% reduction in lung cancer-specific mortality for Medicare patients with lung cancer; no association for others
Fisher ²⁷	Colorectal	Longitudinal, individual level	195,429 Medicare FFS beneficiaries diagnosed in 1993-1995	EOL-EI of an HRR (quintile and continuous)†	All-cause mortality	A 10% increase in EOL-EI associated with a 0.7% increase in mortality
Landrum ²⁸	Colorectal	Longitudinal, individual level	55,549 Medicare FFS beneficiaries diagnosed in 1992-1999	EOL-IEI of an HRR (quintile)§	All-cause, cancer-specific, and noncancer mortality	No association for all-cause or cancer-specific mortality; positive association for noncancer mortality
Brooks ²⁹	Advanced lung, colorectal, pancreatic, breast, prostate‡	Longitudinal, individual level	61,083 Medicare FFS diagnosed in 2002-2007 and 98,935 who died as a result of cancer in 2002-2007	Case mix-adjusted mean 6-month spending for advanced cancer for a decedent cohort in an HRR (quintile)	All-cause mortality	Positive association for breast and prostate cancer; no association for others
Skolarus ³⁰	Early-stage bladder	Longitudinal, individual level	20,328 Medicare FFS beneficiaries diagnosed in 1992-2002	Price-adjusted per capita 24-month Medicare payment for bladder cancer in an HSA (quartiles)	All-cause and cancer-specific mortality	No association for all-cause mortality; positive association for cancer-specific mortality
Tannenbaum ³¹	Localized breast	Longitudinal, individual level	12,610 Medicare FFS beneficiaries diagnosed in 2005-2008	Risk- and price-adjusted per-patient breast cancer-related Medicare payment 2 months before and 12 months after the diagnosis in an HRR (quintile)	All-cause mortality	No association

(continued on following page)

TABLE A1. Studies Conducted in the United States That Examined the Relationship Between Spending and Outcomes of Patients With Cancer (continued)

First Author	Cancer Type	Study Design	Study Population	Expenditure Measure	Outcome Measure	Summary Findings*
Divi ³²	Advanced head and neck	Longitudinal, individual level	3,678 Medicare FFS beneficiaries diagnosed in 2004-2009	Per-patient total Medicare payment 3 months before and 12 months after the diagnosis in a SEER registry (continuous)	All-cause mortality	A \$10,000 increase in spending associated with a 3% increase in hazard
Baumgardner ³³	Advanced breast, and lung; RCC; MM; CML‡	Longitudinal, individual level	21,881 Medicare FFS beneficiaries diagnosed in 2007-2011	Risk- and price-adjusted Medicare spending (A,B, and D) per OCM-defined episode in an HRR (continuous)	All-cause mortality	A \$10,000 increase in spending associated with 7% and 13% lower hazard for lung cancer and MM, respectively; no association for others
Hassett ³⁴	Stage 0-III breast	Cross-sectional, area level	15,357 Medicare FFS beneficiaries diagnosed in 1997-2005	Median per-patient total Medicare expenditure in the year after diagnosis in an HSA (quintile)	All-cause mortality in an HSA	No association
Kim ³⁶	Colon	Repeated cross-sectional with instrumental variable and state fixed effects, individual level	431,637 noninstitutionalized Americans in 1979-1987	State and local public spending per capita on health (continuous)	Cancer-specific mortality	No association
Bradley ³⁸	Lung	Time series with lagged exposure, area level	Residents in 51 states in 2000-2009	Ratio of social to health spending in a state	Cancer-specific mortality in a state	Negative association
Chahoud ³⁷	Any, breast, colorectal‡	Cross-sectional, area level	Residents in 50 states in 2009-2010	Per capita health expenditure in a state (continuous)	All-cause, cancer-specific mortality, MIR in a state	Negative correlation for all

Abbreviations: CML, chronic myeloid leukemia; EI, expenditure index; EOL, end of life; FFS, fee-for-service; HRR, hospital referral region; HSA, health care service area; IEI, inpatient expenditure index; MIR, mortality-to-incidence ratio; MM, multiple myeloma; OCM, oncology care model; RCC, renal cell carcinoma; VA, Veterans Health Administration.

*Change in mortality associated with a unit increase in spending was extracted if reported in the study.

†EOL-EI was age-, sex-, race-, and price-adjusted spending on hospital and physician services.

‡Analysis was performed separately for each cancer, and each analysis was treated as a separate study.

§EOL-IEI was price-adjusted inpatient spending in this study.

TABLE A2. Studies Conducted Outside the United States That Examined the Relationship Between Spending and Outcomes of Patients With Cancer

First Author	Region	Cancer Type	Study Design	Study Population	Expenditure Measure	Outcome Measure	Summary Findings
Martin ²⁴	United Kingdom	Any	Cross-sectional with instrumental variables, area level	Residents in England in 2004-2005	Spending per capita in the cancer program in a PCT (continuous)	Standardized years of life lost and mortality as a result of cancer	Negative association for both
Martin ⁴⁰	United Kingdom	Any	Cross-sectional with instrumental variables, area level	Residents in England in 2005-2006	Spending per capita in the cancer program in a PCT (continuous)	Standardized years of life lost and mortality as a result of cancer	Negative association for both
Claxton ⁴¹	United Kingdom	Any	Cross-sectional with instrumental variables, area level	Residents in England in 2005-2006	NHS total and cancer program spending per capita in a PCT (continuous)	Standardized years of life lost as a result of cancer	No association
Herman ⁴³	Poland	Rectal	Cross-sectional, area level	All patients with rectal cancer diagnosed in 2005-2007	Per-patient cost of rectal cancer in a province (continuous)	5-year survival in a province	No association
Stukel ⁴⁵	Canada	Colon	Longitudinal, individual level	Patients with incident cancer with surgical resection in 1998-2008	EOL-EI of a hospital (tertile)*	30-day and 1-year all-cause mortality, readmission of individual patients with cancer	Negative association for all
Chang ⁴⁴	Taiwan	Colorectal, head and neck, lung, breast, and prostate and hepatoma†	Longitudinal, individual level	Patients with incident cancers who received surgery in 2002	EOL-EI of a hospital (tertile)*	5-year all-cause mortality of individual patients with cancer	No association for head and neck cancer; negative association for others

Abbreviations: EI, expenditure index; EOL, end of life; NHS, National Health Service; PCT, primary care trust.

*EOL-EI was age-, sex-, race-, and price-adjusted spending on hospital and physician services.

†Analysis was performed separately for each cancer, and each analysis was treated as a separate study.

TABLE A3. International Comparisons of Spending and Cancer Outcomes in a Country

First Author	Cancer Type	Study Design	Study Population/Country	Expenditure Measure	Outcome Measure	Summary Findings
Pritchard ⁴⁶	Any	Repeated cross-sectional, country level	United States and nine other developed countries in 1979-2002	Total national health expenditure (% GDP)	Cancer deaths	Negative correlation
Evans ⁴⁷	Any	Cross-sectional, country level	United States and nine other developed countries in 1980-1995	Total national health expenditure (% GDP)	5-year survival	Positive correlation
Wang ⁴⁹	Liver	Cross-sectional, country level	United States and 28 developed and developing countries in 2012	Total national health expenditure (% GDP)	MIR	Negative correlation
Wang ⁴⁸	Bladder	Cross-sectional, country level	United States and 32 developed and developing countries in 2012	Total national health expenditure (% GDP)	MIR	Negative correlation
Chen ⁵⁰	Prostate	Cross-sectional, country level	United States and 34 developed and developing countries in 2012	Total national health expenditure (% GDP)	MIR	Negative correlation
Neupane ⁵¹	Prostate	Cross-sectional, country level	United States and 48 developed and developing countries in 2003-2007	Total national health expenditure (% GDP)	Prostate cancer mortality per 100,000	Positive association
Ades ⁵²	Any	Cross-sectional, country level	27 European Union states in 2008	Total national health expenditure (% GDP, per capita)	MIR	Negative correlation
Gatta ⁵³	Any	Cross-sectional, country level	18 European countries in 2000-2002	Total national health expenditure	5-year survival	Positive correlation
Maruthappu ⁵⁵	Stomach	Time series with fixed effects, country level	25 European Union states in 1981-2009	Public sector health expenditure (% GDP)	Stomach cancer mortality per 100,000	Negative association
Maruthappu ⁵⁶	Breast	Time series with fixed effects, country level	27 European Union states in 1990-2009	Public sector health expenditure (% GDP)	Breast cancer mortality per 100,000	Negative association
Maruthappu ⁵⁴	Colorectal	Time series with fixed effects, country level	27 European Union states in 1990-2009	Government health expenditure (% GDP)	Colorectal cancer mortality per 100,000	Negative association
Philipson ³	13 cancers	Longitudinal, individual level, and time series, country level	United States and 10 European countries in 1983-1999	Per incident case cancer spending	All-cause mortality, survival gains	Negative association
Stevens ⁵⁷	Any	Time series with fixed effects, country level	United States and 15 other OECD countries in 1995-2007	Per incident case cancer spending	Amenable and excess mortality per 100,000	Negative association
Vrdoljak ⁵⁸	Any	Cross-sectional, country level	European countries	Per capita cancer drug spending	MIR	Negative correlation

Abbreviations: GDP, gross domestic product; MIR: mortality-to-incidence ratio; OECD, Organization for Economic Cooperation and Development.

TABLE A4. Studies That Examined the Impact of an Innovative Care or Payment Model on the Spending and Outcomes of Patients With Cancer

First Author	Payment or Care Model	Region	Cancer Type	Study Design	Study Population	Exposure or Intervention	Outcome Measures	Summary Findings
Wang ⁶⁴	Bundled payment	Taiwan	Breast	Longitudinal, individual level	17,940 patients with incident cancer in 2004-2008	Participation in the program	5-year medical payment per patient, event-free survival, overall survival	No change in spending or overall survival, 18% reduction in hazard for event-free survival
Newcomer ⁶⁵	Episode payment	United States	Breast, colon, and lung	Difference in difference, individual level	810 UnitedHealthcare beneficiaries in 2006-2012	Participation in the program	Total medical spending of a medical group, mortality as a result of lung cancer	34% reduction in spending, no change in mortality
Colla ³⁵	Physician group practice demonstration	United States	Any	Difference in difference, individual level	988,781 Medicare FFS beneficiaries with cancer in 2001-2009	Participation in the demonstration	Medicare spending per patient with cancer annually, annual mortality	3.9% reduction in cancer spending per patient and 5.6% reduction in mortality
Borza ⁶⁸	ACO	United States	Prostate	Difference in difference, individual level	33,011 Medicare FFS male beneficiaries with incident cancer in 2010-2013	Participation in an ACO	Annual prostate cancer-related payment, treatment rate, overtreatment rate	No change in spending or overall treatment, 11% reduction in overtreatment
Waters ⁶⁶	Oncology medical homes	United States	Breast, lung, colorectal, thyroid, pancreatic; lymphoma; melanoma	Difference in difference, individual level	Medicare FFS beneficiaries diagnosed in 2011-2015	Participation in medical homes	6-month medical spending per beneficiary, ED visits, hospitalizations, readmissions	8% reduction in 6-month spending, 10% reduction in ED visits per 1,000 patients, no change in other outcomes
Colligan ⁶⁷	Oncology medical homes	United States	Breast, lung, colorectal, genitourinary, head and neck; lymphoma	Longitudinal, individual level	1,244 Medicare FFS beneficiaries in 2012-2015 and died before the end of 2015	Participation in medical homes	Per-person Medicare cost in the last 30, 90, and 180 days of life, use of hospitalization, hospice, and chemotherapy in the last 2 weeks of life	6.3%, 11.4%, and 12.6% reduction in cost in the last 30, 90, and 180 days of life, respectively; 30% reduction in hospitalization in the last 30 days; no change in hospice or chemotherapy
Jackman ⁵⁹	Oncology care pathway	United States	Lung	Prepost, individual level	370 Dana-Farber patients diagnosed in 2012-2014	After implementation of a pathway	1-year per-patient spending on cancer care, 1-year mortality	25% reduction in spending, no change in mortality
Kreys ⁶⁰	Oncology care pathway	United States	Breast, lung, colorectal	Prepost, site level	4,713 CareFirst Blue Cross Blue Shield beneficiaries with cancer in 2007-2011	After implementation of a pathway	Per-patient hospital costs of a site, number of hospitalizations	57% reduction in hospital cost, no change in other outcomes

(continued on following page)

TABLE A4. Studies That Examined the Impact of an Innovative Care or Payment Model on the Spending and Outcomes of Patients With Cancer (continued)

Payment or Care Model		Region	Cancer Type	Study Design	Study Population	Exposure or Intervention	Outcome Measures	Summary Findings
First Author	Kobayashi ⁶¹	Brazil	Rectal	Prepost, individual level	330 consecutive patients admitted to a hospital in 2008-2013	After implementation of a pathway	Per-patient cost, mortality	No change in either
	Zhu ⁶²	China	Hepatocellular carcinoma	Prepost, individual level	133 patients diagnosed in 2012-2013 in a hospital	After implementation of a pathway	Hospital cost, mortality, postoperative complications	20% decrease in hospital cost, no change in other outcomes
First Author	So ⁶³	Singapore	Gastric	Prepost, individual level	115 consecutive patients undergoing gastrectomy in 2000-2005	After implementation of a pathway	Hospital cost, hospital mortality, complication rate, 30-day readmission rate	23% reduction in hospital cost, no change in other outcomes

Abbreviations: ACO, accountable care organization; ED, emergency department; FFS, fee for service.