Supplementary Online Content

Mitchell AP, Rotter JS, Patel E, et al. Association between reimbursement incentives and physician practice in oncology: a systematic review. *JAMA Oncol*. Published online January 3, 2019. doi:10.1001/jamaoncol.2018.6196

This supplementary material has been provided by the authors to give readers additional information about their work.

eAppendix. Search Terms

Pubmed/MEDLINE:
(fees and charges[mesh] OR "Reimbursement, Incentive"[Mesh] OR "Physician Incentive Plans"[Mesh] OR reimburs*[tiab] OR capitation fee[mesh] OR incentive*[tiab] OR “pay for performance” OR “incentive reimbursement” OR “incentive reimbursements” OR "fee-for-service" OR “fee for service” OR fee for service plans[mesh] OR unnecessary procedures[mesh] OR physician self-referral[mesh] OR capitation[tiab] OR reimbursement mechanisms[mesh] OR insurance claim review[mesh]) AND (provider* OR physician* OR physicians[mesh] OR practice patterns, physicians'[mesh] OR physician’s role[mesh] OR oncolog*[tiab]) NOT (comment[pt] OR letter[pt]) AND (oncology[mesh] OR cancer[mesh] OR chemotherapy[mesh] OR antineoplastic[mesh] OR cancer*[tiab] OR neoplas*[tiab] OR oncol*[tiab] OR antineoplas*[tiab] OR chemotherap*[tiab])

Web of Science:
(“fees and charges” OR "Reimbursement, Incentive" OR “reimbursement incentive” OR "Physician Incentive Plans" OR “physician reimbursement” OR reimburs* OR “capitation fee” OR incentive* OR “pay for performance” OR “incentive reimbursement” OR “incentive reimbursements” OR "fee-for-service" OR “fee for service plans” OR “unnecessary procedures” OR “self-referral” OR capitation OR “reimbursement mechanisms” OR “insurance claim review” OR billing OR “fee schedule” OR “buy and bill” OR “financial incentive” OR “payment reform”) AND (provider* OR physician* OR physicians OR “practice patterns, physicians” OR “physician’s role”) AND (cancer* OR neoplas* OR oncol* OR antineoplas* OR chemotherap*)

Proquest Health Management:
(“fees and charges” OR "Reimbursement, Incentive" OR “reimbursement incentive” OR "Physician Incentive Plans" OR “physician reimbursement” OR reimburs* OR “capitation fee” OR incentive* OR “pay for performance” OR “incentive reimbursement” OR "fee-for-service" OR “fee for service plans” OR “unnecessary procedures” OR “self-referral” OR capitation OR “reimbursement mechanisms” OR “insurance claim review” OR billing OR “fee schedule” OR “buy and bill” OR “financial incentive” OR “payment reform” OR “physician compensation”) AND ti(cancer* OR neoplas* OR oncol* OR antineoplas* OR chemotherap*)

Econlit and Business Source Premier:
("medical fees" OR "medicare reimbursement" OR “fees and charges” OR "Reimbursement, Incentive" OR “reimbursement incentive” OR "Physician Incentive Plans" OR “physician reimbursement” OR reimburs* OR “capitation fee” OR incentive* OR “pay for performance” OR “incentive reimbursement” OR "fee-for-service" OR “fee for service plans” OR “unnecessary procedures” OR “self-referral” OR capitation OR “reimbursement mechanisms” OR “insurance claim review” OR billing OR “fee schedule” OR “buy and bill” OR “financial incentive” OR “payment reform” OR “physician compensation” OR “reimbursement policy”) AND ti(cancer* OR neoplas* OR oncol* OR antineoplas* OR chemotherap*)

eMethods. Risk of Bias Assessment

We applied the Risk of Bias in Non-randomized Studies (ROBINS-I) tool to assess risk of bias[1]. This tool assesses risk of bias across several different domains. For each domain, a judgement is made as to whether there may have been risk of bias due to that domain, using the following definitions:
Low risk of bias: the study is comparable to a well-performed randomized trial
Moderate risk of bias: the study provides sound evidence for a non-randomized study but cannot be considered comparable to a well-performed randomized trial
High risk of bias: the study has some important problems
Critical risk of bias: the study is too problematic to provide any useful evidence and should not be included in any synthesis
Unclear risk of bias: No information on which to base a judgement about risk of bias

The authors of the ROBINS-I tool note that all non-randomized trials are anticipated to have at least a moderate risk of bias in the domain of risk of bias due to confounding.

The following is a brief, abridged summary of the factors ROBINS-I users are asked to consider in rendering a judgement for each domain:
Bias due to confounding: whether study authors appropriately controlled for all confounding factors, and whether confounding factors were measured validly and reliably.
Bias due to selection of participants into study: whether participants were selected based on characteristics observed after the intervention period began.
Bias due to classification of interventions: whether intervention groups were clearly defined, and whether knowledge of an individual's outcome may have affected the intervention group classification.
Bias due to deviations from intended interventions: whether deviations from the intended interventions occurred, whether such deviations occurred in an unbalanced fashion, whether deviations were likely to have affected the outcome, and whether participants adhered to the assigned intervention.
Bias due to missing data: whether missingness occurred, whether missingness resulted in participant exclusion, and whether missingness was similar between intervention groups.
Bias in measurement of outcomes: whether the outcome measure may have been influenced by knowledge of intervention group assignment, and whether methods of outcome assessment or errors in outcome assessment were likely to be balanced between intervention groups
Bias in selection of the reported result: whether the study's reported result may have been selectively chosen from among several different analyses, or from among one subgroup within a larger cohort.

eTable 1. Studies Excluded at Full Text Review. For each study, "reason for exclusion" identifies which of the specific exclusion criterion was cited. "Further explanation" provides additional context about the study that resulted in exclusion for that reason.

Lead author and year of publication	Reason for Exclusion	Further explanation
Ata, 2013[2]	Study did not contain an empirical analysis	Theoretical/simulation model
Bennett, 1999[3]	Outcome not measured directly	Study outcome was measured through a survey of providers
Bennett, 2000[4]	Wrong study design	Book chapter
Colla, 2012[5]	Duplicate	This study was included in the final analysis, but was duplicated in our search
Ellis, 2013[6]	Not peer reviewed	Dissertation
Halpern, 2017[7]	Study did not focus on cancer patients	
Hemani, 2010[8]	Study did not contain a measure of contrast between groups of interest	Trends in utilization for both the experimental and control groups are described, but there is no statistical measure of comparison
Herman, 2003[9]	Outcome was not a form of patient care delivery	Outcome was the cost and spending on various radiation oncology procedures
Makarov, 2016[10]	Reimbursement not identified as the main difference between exposure/control groups	Exposure and control groups were treated in different health care systems
McKoy, 2008[11]	Wrong study design	Book chapter
Millman, 1989[12]	Wrong study design	Opinion/editorial
Newcomer, 2014[13]	Outcome was not a form of patient care delivery	The outcome was health care spending, not delivery of any specific service
O'Shaughnessy, 2013[14]	Study did not contain a measure of contrast between groups of interest	Study describes changing use of androgen deprivation therapy over time, but does not test a specific hypothesis
Ramsey, 2015[15]	Study did not contain a measure of contrast between groups of interest	Study describes the delivery of several low-value forms of cancer care, but does not assess delivery with respect to any specific reimbursement changes
Retchin, 1997[16]	Reimbursement not identified as the main difference between exposure/control groups	Exposure and control groups were treated in different health care systems
Shahinian, 2017[17]	Study did not contain a measure of contrast between groups of interest	Trends in utilization for both the experimental and control groups are described, but there is no statistical measure of comparison

Shen, 2014[18]	Study did not contain a measure of contrast between groups of interest	Study describes changing use of radiation therapy over time, but does not test a specific hypothesis
Soumerai, 1990[19]	Study did not focus on cancer patients	
Jacobson, 2006[20]	Duplicate	This study was included in the final analysis, but was duplicated in our search
Weight, 2008[21]	Study did not contain a measure of contrast between groups of interest	Study describes changing use of androgen deprivation therapy over time, but does not test a specific hypothesis

eTable 2: Study Results. Studies were grouped in to three subject areas: 1) studies evaluating the effect of reimbursement differences created by inter-provider or inter-treatment variability in reimbursement, 2) studies of reimbursement incentives resulting from physician ownership and/or self-referral practices, and 3) studies evaluating the effect of changes in reimbursement for oncology treatment services over time. "Direction of association between financial incentives and care delivery" describes whether the measured association was in the direction hypothesized by the study authors under the assumption of physician responsiveness to financial incentives ("In hypothesized direction"), in the direction counter to the hypothesis ("Contrary to hypothesized direction"), or in neither direction ("no association").

Lead author and year of publication	Study design, time period, and patient population	Financial incentive studied, and analytic question	Exposure and control groups	Primary outcome[s]	Result and measure of confidence	Direction of association between financial incentives and care delivery
Studies of inter-provider or inter-treatment variability in reimbursement						
Hadley, 2003[22]	Retrospective cross-sectional analysis, 1994 Patients receiving surgical treatment for breast cancer (N = 1,787)	Variation in Medicare fees for breast conserving surgery (BCS) and mastectomy (MST) Do physicians with higher Medicare fees for BCS use BCS more often?	Patients treated by physicians with higher Medicare fees for BCS fees (or lower MST fees), compared to those treated by physicians with lower BCS fees (or higher MST fees)	Change in the likelihood of patient receiving BCS+RT instead of MST, associated with a 10% increase in physician BCS fees	OR = 1.34 (p = 0.02)	In hypothesized direction
				Change in the likelihood of patient receiving BCS instead of MST, associated with a 10% increase in physician BCS fees	OR = 1.23 (p = 0.23)	In hypothesized direction
				Change in the likelihood of patient receiving BCS+RT instead of	OR = 1.86 (p < 0.01)	In hypothesized direction

				MST, associated with a 10% decrease in physician MST fees		
				Change in the likelihood of patient receiving BCS instead of MST, associated with a 10% decrease in physician MST fees	OR = 1.46 (p = 0.23)	In hypothesized direction
Jacobson, 2006[20,a]	Retrospective cohort, 1995-1998 Patients with metastatic breast, colon, other gastrointestinal, or lung cancer (N = 2,246)	Differences in Medicare reimbursement for chemotherapy based on local carrier payment rates. Are physicians who are reimbursed more generously for chemotherapy more likely to use chemotherapy, or do they use more expensive chemotherapy?	Patients treated by physicians with higher Medicare fees for chemotherapy, compared to those treated by physicians with lower fees	Receipt of chemotherapy for breast cancer associated with 1SD greater physician reimbursement	PD = 1.1% (95%CI -0.9%, 3.1%)	In hypothesized direction
				Change in cost of breast cancer chemotherapy associated with $1 greater physician reimbursement	+$23.10 (p = 0.038)	In hypothesized direction
				Receipt of chemotherapy for colorectal cancer associated with 1SD greater physician reimbursement	PD = -15.0% (95%CI -42.2%, 12.2%)	Contrary to hypothesized direction
				Change in cost of colorectal cancer chemotherapy associated with $1 greater physician reimbursement	+$35.50 (p = 0.079)	In hypothesized direction

				Receipt of chemotherapy for GI cancer associated with 1SD greater physician reimbursement	PD = -2.5% (95%CI -6.3%, 1.3%)	Contrary to hypothesized direction
				Change in cost of GI cancer chemotherapy associated with $1 greater physician reimbursement	-$6.33 (p = 0.038)	Contrary to hypothesized direction
				Receipt of chemotherapy for lung cancer associated with 1SD greater physician reimbursement	PD = -0.1% (95% CI -2.0%, 1.9%)	Contrary to hypothesized direction
				Change in cost of lung cancer chemotherapy associated with $1 greater physician reimbursement	+$13.00 (p = 0.039)	In hypothesized direction
Epstein, 2012[23]	Retrospective cohort, 1992-2002 Patients receiving chemotherapy for breast cancer (N = 3,856)	Physician use of chemotherapy drugs with respect to profit margin. Are physicians more likely to use chemotherapy drugs with higher profit margins over those with lower profit margins?	N/A: physician use of chemotherapy drugs was analyzed across entire cohort	Change in likelihood of physician selection of a chemotherapy drug associated with a 1% increase in the profit margin of the average daily dose	+1.1% to +17.7%[b]	In hypothesized direction

Ellis, 2016[24]	Retrospective cohort, 2000-2003 Patients with prostate cancer (N = 15,128)	Differences in Medicare reimbursement for ADT based on local carrier payment rates. Are physicians who are reimbursed more generously for ADT more likely to use ADT?	Patients treated by physicians with higher Medicare fees for ADT, compared to those treated by physicians with lower fees	Change in the likelihood of patient receiving ADT associated with a $1 increase in physician reimbursement for ADT	OR = 1.00 (95%CI 1.00, 1.00	No association
Jung, 2018[25,a]	Retrospective cohort, 2010-2013 Cancer treatment in hospitals participating in the 340B drug discount program (N = 9,062)	Access to 340B discount pricing, vs. no 340B discount pricing. Are patients treated by health systems participating in the 340B discount program more likely to receive chemotherapy, or more likely to receive chemotherapy in the hospital outpatient setting vs. the office setting?	Medicare patients treated in HRRs that gained a 340B hospital during the study period, compared to those treated in HRRs without 340B hospitals	Change in the likelihood of receiving chemotherapy	PD = 0.49% (95% CI -0.29%, 1.27%)	In hypothesized direction
				Change in the likelihood of receiving chemotherapy in the hospital outpatient setting (vs. the office setting)	PD = 7.76% (95% CI 2.66, 12.56)	In hypothesized direction
				Change in the number of chemotherapy drug claims	PD = 0.04% (95% CI -0.67, 0.75)	In hypothesized direction
Studies of physician ownership interests and self-referral practices						
Mitchell, 1992[26]	Cross-sectional market share, 1989 Patients receiving radiation therapy (N = N/A)	Physician self-referral for radiation therapy Do physicians use radiation therapy more often when self-referring for services?	Patients treated in free-standing radiation centers in the state of Florida (likely to be self-referring), compared to those treated in the rest of the United States (not likely to be self-referring)	Number of treatments per 1,000 Medicare beneficiaries	RR = 1.58	In hypothesized direction[c]
				Allowed charges per 1,000 Medicare beneficiaries	RR = 1.46	In hypothesized direction[c]
Smith, 2011[27]	Retrospective cohort, 2001-2005	Office-based radiation centers vs. hospital-based	Patients treated with RT in freestanding radiation centers, compared to those	Likelihood of receiving IMRT	OR = 1.36 (95%CI 1.20, 1.53)	In hypothesized direction

	Patients receiving radiation therapy for breast cancer (N = 26,163)	Are office-based radiation centers, which are more often self-referring, more likely to use IMRT?	treated in hospital-based outpatient canters			
Bekelman, 2013[28]	Retrospective cohort, 2004-2007 Patients with prostate cancer (N = 3,980)	Prostate cancer treatment before and after conversion of a urology practice to an integrated prostate cancer center (IPCC), exempt from Stark Law. Are IPCCs more or less likely to treat patients with IMRT, ADT, prostatectomy, non-IMRT RT, or expectant management?	Patients treated in a urology practice after vs. before transition to an IPCC, compared to those treated in non-IPCC practices elsewhere within the same HRR, and to those treated in non-IPCC practices elsewhere within the same state.	Likelihood of receiving IMRT	PD = 11.7% (95%CI 3.9%, 19.2%) vs. state control, 10.5% (95%CI 0.9, 20.7%) vs HRR control	In hypothesized direction
				Likelihood of receiving ADT	PD = -5.3% (95%CI -12.1%, 1.3%) vs state control, -7.5% (95%CI -16.7%, 0.5%) vs HRR control	In hypothesized direction
				Likelihood of receiving prostatectomy	PD = -12.9% (95%CI -23.5%, -1.9%) vs state control, -12.0% (95%CI -19.4%, -5.2%) vs HRR control	In hypothesized direction
				Likelihood of receiving non-IMRT RT	NR	NR
				Likelihood of receiving expectant management	NR	NR
Mitchell, 2013[29]	Retrospective cohort, 2005-2010 Patients with prostate cancer (N = 38,765)	Prostate cancer treatment before vs. after private-practice urology groups became self-referring, compared to urology groups that did not become self-referring. Are self-referring urology practices more or less likely to treat patients with IMRT?	Patients treated in private-practice urology practices after vs. before self-referral period, compared to similar practices that did not become self-referring	Likelihood of receiving IMRT	PD = 16.9% ($p < 0.0001$) OR = 2.79 (95%CI 2.53, 3.08)	In hypothesized direction

Williams, 2017[30]	Retrospective cohort, 2004-2009 Patients with prostate cancer (N = 17,982)	Prostate cancer treatment in older men in self-referring vs. non-self-referring urology practices. Are self-referring urology practices more or less likely to treat older men with any active therapy, or with RT?	Patients diagnosed in self-referring urology practices, compared to those diagnosed in non-self-referring urology practices.	Likelihood of receiving active therapy (prostatectomy, RT, cryotherapy, or ADT)	OR = 1.61 (95%CI 1.30, 2.00)	In hypothesized direction
				Likelihood of receiving external beam RT	OR = 1.59 (95%CI 1.37, 1.84)	In hypothesized direction
Studies of changes in reimbursement for oncology services over time						
Elliott, 2010[31]	Retrospective cohort, 1992-2005 Patients with prostate cancer (N = 72,818)	Decrease in reimbursement for ADT, following the Medicare Modernization Act Did physicians decrease use of ADT in response to lower reimbursement?	Men newly diagnosed with prostate cancer after a decrease in reimbursement for ADT, compared to those diagnosed before the decrease. Specific groups compared included men with metastatic disease (for which ADT is indicated) and low-risk localized disease (for which ADT is not indicated)	Likelihood of receiving ADT, for men with metastatic disease	OR = 0.9 (95%CI 0.68, 1.18)	N/A (control)
				Likelihood of receiving ADT, for men with low-risk localized disease	OR = 0.61 (95%CI 0.53, 0.71)	In hypothesized direction
Jacobson, 2010[32,a]	Retrospective cohort, 2003-2005 Patients with lung cancer (N = 222,478)	Decrease in reimbursement for some chemotherapy drugs, following the Medicare Modernization Act Did physicians decrease use of chemotherapy drugs in response to lower reimbursement?	Patients diagnosed with lung cancer after a decrease in reimbursement for some chemotherapy drugs, compared to those diagnosed before the decrease	Likelihood of receiving any chemotherapy	PD = 1.9% (95%CI 1.51%, 2.29%)	In hypothesized direction
				Likelihood of receiving carboplatin	PD = -4.1% (95%CI -4.1%, -2.1%)	In hypothesized direction
				Likelihood of receiving paclitaxel	PD = -4.3% (95%CI -6.3%, -2.3%)	In hypothesized direction
				Likelihood of receiving docetaxel	PD = 0.5% (95%CI -0.9%, 1.9%)	NA (control)

				Likelihood of receiving etoposide	PD = -1.2% (95%CI -2.0%, -0.4%)	In hypothesized direction
				Likelihood of receiving gemcitabine	PD = -2.2% (95%CI -3.0%, -1.4%)	NA (control)
Jacobson, 2011[33]	Retrospective cohort, 2002-2006 Patients with lung cancer (N = 878,923)	Decrease in reimbursement for some chemotherapy drugs, following the Medicare Modernization Act Did physicians in different states respond similarly to reimbursement changes, or was there variation?	Patients diagnosed with lung cancer after a decrease in reimbursement for some chemotherapy drugs, compared to those diagnosed before the decrease	Change in likelihood of receiving chemotherapy within 30 days of diagnosis, within each US state	F-value for null hypothesis that all states' changes are jointly equal to 0 is 38, 279	In hypothesized direction
Colla, 2012[5,a]	Retrospective cohort, 2003-2007 Cancer patients within the last months of life (N = 57,656)	Decrease in reimbursement for some chemotherapy drugs, following the Medicare Modernization Act Did physicians decrease use of chemotherapy within the last month of life in response to lower reimbursement?	Patients who died from cancer after a decrease in reimbursement for some chemotherapy drugs, compared to those who died before the decrease	Likelihood of receiving chemotherapy within the last month of life	PD = -2.6% (95% CI 4.2%, 1.0%)	In hypothesized direction
Conti, 2012[34,a]	Interrupted time series, 2006-2009 Use of irinotecan to treat colon cancer (N = NR)	Expiration of protection of irinotecan and entry of generic version Did physicians decrease use of irinotecan after patient expiration?	Patients treated with irinotecan after patent expiration vs. before, compared to number of administrations of oxaliplatin	Change in number of administrations of irinotecan, compared to oxaliplatin	PD = -17.0% (95%CI -17.1%, 16.9%)	In hypothesized direction
				Change in the proportion of patients treated with irinotecan,	PD = -16.5 (95%CI -16.5, -16.5)	In hypothesized direction

				compared to oxaliplatin		
Quek, 2014[35]	Retrospective cohort, 2001-2007 Patients with prostate cancer (N = 12,255)	Decrease in reimbursement for ADT following the Medicare Modernization Act, and the response to reimbursement decrease among academic (salaried) and non-academic (fee-for-service) urologists Did non-academic urologists decrease use of ADT in non-indicated settings to a larger degree than academic urologists following a reimbursement decrease?	Patients treated by non-academic urologists after vs. before a decrease in reimbursement for ADT, compared to academic urologists	Likelihood of receiving non-indicated ADT	t-statistic for the null hypothesis that the decline in use of non-indicated ADT was the same between non-academic and academic urologists, is -0.07 (p=0.95)	In hypothesized direction
Shahinian, 2015[36]	Retrospective cohort, 2000-2002 and 2004-2007 Patients with prostate cancer (N = 27,169)	Decrease in reimbursement for ADT following the Medicare Modernization Act, and the response to reimbursement decrease among academic (salaried) and non-academic (fee-for-service) urologists Did non-academic urologists decrease use of ADT in non-indicated settings to a larger degree than academic urologists following a	Patients treated by non-academic urologists after vs. before a decrease in reimbursement for ADT, compared to academic urologists	Likelihood of receiving non-indicated ADT, non-academic vs. academic urologists, before reimbursement decrease	OR = 1.32 (95%CI 1.17, 1.56	In hypothesized direction
				Likelihood of receiving non-indicated ADT, non-academic vs. academic urologists, after reimbursement decrease	OR = 1.34 (95%CI 1.15, 1.56	In hypothesized direction

		reimbursement decrease?		p-value for the null hypothesis that there was no difference in the decline in ADT use between non-academic and academic urologists	p = 0.68	Contrary to hypothesized direction
O'Neil, 2016[37]	Interrupted time series, 2001-2013 Patients with bladder cancer, among Medicare beneficiaries (N = approximately 1.2 million)	Increase in reimbursement for office-based cystoscopic procedures Did physicians increase use of office-based cystoscopic procedures after the reimbursement increase?	Patients with bladder cancer treated after vs. before an increase in reimbursement for office-based cystoscopic procedures, compared to patients treated in hospitals or ambulatory surgical centers	Likelihood of receiving an office-based cystoscopic procedure	Relative increase: 644% (95%CI 584%, 704%)	In hypothesized direction

a: Confidence intervals were derived from the point estimate and standard error presented by the authors.
b. Range of results does not represent a statistical confidence interval, but the variation the estimate across various analytic models.
c: Differences were presented without formal tests of significance, because the study included the entire population of interest rather than a sample.
Abbreviations used: N/A, not applicable; NR, not reported; RR, risk ratio; OR, odds ratio; PD, prevalence difference; RT, radiation therapy; IMRT, intensity modulated radiation therapy; PD, prevalence difference; GI, gastrointestinal; SD, standard deviation; ADT, androgen deprivation therapy.

eTable 3. Study Results for Studies With Critical Risk of Bias. "Direction of association between financial incentives and care delivery" describes whether the measured association was in the direction hypothesized by the study authors under the assumption of physician responsiveness to financial incentives ("In hypothesized direction"), or in the direction counter to the hypothesis ("Contrary to hypothesized direction"). NR, not reported; RR, risk ratio; PD, prevalence difference; ADT, androgen deprivation therapy; ESA, erythropoiesis-stimulating agent; RT, radiation therapy;

Lead author and year of publication	Study setting	Financial incentive studied, and analytic question	Exposure and control groups	Primary outcome[s]	Result and measure of confidence	Direction of association between financial incentives and care delivery [a]
Chang, 2009[38]	Retrospective cohort, 2004-2007 Patients receiving ADT for prostate cancer (N = NR)	Decrease in reimbursement for ADT, following the Medicare Modernization Act Did physicians decrease use of ADT in response to lower reimbursement?	Patients treated within fee-for-service Medicare after vs. before a decrease in reimbursement for ADT, compared to those treated within the Veterans Affairs health care system.	Total number of claims for ADT across all patients within health care system.	Difference-in-differences, Medicare vs VA = -8.3%	In hypothesized direction
Elllis, 2015[39]	Retrospective cohort, 2000-2007 Patients receiving ADT for prostate cancer (N = 12,943)	Decrease in reimbursement for ADT, following the Medicare Modernization Act Did physicians decrease use of ADT in non-indicated settings in response to lower reimbursement?	Patients treated after a decrease in reimbursement for ADT, compared to before	Likelihood of receiving non-indicated ADT	PD = -7.4	In hypothesized direction
Feinberg, 2014[40]	Retrospective cohort, 2010-2012 Cancer patients treated within a group of oncology medical home	Oncology practice reimbursement under an "oncology medical home" model Are cancer patients treated under an oncology medical home reimbursement model	Patients treated after vs. before practice conversion to an oncology medical home structure, compared to those treated in practices that did not become oncology medical homes	Change in number of office visit claims	Difference-in-differences, oncology medical home vs not = -0.3 visits	Contrary to hypothesized direction

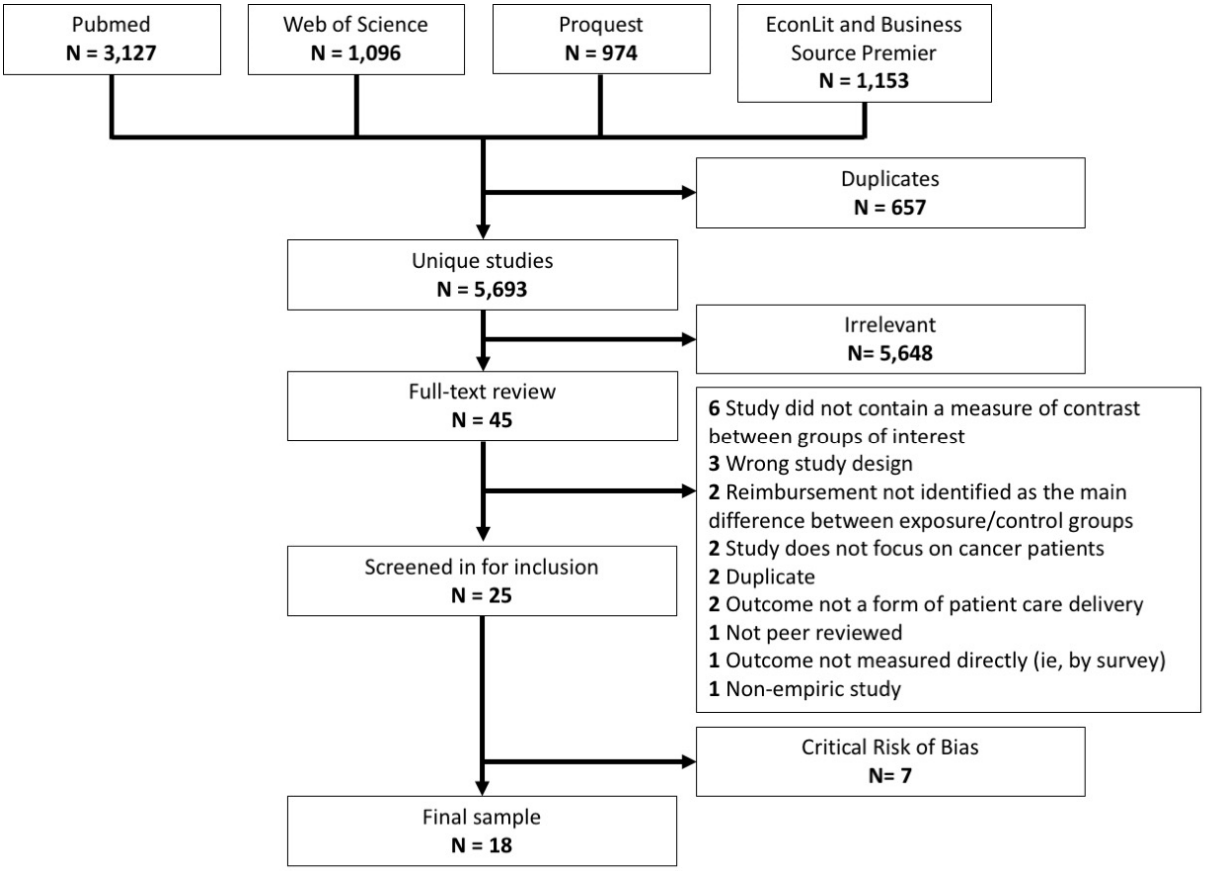
	practices (N = 12,060)	more or less likely to receive chemotherapy, more chemotherapy administrations, more office visits, or generic-only treatment regimens?			(measure of confidence NR)	
				Change in number of chemotherapy administrations	NR[b]	No association
				Change in percentage of patients who received chemotherapy	NR[b]	No association
				Change in percentage of patients whose treatment regimens contained only generic drugs	NR[b]	No association
Gawade, 2017[41]	Retrospective cohort, 2005-2013 Patients receiving chemotherapy for breast, colon, lung ovarian, prostate cancer, multiple myeloma, or non-Hodgkin lymphoma (N = 348,012)[c]	Change in Medicare coverage for ESAs Did physicians decrease the use of ESAs after coverage restrictions limited their reimbursement for many cancer patients?	Patients treated after vs. before coverage restrictions	Likelihood of receiving ESA, breast cancer	PD = -50.5	In hypothesized direction
				Likelihood of receiving ESA, colon cancer	PD = -39.1	In hypothesized direction
				Likelihood of receiving ESA, lung cancer	PD = -52.7	In hypothesized direction
				Likelihood of receiving ESA, multiple myeloma	PD = -52.3	In hypothesized direction
				Likelihood of receiving ESA, non-Hodgkin lymphoma	PD = -36.0	In hypothesized direction
				Likelihood of receiving ESA, ovarian cancer	PD = -60.5	In hypothesized direction

				Likelihood of receiving ESA, prostate cancer	PD = -42.6	In hypothesized direction
Hershman, 2014[42]	Retrospective cohort, 2000-2007 Patients receiving chemotherapy for breast, colon, lung ovarian, or prostate cancer (N = 121,169)	Change in Medicare coverage for ESAs Did physicians decrease the use of ESAs after coverage restrictions limited their reimbursement for many cancer patients?	Patients treated after vs. before coverage restrictions	Likelihood of receiving ESA	PD = -8.3	In hypothesized direction
Hess, 2010[43]	Retrospective cohort, 2006-2008 Cancer patients (N = 10,389)	Change in Medicare coverage for ESAs Did physicians decrease the use of ESAs after coverage restrictions limited their reimbursement for many cancer patients?	Patients treated after vs. before coverage restrictions	Change in the proportion of care episodes during which an ESA was given	PD = -10.9 (p <0.001)	In hypothesized direction
				Change in the proportion of care episodes during which a transfusion was given	PD = 1.3 (p = 0.015)	In hypothesized direction
Loy, 2016[44]	Retrospective cohort, 2011-2013 Patients receiving RT for primary breast, skin, lung, or prostate cancer, or treatment of bone metastasis (N = 984)	Oncology practice reimbursement on a "case based" model rather than fee-for-service Are cancer patients treated with RT under a case based reimbursement model more or less likely to receive a guideline-concordant number of radiation fractions?	Patients treated after vs. before case based payment model began	Likelihood of receiving guideline-concordant number of radiation fractions, all patients	RR = 1.0 (95%CI 0.98, 1.08)	No association
				Likelihood of receiving guideline-concordant number of radiation	RR = 1.0 (95%CI 0.94, 1.04)	No association

				fractions, breast cancer		
				Likelihood of receiving guideline-concordant number of radiation fractions, lung cancer	RR = 1.0 (95%CI 0.89, 1.09)	No association
				Likelihood of receiving guideline-concordant number of radiation fractions, prostate cancer	RR = 1.1 (95%CI 1.01, 1.15)	In hypothesized direction
				Likelihood of receiving guideline-concordant number of radiation fractions, skin cancer	RR = 0.9 (95%CI 0.84, 1.01)	Contrary to hypothesized direction
				Likelihood of receiving guideline-concordant number of radiation fractions, bone metastasis	RR = 2.0 (95%CI 1.21, 3.24)	In hypothesized direction

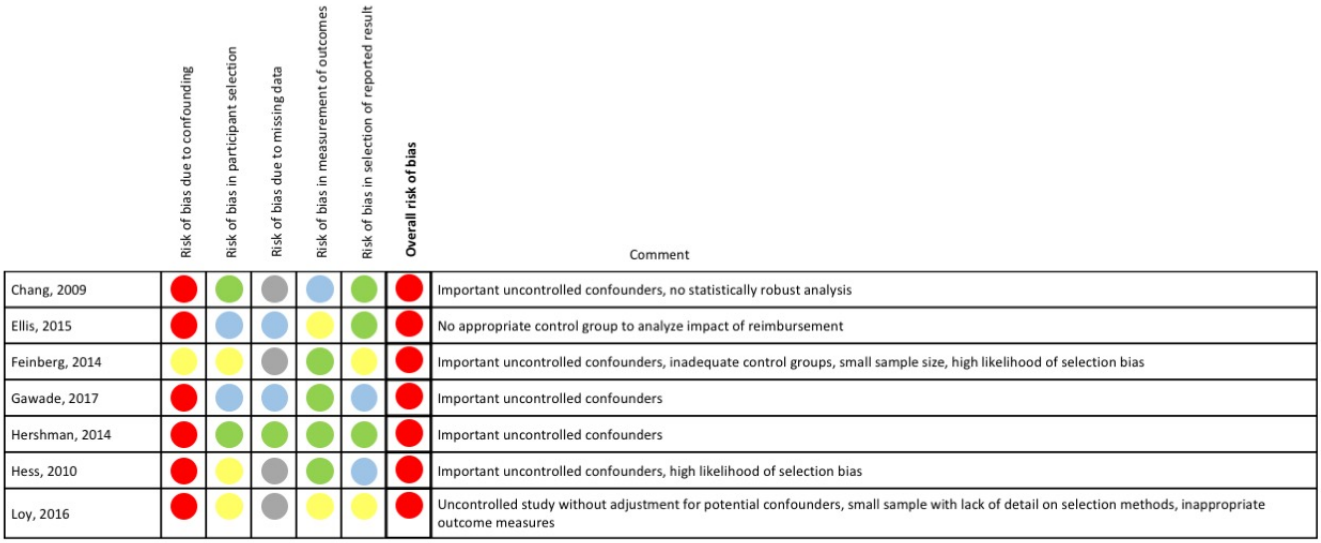
a: In cases where estimates were not reported (or derivable), direction of association was determined from authors' stated conclusions.
b: Results were reported graphically, but not numerically
c: Patient number not directly reported; this figure was derived by summing across disease-specific cohorts

eFigure 1. PRISMA Diagram.



eFigure 2. Risk of Bias Assessment for Studies With Critical Risk of Bias.

Risk of bias assessment of included studies, performed using ROBINS-I tool. The domains “classification of interventions” and “deviations from intended interventions” were assessed as resulting in low risk of bias for all studies, and are not shown. Blue, low risk of bias; green, moderate risk of bias; yellow, high risk of bias; red, critical risk of bias; grey, unknown risk of bias.



eReferences

1. Sterne JA, Hernán MA, Reeves BC, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ*. October 2016:i4919. doi:10.1136/bmj.i4919

2. Ata B, Killaly BL, Olsen TL, Parker RP. On Hospice Operations Under Medicare Reimbursement Policies. *Manag Sci*. 2013;59(5):1027-1044. doi:10.1287/mnsc.1120.1606

3. Bennett CL, Bishop MR, Tallman MS, Somerfield MR, Feinglass J, Smith TJ. The association between physician reimbursement in the US and use of hematopoietic colony stimulating factors as adjunct therapy for older patients with acute myeloid leukemia: results from the 1997 American Society of Clinical Oncology survey. Health Services Research Committee of the American Society of Clinical Oncology. *Ann Oncol Off J Eur Soc Med Oncol*. 1999;10(11):1355-1359.

4. Bennett CL, Stinson TJ. Does reimbursement affect physician decision making? *Cancer Treat Res*. 2000;102:137-149.

5. Colla CH, Morden NE, Skinner JS, Hoverman JR, Meara E. Impact of payment reform on chemotherapy at the end of life. *J Oncol Pract Am Soc Clin Oncol*. 2012;8(3 Suppl):e6s-e13s. doi:10.1200/JOP.2012.000539

6. Ellis S. Declining overuse of hormone therapy for localized prostate cancer: Predictors of reimbursement responsiveness and emerging patterns of care. 2013. https://sph.unc.edu/files/2015/10/ellis_hpm_abstract.pdf. Accessed June 1, 2018.

7. Halpern MT, Fiero MH. Factors Influencing Receipt of Mental Health Services Among Medicaid Beneficiaries With Breast Cancer. *Psychiatr Serv Wash DC*. 2018;69(3):332-337. doi:10.1176/appi.ps.201700024

8. Hemani ML, Makarov DV, Huang WC, Taneja SS. The effect of changes in Medicare reimbursement on the practice of office and hospital-based endoscopic surgery for bladder cancer. *Cancer*. 2010;116(5):1264-1271. doi:10.1002/cncr.24875

9. Herman MG, Mills MD, Gillin MT. Reimbursement versus effort in medical physics practice in radiation oncology. *J Appl Clin Med Phys*. 2003;4(2):179-187. doi:10.1120/1.1566491

10. Makarov DV, Hu EYC, Walter D, et al. Appropriateness of Prostate Cancer Imaging among Veterans in a Delivery System without Incentives for Overutilization. *Health Serv Res*. 2016;51(3):1021-1051. doi:10.1111/1475-6773.12395

11. McKoy JM, Tigue CC, Bennett CL. Does reimbursement affect physicians' decision making? Examples from the use of recombinant erythropoietin. *Cancer Treat Res*. 2008;140:235-251.

12. Millman DS. Reimbursement of freestanding radiation oncology centers. *Adm Radiol AR*. 1989;8(10):49-50.

13. Newcomer LN, Gould B, Page RD, Donelan SA, Perkins M. Changing physician incentives for affordable, quality cancer care: results of an episode payment model. *J Oncol Pract*. 2014;10(5):322-326. doi:10.1200/JOP.2014.001488

14. O'Shaughnessy MJ, Jarosek SL, Virnig BA, Konety BR, Elliott SP. Factors associated with reduction in use of neoadjuvant androgen suppression therapy before radical prostatectomy. *Urology*. 2013;81(4):745-751. doi:10.1016/j.urology.2012.12.044

15. Ramsey SD, Fedorenko C, Chauhan R, et al. Baseline Estimates of Adherence to American Society of Clinical Oncology/American Board of Internal Medicine Choosing Wisely Initiative Among Patients With Cancer Enrolled With a Large Regional Commercial Health Insurer. *J Oncol Pract*. 2015;11(4):338-343. doi:10.1200/JOP.2014.002717

16. Retchin SM. Perioperative Management of Colon Cancer Under Medicare Risk Programs. *Arch Intern Med*. 1997;157(16):1878. doi:10.1001/archinte.1997.00440370126013

17. Shahinian VB, Kaufman SR, Yan P, Herrel LA, Borza T, Hollenbeck BK. Reimbursement and use of intensity-modulated radiation therapy for prostate cancer. *Medicine (Baltimore)*. 2017;96(25):e6929. doi:10.1097/MD.0000000000006929

18. Shen X, Showalter TN, Mishra MV, et al. Radiation oncology services in the modern era: evolving patterns of usage and payments in the office setting for medicare patients from 2000 to 2010. *J Oncol Pract*. 2014;10(4):e201-207. doi:10.1200/JOP.2013.001270

19. Soumerai SB, Ross-Degnan D, Gortmaker S, Avorn J. Withdrawing payment for nonscientific drug therapy. Intended and unexpected effects of a large-scale natural experiment. *JAMA*. 1990;263(6):831-839.

20. Jacobson M, O'Malley AJ, Earle CC, Pakes J, Gaccione P, Newhouse JP. Does reimbursement influence chemotherapy treatment for cancer patients? *Health Aff Proj Hope*. 2006;25(2):437-443. doi:10.1377/hlthaff.25.2.437

21. Weight CJ, Klein EA, Jones JS. Androgen deprivation falls as orchiectomy rates rise after changes in reimbursement in the U.S. Medicare population. *Cancer*. 2008;112(10):2195-2201. doi:10.1002/cncr.23421

22. Hadley J, Mandelblatt JS, Mitchell JM, et al. Medicare breast surgery fees and treatment received by older women with localized breast cancer. *Health Serv Res*. 2003;38(2):553-573.

23. Epstein AJ, Johnson SJ. Physician response to financial incentives when choosing drugs to treat breast cancer. *Int J Health Care Finance Econ*. 2012;12(4):285-302. doi:10.1007/s10754-012-9117-y

24. Ellis SD, Chen RC, Dusetzina SB, et al. Are Small Reimbursement Changes Enough to Change Cancer Care? Reimbursement Variation in Prostate Cancer Treatment. *J Oncol Pract*. 2016;12(4):e423-436. doi:10.1200/JOP.2015.007344

25. Jung J, Xu WY, Kalidindi Y. Impact of the 340B Drug Pricing Program on Cancer Care Site and Spending in Medicare. *Health Serv Res*. January 2018. doi:10.1111/1475-6773.12823

26. Mitchell JM, Sunshine JH. Consequences of physicians' ownership of health care facilities--joint ventures in radiation therapy. *N Engl J Med*. 1992;327(21):1497-1501. doi:10.1056/NEJM199211193272106

27. Smith BD, Pan I-W, Shih Y-CT, et al. Adoption of intensity-modulated radiation therapy for breast cancer in the United States. *J Natl Cancer Inst*. 2011;103(10):798-809. doi:10.1093/jnci/djr100

28. Bekelman JE, Suneja G, Guzzo T, Pollack CE, Armstrong K, Epstein AJ. Effect of practice integration between urologists and radiation oncologists on prostate cancer treatment patterns. *J Urol*. 2013;190(1):97-101. doi:10.1016/j.juro.2013.01.103

29. Mitchell JM. Urologists' use of intensity-modulated radiation therapy for prostate cancer. *N Engl J Med*. 2013;369(17):1629-1637. doi:10.1056/NEJMsa1201141

30. Williams SB, Huo J, Chapin BF, Smith BD, Hoffman KE. Impact of urologists' ownership of radiation equipment in the treatment of prostate cancer. *Prostate Cancer Prostatic Dis*. 2017;20(3):300-304. doi:10.1038/pcan.2017.9

31. Elliott SP, Jarosek SL, Wilt TJ, Virnig BA. Reduction in physician reimbursement and use of hormone therapy in prostate cancer. *J Natl Cancer Inst*. 2010;102(24):1826-1834. doi:10.1093/jnci/djq417

32. Jacobson M, Earle CC, Price M, Newhouse JP. How Medicare's payment cuts for cancer chemotherapy drugs changed patterns of treatment. *Health Aff Proj Hope*. 2010;29(7):1391-1399. doi:10.1377/hlthaff.2009.0563

33. Jacobson M, Earle CC, Newhouse JP. Geographic variation in physicians' responses to a reimbursement change. *N Engl J Med*. 2011;365(22):2049-2052. doi:10.1056/NEJMp1110117

34. Conti RM, Rosenthal MB, Polite BN, Bach PB, Shih Y-CT. Infused chemotherapy use in the elderly after patent expiration. *J Oncol Pract*. 2012;8(3 Suppl):e18s-23s. doi:10.1200/JOP.2012.000541

35. Quek RGW, Master VA, Portier KM, et al. Association of reimbursement policy and urologists' characteristics with the use of medical androgen deprivation therapy for clinically localized prostate cancer. *Urol Oncol*. 2014;32(6):748-760. doi:10.1016/j.urolonc.2014.02.017

36. Shahinian VB, Kuo Y-F. Reimbursement cuts and changes in urologist use of androgen deprivation therapy for prostate cancer. *BMC Urol*. 2015;15:25. doi:10.1186/s12894-015-0020-y

37. O'Neil B, Graves AJ, Barocas DA, Chang SS, Penson DF, Resnick MJ. Doing More for More: Unintended Consequences of Financial Incentives for Oncology Specialty Care. *J Natl Cancer Inst*. 2016;108(2). doi:10.1093/jnci/djv331

38. Chang SL, Liao JC, Shinghal R. Decreasing use of luteinizing hormone-releasing hormone agonists in the United States is Independent of Reimbursement Changes: A Medicare and Veterans Health Administration claims analysis. *J Urol*. 2009;182(1):255-260; discussion 261. doi:10.1016/j.juro.2009.02.141

39. Ellis SD, Nielsen ME, Carpenter WR, et al. Gonadotropin-releasing hormone agonist overuse: urologists' response to reimbursement and characteristics associated with persistent overuse. *Prostate Cancer Prostatic Dis*. 2015;18(2):173-181. doi:10.1038/pcan.2015.10

40. Feinberg B, Milligan S, Olson T, et al. Physician behavior impact when revenue shifted from drugs to services. *Am J Manag Care*. 2014;20(4):303-310.

41. Gawade PL, Berlin JA, Henry DH, et al. Changes in the use of erythropoiesis-stimulating agents (ESAs) and red blood cell transfusion in patients with cancer amidst regulatory and reimbursement changes. *Pharmacoepidemiol Drug Saf*. 2017;26(11):1357-1366. doi:10.1002/pds.4293

42. Hershman DL, Neugut AI, Shim JJ, Glied S, Tsai W-Y, Wright JD. Erythropoiesis-stimulating agent use after changes in medicare reimbursement policies. *J Oncol Pract*. 2014;10(4):264-269. doi:10.1200/JOP.2013.001255

43. Hess G, Nordyke RJ, Hill J, Hulnick S. Effect of reimbursement changes on erythropoiesis-stimulating agent utilization and transfusions. *Am J Hematol*. 2010;85(11):838-843. doi:10.1002/ajh.21837

44. Loy BA, Shkedy CI, Powell AC, et al. Do Case Rates Affect Physicians' Clinical Practice in Radiation Oncology?: An Observational Study. *PloS One*. 2016;11(2):e0149449. doi:10.1371/journal.pone.0149449

