Supplementary Online Content

Obermeyer z, Makar M, Abujaber S, Dominici F, Block S, Cutler DM. Association between the Medicare hospice benefit and health care utilization and costs for patients with poor-prognosis cancer. *JAMA*. doi:10.1001/jama.2014.14950

eTable 1. List of International Classification of Diseases (ICD) Codes Corresponding to Poor-Prognosis Malignancies

eAppendix. Propensity Score Matching (PSM) Methods

eTable 2. Coarsened Exact Matching (CEM) Algorithm

eTable 3. List of Claims-Based Codes Corresponding to Cancer-Directed Treatment

eTable 4. Characteristics of the CEM Cohort Compared to All Medicare Fee-for-Service Poor-Prognosis Cancer Deaths (2011)

eFigure 1. Histogram of Time From Poor-Prognosis Cancer Diagnosis to Death

eFigure 2. Study Population, PSM Cohort

eTable 5. Baseline Characteristics, PSM Cohort

eTable 6. Cost Trajectories Before and After Hospice Start, PSM Cohort

eFigure 3. Visualization of Cost Trajectories Before and After Hospice Start, PSM Cohort

eTable 7. Care Utilization During Exposure Periods in the Last Year of Life for the PSM Cohort

eTable 8. Total Costs in the Last Year of Life, PSM Cohort

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

eTable 1. List of *International Classification of Diseases* (*ICD*) Codes Corresponding to Poor-Prognosis Malignancies

Poor-prognosis solid (incl. metastatic and ill defined)		**Poor prognosis hematological**	
Diagnosis	*ICD9*	*Diagnosis*	*ICD9*
mal neo head/face/neck	195.0	retclsrc unsp xtrndl org	200.00
mal neo oth/ill-def site*	195	reticulosarcoma head	200.01
malign neopl thorax	195.1	reticulosarcoma thorax	200.02
malig neo abdomen	195.2	reticulosarcoma abdom	200.03
malign neopl pelvis	195.3	reticulosarcoma axilla	200.04
malign neopl arm	195.4	reticulosarcoma inguin	200.05
malign neopl leg	195.5	reticulosarcoma pelvic	200.06
malig neo site nec	195.8	reticulosarcoma spleen	200.07
mal neo lymph-head/neck	196.0	reticulosarcoma mult	200.08
mal neo lymph-intrathor	196.1	lymphsrc unsp xtrndl org	200.10
mal neo lymph intra-abd	196.2	lymphosarcoma head	200.11
mal neo lymph-axilla/arm	196.3	lymphosarcoma thorax	200.12
mal neo lymph-inguin/leg	196.5	lymphosarcoma abdom	200.13
mal neo lymph-intrapelv	196.6	lymphosarcoma axilla	200.14
mal neo lymph node-mult	196.8	lymphosarcoma inguin	200.15
mal neo lymph node nos	196.9	lymphosarcoma pelvic	200.16
secondary malig neo lung	197.0	lymphosarcoma spleen	200.17
secondry mal neo gi/resp*	197	lymphosarcoma mult	200.18
sec mal neo mediastinum	197.1	brkt tmr unsp xtrndl org	200.20
second malig neo pleura	197.2	burkitt's tumor head	200.21
sec malig neo resp nec	197.3	burkitt's tumor thorax	200.22
sec malig neo sm bowel	197.4	burkitt's tumor abdom	200.23
sec malig neo lg bowel	197.5	burkitt's tumor axilla	200.24
sec mal neo peritoneum	197.6	burkitt's tumor inguin	200.25
second malig neo liver	197.7	burkitt's tumor pelvic	200.26
sec mal neo gi nec	197.8	burkitt's tumor spleen	200.27
second malig neo kidney	198.0	burkitt's tumor mult	200.28
sec malig neo urin nec	198.1	margnl zone lym xtrndl	200.30
secondary malig neo skin	198.2	margin zone lym head	200.31
sec mal neo brain/spine	198.3	margin zone lym thorax	200.32
sec malig neo nerve nec	198.4	margin zone lym abdom	200.33
secondary malig neo bone	198.5	margin zone lym axilla	200.34
second malig neo ovary	198.6	margin zone lym inguin	200.35
second malig neo adrenal	198.7	margin zone lym pelvic	200.36
oth secondary malig neo*	198.8	margin zone lymph spleen	200.37
second malig neo breast	198.81	margin zone lymph multip	200.38
second malig neo genital	198.82	mantle cell lym xtrrndl	200.40
secondary malig neo nec	198.89	mantle cell lymph head	200.41
malig neo disseminated	199.0	mantle cell lymph thorax	200.42
malignant neoplasm nos	199.1	mantle cell lymph abdom	200.43
malig neopl-transp organ	199.2	mantle cell lymph axilla	200.44
sec neuroendo tumor nos	209.70	mantle cell lymph inguin	200.45
sec neuroend tu dist lym	209.71	mantle cell lymph pelvic	200.46
sec neuroend tumor-liver	209.72	mantle cell lymph spleen	200.47
sec neuroendo tumor-bone	209.73	mantle cell lymph multip	200.48
sec neuroendo tu-periton	209.74	primary cns lymph xtrndl	200.50
secondary merkel cell ca	209.75	primary cns lymph head	200.51
sec neuroend tu oth site	209.79	primary cns lymph thorax	200.52

…continued eTable 1.

Poor-prognosis solid (incl. metastatic and ill-defined)		**Poor prognosis hematological**	
Diagnosis	*ICD9*	*Diagnosis*	*ICD9*
path fx unspecified site	733.10	primary cns lymph abdom	200.53
path fx humerus	733.11	primary cns lymph axilla	200.54
path fx dstl radius ulna	733.12	primary cns lym inguin	200.55
path fx vertebrae	733.13	primary cns lymph pelvic	200.56
path fx neck of femur	733.14	primary cns lymph spleen	200.57
path fx oth spcf prt fmr	733.15	primary cns lymph multip	200.58
path fx tibia fibula	733.16	anaplastic lymph xtrndl	200.60
path fx oth specif site	733.19	anaplastic lymph head	200.61
malignant ascites	789.51	anaplastic lymph thorax	200.62
aftrcare path fx arm nos	V54.20	anaplastic lymph abdom	200.63
aftercare path fx up arm	V54.21	anaplastic lymph axilla	200.64
aftrcare path fx low arm	V54.22	anaplastic lymph inguin	200.65
aftercare path fx hip	V54.23	anaplastic lymph pelvic	200.66
aftrcare path fx leg nos	V54.24	anaplastic lymph spleen	200.67
aftrcare path fx up leg	V54.25	anaplastic lymph multip	200.68
aftrcare path fx low leg	V54.26	large cell lymph xtrndl	200.70
aftrcare path fx vertebr	V54.27	large cell lymphoma head	200.71
aftrcre path fx bone nec	V54.29	large cell lymph thorax	200.72
mal neo cervical esophag	150.0	large cell lymph abdom	200.73
mal neo thoracic esophag	150.1	large cell lymph axilla	200.74
mal neo abdomin esophag	150.2	large cell lymph inguin	200.75
mal neo upper 3rd esoph	150.3	large cell lymph pelvic	200.76
mal neo middle 3rd esoph	150.4	large cell lymph spleen	200.77
mal neo lower 3rd esoph	150.5	large cell lymph multip	200.78
mal neo esophagus nec	150.8	oth varn unsp xtrndl org	200.80
mal neo esophagus nos	150.9	mixed lymphosarc head	200.81
mal neo stomach cardia	151.0	mixed lymphosarc thorax	200.82
malignant neo stomach*	151	mixed lymphosarc abdom	200.83
malignant neo pylorus	151.1	mixed lymphosarc axilla	200.84
mal neo pyloric antrum	151.2	mixed lymphosarc inguin	200.85
mal neo stomach fundus	151.3	mixed lymphosarc pelvic	200.86
mal neo stomach body	151.4	mixed lymphosarc spleen	200.87
mal neo stom lesser curv	151.5	mixed lymphosarc mult	200.88
mal neo stom great curv	151.6	mult mye w/o achv rmson	203.00
malig neopl stomach nec	151.8	mult myeloma in relapse	203.02
malig neopl stomach nos	151.9	pls cl leu w/o achv rmsn	203.10
mal neo liver, primary	155.0	oth imno npl wo ach rmsn	203.80
malignant neoplasm liver*	155	ac lym leuk wo achv rmsn	204.00
mal neo intrahepat ducts	155.1	ch lym leuk wo achv rmsn	204.10
malignant neo liver nos	155.2	chr lymp leuk in relapse	204.12
mal neo pancreas head	157.0	oth lym leu wo achv rmsn	204.80
mal neo pancreas body	157.1	uns lym leu wo ach rmsn	204.90
mal neo pancreas tail	157.2	ac myl leuk wo achv rmsn	205.00
mal neo pancreatic duct	157.3	act myel leuk in relapse	205.02
mal neo islet langerhans	157.4	ch myl leuk wo achv rmsn	205.10
malig neo pancreas nec	157.8	chr myel leuk in relapse	205.12
malig neo pancreas nos	157.9	sbac myl leu wo ach rmsn	205.20
mal neo retroperitoneum	158.0	sbac myl leuk in relapse	205.22
mal neo peritoneum nec	158.8	myl sarcoma wo achv rmsn	205.30
mal neo peritoneum nos	158.9	myel sarcoma in relapse	205.32
malig neo intestine nos	159.0	oth my leuk wo achv rmsn	205.80

…continued eTable 1.

Poor-prognosis solid (incl. metastatic and ill-defined)		**Poor prognosis hematological**	
Diagnosis	*ICD9*	*Diagnosis*	*ICD9*
oth malig neo gi/periton*	159	oth myel leuk in relapse	205.82
malignant neo spleen nec	159.1	uns my leu wo ach rmsn	205.90
mal neo gi/intra-abd nec	159.8	myel leuk nos in relapse	205.92
mal neo gi tract ill-def	159.9	ac mono leu wo achv rmsn	206.00
malignant neo trachea	162.0	act mono leuk w rmsion	206.01
malig neo main bronchus	162.2	act mono leuk in relapse	206.02
mal neo upper lobe lung	162.3	ch mono leu wo achv rmsn	206.10
mal neo middle lobe lung	162.4	chr mono leuk w rmsion	206.11
mal neo lower lobe lung	162.5	chr mono leuk in relapse	206.12
mal neo bronch/lung nec	162.8	sbac mno leu wo ach rmsn	206.20
mal neo bronch/lung nos	162.9	sbac mono leuk w rmsion	206.21
mal neo parietal pleura	163.0	sbac mono leu in relapse	206.22
mal neo visceral pleura	163.1	ot mono leu wo achv rmsn	206.80
malig neopl pleura nec	163.8	oth mono leuk w rmsion	206.81
malig neopl pleura nos	163.9	uns mno leu wo ach rmsn	206.90
malignant neopl thymus	164.0	uns mono leuk w rmsion	206.91
malignant neopl heart	164.1	mono leuk nos relapse	206.92
mal neo ant mediastinum	164.2	oth leuk w/o achv rmsn	207.80
mal neo post mediastinum	164.3	ac leu un cl wo ach rmsn	208.00
mal neo mediastinum nec	164.8	ch leu un cl wo ach rmsn	208.10
mal neo mediastinum nos	164.9	ot leu un cl wo ach rmsn	208.80
mal neo upper resp nos	165.0	leuk nos w/o achv rmsn	208.90
mal neo thorax/resp nec	165.8	leukemia nos in relapse	208.92
mal neo resp system nos	165.9	hi grde myelodys syn les	238.73
malign neopl cerebrum	191.0		
malignant neoplasm brain*	191		
malig neo frontal lobe	191.1		
mal neo temporal lobe	191.2		
mal neo parietal lobe	191.3		
mal neo occipital lobe	191.4		
mal neo cereb ventricle	191.5		
mal neo cerebellum nos	191.6		
mal neo brain stem	191.7		
malig neo brain nec	191.8		
malig neo brain nos	191.9		
mal neo cranial nerves	192.0		
mal neo cerebral mening	192.1		
mal neo spinal cord	192.2		
mal neo spinal meninges	192.3		
mal neo nervous syst nec	192.8		
mal neo nervous syst nos	192.9		
primary cns lymph xtrndl	200.50		
primary cns lymph head	200.51		
primary cns lymph thorax	200.52		
primary cns lymph abdom	200.53		
primary cns lymph axilla	200.54		
primary cns lym inguin	200.55		
primary cns lymph pelvic	200.56		
primary cns lymph spleen	200.57		
primary cns lymph multip	200.58		

…continued eTable 1.

Poor-prognosis solid (incl. metastatic and ill-defined)		**Poor prognosis hematological**	
Diagnosis	*ICD9*	*Diagnosis*	*ICD9*
mal crcnoid sm intst nos	209.00		
malig carcinoid duodenum	209.01		
malig carcinoid jejunum	209.02		
malig carcinoid ileum	209.03		
mal crcnoid lg intst nos	209.10		
malig carcinoid appendix	209.11		
malig carcinoid cecum	209.12		
mal crcnoid ascend colon	209.13		
mal crcnoid transv colon	209.14		
mal carcinoid desc colon	209.15		
mal carcinoid sig colon	209.16		
malig carcinoid rectum	209.17		
mal crcnd prim site unkn	209.20		
mal carcinoid bronc/lung	209.21		
malig carcinoid thymus	209.22		
malig carcinoid stomach	209.23		
malig carcinoid kidney	209.24		
mal carcnoid foregut nos	209.25		
mal carcinoid midgut nos	209.26		
mal carcnoid hindgut nos	209.27		
malig carcinoid oth site	209.29		
malig neuroendo ca nos	209.30		
merkel cell ca-face	209.31		
merkel cell ca-sclp/neck	209.32		
merkel cell ca-up limb	209.33		
merkel cell ca-low limb	209.34		
merkel cell ca-trunk	209.35		
merkel cell ca-oth sites	209.36		
unc beh neo brain/spinal	237.5		
respiratory neoplasm nos	239.1		
brain neoplasm nos	239.6		

eAppendix. Propensity Score Matching (PSM) Methods

Matching

The study population was defined in the same way as described in the main article, and we similarly split the sample into beneficiaries who claimed the hospice benefit at any time before death, and those who did not.

To match beneficiaries, we implemented the PSM algorithm described by Ho *et. al.*.[1] We first estimated the propensity to receive hospice care by logistic regression of hospice status on age, sex, race, household income (based on zip code), time from poor-prognosis diagnosis to death, state of residence, comorbidity, inpatient days, and cost in the year prior to cancer diagnosis. We did not match on any variables defined with respect to hospice start, since control exposure periods could only be defined after matching—with respect to the hospice start date of the matched hospice beneficiary. Cases were matched to controls by iteratively identifying pairs with the smallest difference in modeled propensity score, in descending order of score. After defining exposure periods for hospice and non-hospice groups, we identified and excluded matched pairs where one or both beneficiaries received chemotherapy or cancer-directed surgery after exposure. This created a cohort matched on preference for no further treatment.

The remainder of the statistical analysis proceeded in the same manner as described in the main article.

Study population

Of the 86,851 beneficiaries with a prior diagnosis of end-stage malignancy, less 0.9% with non-US addresses or missing death date, 100% of the smaller non-hospice group were matched, giving a PSM cohort of 34,927 matched pairs, summarized in eFigure 2[1]. We excluded 4,289 pairs where one or both beneficiaries received chemotherapy or cancer-directed treatment yielding a final cohort of 30,638 matched pairs.

eTable 5 shows baseline characteristics of the PSM cohort, which are generally similar to the CEM cohort described in the main text. One key advantage of PSM over CEM was the ability to match the entire eligible cohort with end-stage cancer. As shown in eFigure 1, distribution of time from diagnosis to death was skewed, meaning that categorical CEM—even in coarse intervals of up to four months—produced fewer matches, particularly when the additional constraints of age, sex, and region were introduced. In general, the ability to match the entire cohort in the PSM framework would be expected to improve generalizability of the findings.

On the other hand, PSM produced imbalance on important covariates, with statistically significant differences between hospice and non-hospice groups on several variables, all of which are known predictors of health care costs as shown in eTable 5. Hospice beneficiaries were significantly older, less likely to be male, were wealthier, had fewer recorded comorbid illnesses, and had a shorter time from diagnosis to death—despite the fact that all these variables were used for matching. In addition, there were major geographic differences between groups, with median distance between pairs of 812 miles (compared to 25 in the CEM cohort). All of these likely correlate with health care costs, and indeed hospice beneficiaries' daily costs over the year prior to exposure were significantly lower, $135 vs. $149 for non-hospice (difference: $14, 95% CI: $12-16; eTable 6).

[1] Figures and tables are numbered in order of appearance in the main manuscript

This was in part the result of the imbalance in time from poor-prognosis diagnosis to death, 436 days for non-hospice and 286 for hospice: this year would have included a median of 79 days before hospice beneficiaries received their poor-prognosis diagnosis, artificially lowering costs. Over the period from 2006 to exposure start, rates of inpatient admission and emergency visits were similar, though more hospice beneficiaries had claims for active cancer treatment, clinic visits and home health days. Hospice beneficiaries had more days of home health assistance, and a smaller percent used skilled nursing facilities.

Utilization and costs

eTable 7 shows measures of care utilization in the last year of life, restricted to the exposure periods (*i.e.*, during hospice or the equivalent period before death for non-hospice controls). Hospitalizations were more common for non-hospice beneficiaries, and dominated by acute conditions (*e.g.*, infections, organ failure) or exacerbations of medical comorbidities. Only one of the ten most common discharge diagnoses directly pertained to cancer. Rates of intensive care, chemotherapy, and invasive procedures were all higher for non-hospice beneficiaries. Seventy two percent of non-hospice beneficiaries died in facilities—two-thirds in acute care hospitals and the rest in long-term hospitals or SNFs—compared to 13% of hospice.

eTable 6 shows the cost trajectories of non-hospice and hospice beneficiaries, comparing mean daily cost during three key periods: the year before the exposure period, excluding the week before exposure; the week prior to exposure start; and the week before death. Over the year prior to exposure, the non-hospice group had daily costs $149 (95% CI: $147-151) compared to $135 (95% CI: $134-137) for hospice, a difference of $14 (95% CI: $12-16). In the one-week period prior to hospice start, the hospice group cost $729 (95% CI: $719-739) daily, a significant difference of $174 (95% CI: $159-188) relative to non-hospice controls, but declined rapidly thereafter. By the last week of life, non-hospice beneficiaries cost $1,730 (95% CI: $1,697, 1,762) compared to $539 (95% CI: $529,549) for hospice, a difference of $1,191 (95% CI: $1,158, 1,223). eFigure 3 graphically represents daily costs for individual groups of beneficiaries, separated based on the length of the exposure period (*i.e.*, time from hospice start to death, or the equivalent period of non-hospice care for controls).

eTable 8 shows cumulative total costs over the last year of life, by length of hospice enrollment; we calculated total costs over the last year, irrespective of exposure period start, for comparability to other studies. Across the entire cohort, costs over the last year of life were $71,860 (95% CI: $71,094-72,626) for non-hospice and $59,037 (95% CI: $58,535-59,538) for hospice, a difference of $12,823 (95% CI: $11,921-13,726). The maximum difference occurred in beneficiaries enrolled in hospice for 3-4 weeks, who had a total cumulative cost of $55,608 (95% CI: 54,333- 56,882) compared to $73,890 (95% CI: 71,862-75,918) for non-hospice, a difference of $18,282 (95% CI: 15,938-20,627). The maximum difference in the CEM cohort, on the other hand, was at 5-8 weeks; PSM beneficiaries at this length of hospice stay had cumulative costs of $55,519 (95% CI: $54,222-56,815) compared to $72,904 (95% CI: $70,691-75,118) for non-hospice controls, a difference of $17,386 (95% CI: $14,864-19,926).

References

1. Ho DE, Imai K, King G, Stuart EA. Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference. Polit Anal 2007;15(3):199–236.

eTable 2. Coarsened Exact Matching (CEM) Algorithm

	Variable				
Matching iteration	**Sex**	**Illness duration**	**Region**	**Age**	**Number of matched pairs**
1	Male/female	Months from diagnosis to death	Home zip code	Year of birth (YOB)	<10
2				2-year YOB blocks	<10
3				5-year YOB blocks	<10
7			Home hospital service area	YOB	973
8				2-year YOB blocks	954
9				5-year YOB blocks	1,647
10			Home hospital referral region	YOB	2,626
11				2-year YOB blocks	2,197
12				5-year YOB blocks	3,056
13		2-month blocks of time from diagnosis to death	Home zip code	YOB	<10
14				2-year YOB blocks	<10
15				5-year YOB blocks	<10
19			Home hospital service area	YOB	255
20				2-year YOB blocks	340
21				5-year YOB blocks	535
22			Home hospital referral region	YOB	775
23				2-year YOB blocks	861
24				5-year YOB blocks	1,364
…					
36	Male/female	4-month blocks of time from diagnosis to death	Home hospital referral region	5-year YOB blocks	599
Matched					20,612
Excluded 2,447 pairs because one of the beneficiaries received chemotherapy or surgical treatment					
Total					18,165

eTable 2 Illustrates the one-to-one CEM algorithm based on region, age, sex, and time from first poor-prognosis cancer diagnosis to death. In iteration 1, beneficiaries are matched based first on the finest strata of each variable (zip code, year of birth, sex, months from diagnosis to death). In iteration 2, beneficiaries not matched in iteration 1 are matched based on the same variables except with a coarsened measure of age, a 2-year block of year of birth. Matching proceeds iteratively with progressively coarsened variables, reaching a maximum of five-year age intervals, four-month illness duration intervals, and hospital referral region.

eTable 3. List of Claims-Based Codes Corresponding to Cancer-Directed Treatment

Chemotherapy		**Surgery**	
Description	Code	Description	Code
HCPCS codes [a]		**ICD 9 procedure codes**	
Chemotherapy J codes	all J9 codes	implant chemotherapy agent	00.10
Chemotherapy administration by other than infusion technique only (e.g. subcutaneous, intramuscular, push), per visit	Q0083	high-dose infusion il-2	00.15
Chemotherapy administration by infusion technique only, per visit	Q0084	unilat thyroid lobectomy	06.2
Chemotherapy administration by both infusion technique and other technique(s) (e.g. subcutaneous, intramuscular, push), per visit	Q0085	excision thyroid lesion	06.31
Chemotherapy administration	96400-96549	part thyroidectomy nec	06.39
		complete thyroidectomy	06.4
Revenue center codes		substern thyroidect nos	06.50
Radiology therapeutic-chemotherapy injected	0331	part substern thyroidect	06.51
Radiology therapeutic-chemotherapy oral	0332	tot substern thyroidect	06.52
Radiology therapeutic-chemotherapy IV	0335	lingual thyroid excision	06.6
		lap mul seg res lg intes	17.31
ICD 9 procedure code		laparoscopic cecectomy	17.32
inject ca chemother nec	99.25	lap right hemicolectomy	17.33
		lap res transverse colon	17.34
ICD 9 diagnosis code		lap left hemicolectomy	17.35
chemotherapy encounter#	V58.1	lap sigmoidectomy	17.36
		lap pt ex lrg intest nec	17.39
		iv infusion clofarabine	17.70
		thorac exc lung lesion	32.20
		emphysema bleb plication	32.21
		lung vol reduction surg	32.22
		open abltn lung les/tiss	32.23
		perc abltn lung les/tiss	32.24
		thor abltn lung les/tiss	32.25
		abltn lung tiss nec/nos	32.26
		brnc thrmplsty,ablt mscl	32.27
		destroy loc lung les nec	32.29
		segmental lung resection#	32.3
		thorac seg lung resect	32.30

…continued eTable 3.

		oth seg lung resect nos	32.39
		lobectomy of lung#	32.4
		thorac lobectomy lung	32.41
		lobectomy of lung nec	32.49
		complete pneumonectomy#	32.5
		thoracospc pneumonectomy	32.50
		other pneumonectomy nos	32.59
		bone marrow trnsplnt nos	41.00
		auto bone mt w/o purg	41.01
		alo bone marrow trnsplnt	41.02
		allogrft bone marrow nos	41.03
		auto hem stem ct w/o pur	41.04
		allo hem stem ct w/o pur	41.05
		cord bld stem cell trans	41.06
		auto hem stem ct w purg	41.07
		allo hem stem ct w purg	41.08
		auto bone mt w purging	41.09
		proximal gastrectomy	43.5
		distal gastrectomy	43.6
		part gastrec w jej anast	43.7
		part gast w jej transpos	43.81
		lap vertical gastrectomy	43.82
		opn/oth part gastrectomy	43.89
		tot gast w intes interpo	43.91
		total gastrectomy nec	43.99
		mult seg sm bowel excis	45.61
		part sm bowel resect nec	45.62
		total removal sm bowel	45.63
		opn mul seg lg intes nec	45.71
		open cecectomy nec	45.72
		opn rt hemicolectomy nec	45.73
		opn transv colon res nec	45.74
		opn lft hemicolectmy nec	45.75
		open sigmoidectomy nec	45.76
		prt lg intes exc nec/nos	45.79
		tot intra-abd colectomy#	45.8
		lap tot intr-ab colectmy	45.81
		op tot intr-abd colectmy	45.82
		tot abd colectmy nec/nos	45.83
		pull-thru res rectum nos	48.40
		soave submuc rect resect	48.41

…continued eTable 3.

		lap pull-thru res rectum	48.42
		opn pull-thru res rectum	48.43
		pull-thru rect resec nec	48.49
		abd-perineal rect resect#	48.5
		abdperneal res rectm nos	48.50
		lap abdperneal resc rec	48.51
		opn abdperneal resc rec	48.52
		abdperneal resc rect nec	48.59
		transsac rectosigmoidect	48.61
		ant rect resect w colost	48.62
		anterior rect resect nec	48.63
		posterior rect resection	48.64
		duhamel rectal resection	48.65
		rectal resection nec	48.69
		partial nephrectomy	55.4
		nephroureterectomy	55.51
		solitary kidney nephrect	55.52
		rejected kidney nephrect	55.53
		bilateral nephrectomy	55.54
		unilateral oophorectomy*	65.3
		lap unilat oophorectomy	65.31
		oth unilat oophorectomy	65.39
		unilat salpingo-oophorec*	65.4
		lap uni salpingo-oophor	65.41
		oth uni salpingo-oophor	65.49
		oth remove both ovaries	65.51
		oth remove remain ovary	65.52
		lap remove both ovaries	65.53
		lap remove remain ovary	65.54
		oth remove ovaries/tubes	65.61
		oth remove rem ova/tube	65.62
		lap remove ovaries/tubes	65.63
		lap remove rem ova/tube	65.64
		subtot abd hysterectomy#	68.3
		lap scervic hysterectomy	68.31
		subtotl abd hyst nec/nos	68.39
		total abd hysterectomy#	68.4
		lap total abdominal hyst	68.41
		total abd hyst nec/nos	68.49
		vaginal hysterectomy*	68.5
		lap ast vag hysterectomy	68.51

…continued eTable 3.

		vag hysterectomy nec/nos	68.59
		radical abd hysterectomy#	68.6
		lap radical abdomnl hyst	68.61
		radical abd hyst nec/nos	68.69
		radical vag hysterectomy#	68.7
		lap radical vaginal hyst	68.71
		radical vag hyst nec/nos	68.79
		hysterectomy nec/nos	68.9
		unilat simple mastectomy	85.41
		bilat simple mastectomy	85.42
		unilat exten simp mastec	85.43
		bilat extend simp mastec	85.44
		unilat radical mastectom	85.45
		bilat radical mastectomy	85.46
		unil ext rad mastectomy	85.47
		bil exten rad mastectomy	85.48
		inject ca chemother nec	99.25
		immunotherapy as antineo	99.28

[a] HCPCS refers to healthcare common procedure coding system

All ICD9 procedure codes were acquired from outpatient and MedPar files while ICD9 diagnosis codes were acquired from outpatient, MedPar and carrier files.

All revenue center codes were acquired from the outpatient file while HCPCS codes were acquired from carrier and outpatient files

eTable 4. Characteristics of the CEM Cohort Compared to All Medicare Fee-for-Service Poor-Prognosis Cancer Deaths (2011)

Variable	All poor-prognosis non-hospice deaths (N=34,927)	All poor-prognosis hospice deaths (N=51,924)	Difference: all poor-prognosis non-hospice deaths vs. matched non-hospice cohort	Difference: all poor-prognosis hospice deaths vs. matched hospice cohort
Variables used for CEM				
Age in years, mean (95% CI) [a]	78.5 (78.4, 78.6)	79.4 (79.3, 79.5)	-1.4 (-1.6, -1.3)	-0.6 (-0.8, -0.4)
Male, % (95% CI)[a]	49.8 (49.2, 50.3)	46.7 (46.3, 47.2)	1.7 (0.8, 2.6)	-1.3 (-2.1, -0.4)
Days from poor-prognosis cancer diagnosis to death, median (25th, 75th percentile) [b]	413 (77, 1074)	367 (92.5, 962)	200 (183.9, 216.1)	157 (144.4, 169.6)
Demographics				
White, % (95% CI) [a]	84.8 (84.4, 85.2)	88.5 (88.2, 88.8)	0.1 (-0.5, 0.8)	0.8 (0.2, 1.3)
Income of beneficiary home zip code, median (25th, 75th percentile) [b]	62.1 (51.2, 81.2)	63.5 (52.4, 82.8)	-0.7 (-1.2, -0.3)	-1.4 (-1.9, -1)
Region, % (95% CI) [a]				
Northeast	22.6 (22.2, 23)	18 (17.6, 18.3)	-0.1 (-0.9, 0.6)	-4.8 (-5.5, -4.1)
Midwest	23.4 (22.9, 23.8)	25.5 (25.1, 25.8)	-0.2 (-1, 0.5)	1.7 (1, 2.4)
South	36.6 (36.1, 37.1)	40.9 (40.5, 41.4)	-1.2 (-2, -0.3)	3.4 (2.5, 4.2)
West	17.4 (17, 17.8)	15.6 (15.3, 15.9)	1.5 (0.9, 2.2)	-0.3 (-0.9, 0.3)
First poor-prognosis malignancy diagnosis, % (95% CI) [a]				
Solid tumor	87.2 (86.8, 87.5)	91.1 (90.9, 91.4)	-1 (-1.6, -0.4)	0.1 (-0.4, 0.5)
Hematological	13.3 (12.9, 13.7)	9.3 (9, 9.5)	1.1 (0.5, 1.7)	-0.1 (-0.6, 0.4)
Illness and hospice course, median (25th, 75th percentile) [b]				

…continued eTable 4.

Poor-prognosis cancer diagnosis to exposure start, days	-[c]	296 (49, 878)	-[c]	131 (118.4, 143.6)
Exposure start to death, days	-[c]	16 (5, 54)	-[c]	5 (4.4, 5.6)
2006 to poor prognosis cancer diagnosis, days	1579 (921, 1888)	1626 (1040, 1886)	-188 (-203, -173)	-144 (-156.3, -131.7)
Comorbidity index, median (25th, 75th percentile) [b d]				
2006 to poor-prognosis cancer diagnosis	3 (1, 6)	3 (1, 5)	0 (-0.1, 0.1)	0 (-0.1, 0.1)
Poor-prognosis diagnosis to exposure start	-[c]	7 (4, 9)	-[c]	0 (0, 0)
Presence of selected individual comorbidities related to functional status, 2006 to exposure start, % (95% CI) [a]				
Anemia	40.1 (39.6, 40.6)	68.5 (68.1, 68.9)	-28.4 (-29.3, -27.5)	0.2 (-0.6, 1)
Dementia	9.7 (9.4, 10)	17.5 (17.1, 17.8)	-8.3 (-8.9, -7.7)	-0.6 (-1.2, 0.1)
Fluid and electrolyte disorders	41.2 (40.7, 41.8)	71.5 (71.1, 71.9)	-30.4 (-31.3, -29.5)	0.3 (-0.5, 1.1)
Hemiplegia	3.8 (3.6, 4)	6.9 (6.7, 7.1)	-3 (-3.4, -2.6)	0.2 (-0.3, 0.6)
Weight loss	14.6 (14.2, 15)	25.6 (25.2, 26)	-11.6 (-12.3, -10.9)	-0.2 (-1, 0.5)
Healthcare utilization, 2006 to exposure start				
Inpatient admissions, median (25th, 75th percentile) [b]	-[c]	3 (2, 6)	-[c]	0 (0, 0)
Emergency visits, median (25th, 75th percentile) [b]	-[c]	4 (2, 7)	-[c]	0 (0, 0)
Clinic visits, median (25th, 75th percentile) [b]	-[c]	47 (25, 75)	-[c]	2 (1.2, 2.8)
Home health days , median (25th, 75th percentile) [b]	-[c]	8 (0, 32)	-[c]	1 (0.5, 1.5)
Use of SNF, % (95% CI) [a]	-[c]	46.5 (46.1, 46.9)	-[c]	0 (-0.8, 0.9)
Claim for active cancer treatment, % (95% CI) [a f]	-[c]	51.1 (50.5, 51.6)	-[c]	6.5 (5.6, 7.4)

eTable 4 shows characteristics and differences between the CEM cohort and the overall cohort of all poor-prognosis cancer deaths from which it was drawn during the baseline period before exposure, *i.e.*, before the start of hospice or the equivalent period for non-hospice beneficiaries.

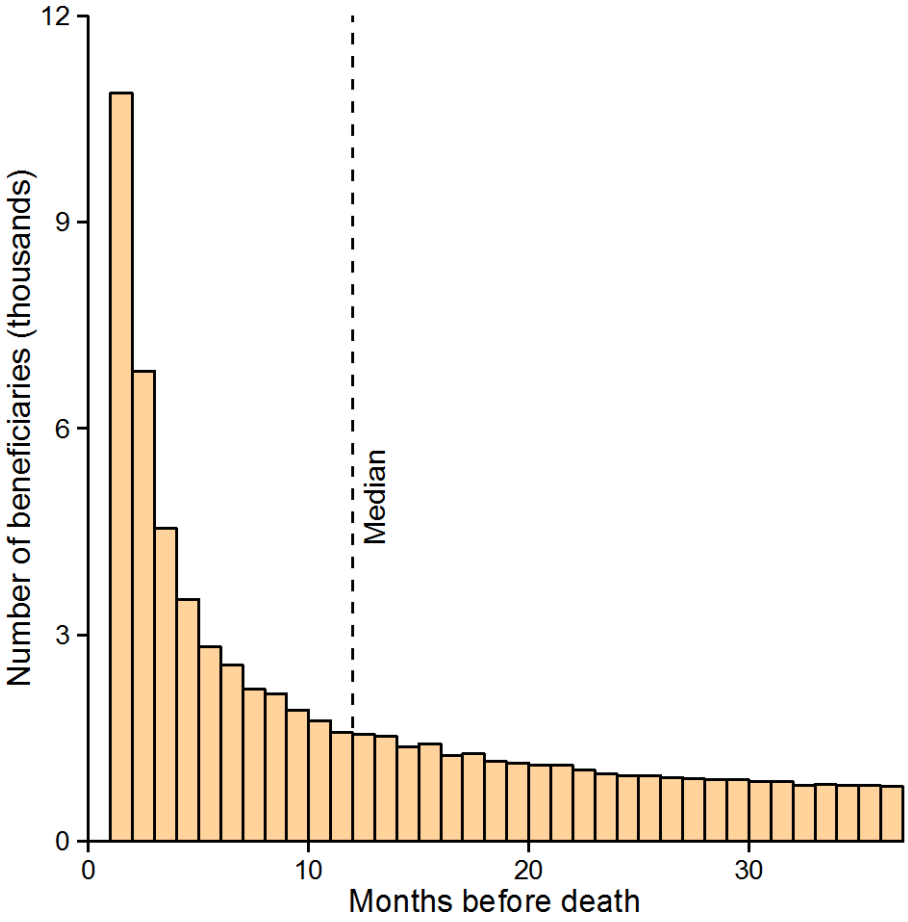
[a] For normally-distributed and binary variables, we report means and proportions, respectively, with 95% confidence intervals in parentheses. Differences are calculated by *t*-test and proportion test, respectively.

[b] For non-normally-distributed variables, medians are reported, with 25th, 75th percentiles in parentheses. Difference and 95% confidence interval are calculated by quantile regression.

…continued eTable 4.

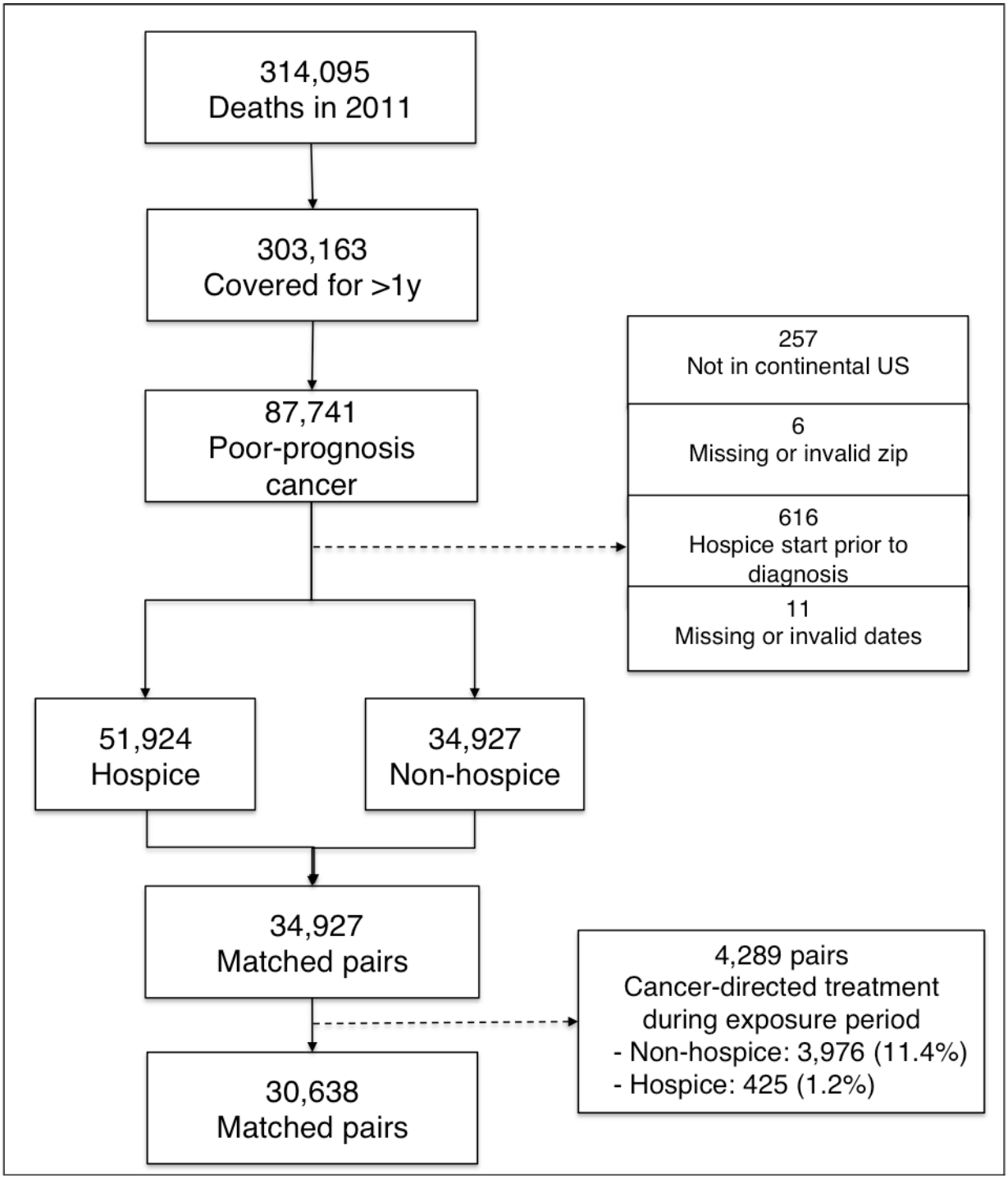
[c] Since exposure period for non-hospice controls is defined as the same number of days prior to death as their matched hospice pair, unmatched non-hospice beneficiaries do not have an exposure period yielding missing values for variables measured during time periods defined relative to exposure start.
[d] Gagne comorbidity score, measured on a composite scale synthesizing Elixhauser and Charlson indices, scale ranges from -2 to 26.

eFigure 1. Histogram of Time From Poor-Prognosis Cancer Diagnosis to Death



Each bar shows the number of beneficiaries with the calculated time from diagnosis to death on the x-axis.

eFigure 2. Study Population, PSM Cohort



eFigure 2 shows the creation of the matched cohort, starting with all beneficiaries who died in 2011 and restricting to those with a poor-prognosis cancer diagnosis. Some beneficiaries were excluded because of missing zip code or dates, and others because they started hospice prior to cancer diagnosis, likely due to another concurrent terminal illness. After matching exposure periods (see Figure 1b), we drop pairs in which one or both beneficiaries received chemotherapy or potentially curative surgery during the periods, the numbers do not sum since in some pairs both the hospice and the non-hospice beneficiaries received cancer-directed therapy.

eTable 5. Baseline Characteristics of the PSM Cohort

Variable	Matched cohort			
	Non-hospice (N=30,638)	Hospice (N=30,638)	Difference	Std Diff.[d]
Variables used for PSM				
Age in years, mean (95% CI) [a]	79 (78.9, 79.1)	80.6 (80.5, 80.7)	-1.6 (-1.7, -1.4)	-0.16
Male, % (95% CI)[a]	48.9 (48.3, 49.5)	42.4 (41.9, 43)	6.5 (5.7, 7.3)	0.13
White, % (95% CI) [a]	84.7 (84.3, 85.1)	93.9 (93.7, 94.2)	-9.3 (-9.8, -8.8)	-0.30
Income of beneficiary home zip code, median (25th, 75th percentile) [b]	62.1 (51.2, 81.2)	64.1 (53.1, 83.6)	-2 (-2.4, -1.6)	-0.09
Inpatient days in the year before first cancer diagnosis, median (25th, 75th percentile) [b]	0 (0, 6)	0 (0, 3)	0 (0, 0)	0.29
Comorbidity in the year before first cancer diagnosis, median (25th, 75th percentile)[b c]	2 (0, 5)	1 (0, 4)	1 (0.8, 1.2)	-[e]
Costs in the year before first cancer diagnosis in thousands, median (25th, 75th percentile) [b]	9 (2.8, 27.6)	6.6 (2.3, 17.8)	2.4 (2.1, 2.6)	0.28
Days from poor prognosis cancer diagnosis to death , median (25th, 75th percentile) [b]	436 (77, 1103)	286 (69, 821)	150 (135.9, 164.1)	0.22
Demographics				
Region, % (95% CI) [a]				
Northeast	22.8 (22.4, 23.3)	12.3 (11.9, 12.7)	10.5 (9.9, 11.1)	0.28
Midwest	23.4 (22.9, 23.9)	29.8 (29.3, 30.3)	-6.4 (-7.1, -5.7)	-0.15
South	36.2 (35.7, 36.8)	46.3 (45.7, 46.9)	-10.1 (-10.9, -9.3)	-0.21
West	17.5 (17.1, 18)	11.6 (11.2, 12)	5.9 (5.4, 6.5)	0.17
Distance between pairs in miles, median (25th, 75th percentile) [b]	811.9 (465.2, 1302.0)			
First poor-prognosis malignancy diagnosis, % (95% CI) [a]				
Solid tumor	87.7 (87.4, 88.1)	91.1 (90.8, 91.4)	-3.4 (-3.9, -2.9)	-0.11
Hematological	12.7 (12.4, 13.1)	9.3 (9, 9.6)	3.4 (2.9, 3.9)	0.11

…continued eTable 5.

Illness and hospice course, median (25th, 75th percentile) [b]				
Poor-prognosis cancer diagnosis to exposure start, days	393 (49, 1055)	234 (37, 753)	159 (145.4, 172.6)	0.22
Exposure start to death, days	12 (4, 40)	12 (4, 40)	0 (-0.5, 0.5)	0.00
2006 to poor prognosis cancer diagnosis, days	1555 (890, 1885)	1703 (1181, 1913)	-148 (-161.3, -134.7)	-0.22
Comorbidity index, median (25th, 75th percentile) [b c]				
2006 to poor-prognosis cancer diagnosis	3 (1, 6)	2 (1, 5)	1 (1, 1)	- [e]
Poor-prognosis diagnosis to exposure start	6 (2, 9)	7 (4, 9)	-1 (-1, -1)	- [e]
Presence of selected individual comorbidities related to functional status, 2006 to exposure start, % (95% CI) [a]				
Anemia	68.8 (68.3, 69.3)	65.9 (65.3, 66.4)	2.9 (2.2, 3.7)	0.06
Dementia	18.4 (18, 18.9)	16.5 (16.1, 16.9)	1.9 (1.3, 2.5)	0.05
Fluid and electrolyte disorders	70.3 (69.8, 70.8)	69.7 (69.2, 70.2)	0.6 (-0.1, 1.3)	0.01
Hemiplegia	7.1 (6.8, 7.4)	6.2 (6, 6.5)	0.8 (0.5, 1.2)	0.03
Weight loss	25.5 (25, 26)	24.3 (23.8, 24.8)	1.2 (0.5, 1.9)	0.03
Healthcare utilization, 2006 to exposure start				
Inpatient admissions, median (25th, 75th percentile) [b]	3 (1, 6)	3 (1, 5)	0 (0, 0)	- [e]
Emergency visits, median (25th, 75th percentile) [b]	4 (2, 8)	4 (2, 7)	0 (0, 0)	- [e]
Clinic visits, median (25th, 75th percentile) [b]	44 (22, 73)	45 (24, 71)	-1 (-1.7, -0.3)	- [e]
Home health days , median (25th, 75th percentile) [b]	6 (0, 33)	7 (0, 29)	-1 (-1.4, -0.6)	0.06
Use of SNF, % (95% CI) [a]	52.4 (51.9, 53)	44.9 (44.4, 45.5)	7.5 (6.7, 8.3)	0.15
Claim for active cancer treatment, % (95% CI) [a f]	36.6 (36.1, 37.2)	46.6 (46, 47.1)	-10 (-10.7, -9.2)	-0.20
Daily expenses over year prior to exposure start, mean (95% CI) [a]	$149 ($147, 151)	$135 ($134, 137)	$14 ($12, 16)	0.09

eTable 5 shows variables used for propensity score matching and other measures of health and care utilization in the baseline period before exposure, *i.e.*, before the start of hospice or the equivalent period for non-hospice beneficiaries. The third column shows mean or median differences between groups, calculated as described below, and the last column shows standardized differences between groups.

[a] For normally-distributed and binary variables, we report means and proportions, respectively, with 95% confidence intervals in parentheses. Differences are calculated by *t*-test and proportion test, respectively.

…continued eTable 5.

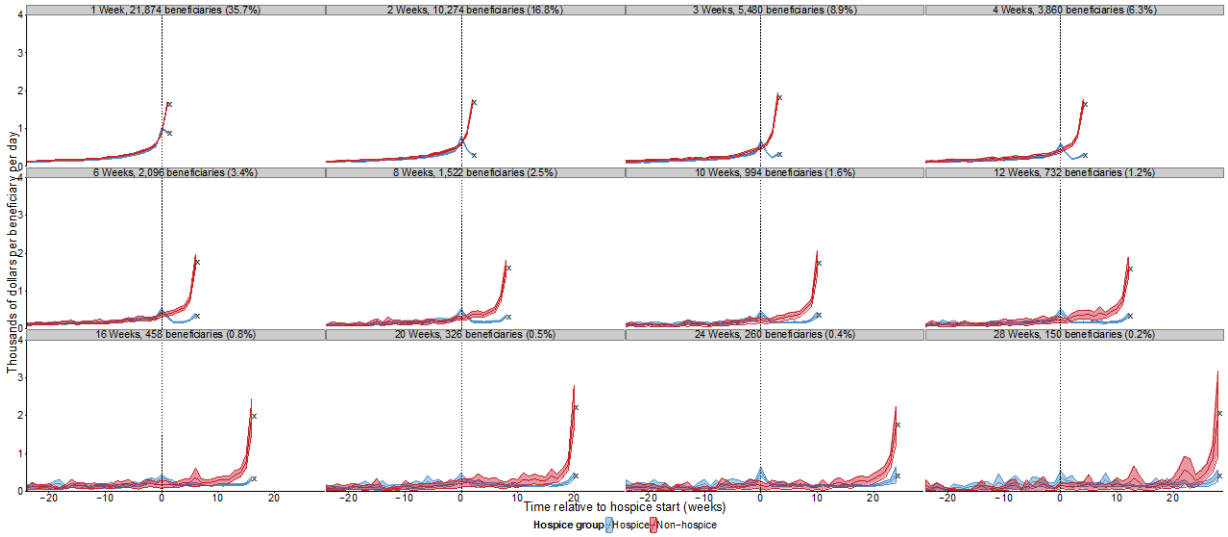
[b] For non-normally-distributed variables, medians are reported, with 25th, 75th percentiles in parentheses. Difference and 95% confidence interval are calculated by quantile regression.
[c] Gagne comorbidity score, measured on a composite scale synthesizing Elixhauser and Charlson indices, scale ranges from -2 to 26.
[d] Standardized difference is the difference in group means divided by the common standard deviation.
[e] Standardized difference cannot be calculated for count variables.
[f] Active cancer treatment refers to chemotherapy or surgery

eTable 6. Cost Trajectories Before and After Hospice Start, PSM Cohort, $/day (95% CI)

	Non Hospice	**Hospice**	**Difference**
Period	**(N=30,638)**	**(N=30,638)**	
Year prior to exposure	$149 ($147, 151)	$135 ($134, 137)	$14 ($12, 16)
Week prior to exposure	$555 ($543, 567)	$729 ($719, 739)	$-174 ($-188, -159)
Last week of life	$1,730 ($1,697, 1,762)	$539 ($529, 549)	$1,191 ($1,158, 1,223)

eTable 6 shows daily costs for non-hospice and hospice beneficiaries, comparing mean daily cost during three key periods: the year before the exposure period, excluding the week before exposure; the week prior to exposure start; and the week before death

eFigure 3. Visualization of Cost Trajectories Before and After Hospice Start, PSM Cohort



eFigure 3 shows mean total daily costs relative to exposure start, with beneficiaries separated into groups based on the length of the exposure period (i.e., the length of hospice or non-hospice care before death). Since showing all 113 groups was not possible, and since aggregation would obscure time trend, we chose representative groups with exposure periods of 1, 2, 3, and 4 weeks, which together make up 67.7% of the entire cohort; every 2 weeks from 6 to 12 weeks (8.7% of the cohort); and every 4 weeks from 16 to 28 (1.9%). "X" marks week of death for each group of beneficiaries. The panel title shows the length of the exposure period in weeks, the number of beneficiaries, and the percentage of the overall matched cohort they make up. The shaded area around the lines shows the 95% confidence interval for the mean; lower CI bounds of less than zero were censored at zero. Week zero is defined as the last week before the first day of hospice.

eTable 7. Care Utilization During Exposure Periods in the Last Year of Life for the PSM Cohort

		Matched cohort		
		Non-hospice	**Hospice**	**Risk ratio**
		(N=30,638)	**(N=30,638)**	
Hospital admission, % (95% CI)		63.1 (62.5, 63.6)	40.5 (40, 41.1)	1.6 (1.5, 1.6)
Primary ICD code (discharge)	Sepsis	9.8 (9.4, 10.1)	3 (2.8, 3.2)	3.3 (3.1, 3.5)
	Pneumonia	4.5 (4.2, 4.7)	2 (1.8, 2.1)	2.2 (2, 2.5)
	Acute/chronic respiratory failure [a]	3.9 (3.7, 4.1)	1.1 (1, 1.3)	3.4 (3, 3.8)
	Pneumonitis (aspiration)	2.2 (2.1, 2.4)	1 (0.9, 1.1)	2.3 (2, 2.6)
	Acute kidney failure	2.1 (2, 2.3)	1.4 (1.3, 1.6)	1.5 (1.3, 1.7)
	Neoplasm of bronchus and lung	1.8 (1.6, 1.9)	1.6 (1.5, 1.8)	1.1 (1, 1.2)
	COPD exacerbation	1.5 (1.4, 1.7)	0.5 (0.5, 0.6)	2.8 (2.3, 3.3)
	Subendocardial infarction	1.2 (1.1, 1.4)	0.4 (0.4, 0.5)	2.9 (2.4, 3.6)
	Urinary tract infection	1.1 (1, 1.2)	0.8 (0.7, 0.9)	1.4 (1.2, 1.7)
	Cerebral artery occlusion (stroke)	1 (0.9, 1.2)	0.7 (0.6, 0.8)	1.4 (1.2, 1.7)
ICU admission, % (95% CI)		34.4 (33.8, 34.9)	14.3 (13.9, 14.7)	2.4 (2.3, 2.5)
ICU		26.2 (25.7, 26.7)	8 (7.7, 8.3)	3.3 (3.2, 3.4)
Step-down or intermediate		9.7 (9.4, 10.1)	6.5 (6.2, 6.7)	1.5 (1.4, 1.6)
Invasive procedures, % (95% CI)		49.3 (48.8, 49.9)	24.5 (24, 25)	2 (2, 2.1)
	Insertion of venous catheter	20.5 (20.1, 21)	6.5 (6.2, 6.7)	3.2 (3, 3.3)
	Endotracheal intubation	18.7 (18.3, 19.2)	2.5 (2.3, 2.7)	7.6 (7, 8.1)
	Packed cell transfusion	15.7 (15.3, 16.1)	7.4 (7.1, 7.7)	2.1 (2, 2.2)
	Platelet or plasma transfusion	6.2 (5.9, 6.5)	2.5 (2.3, 2.6)	2.5 (2.3, 2.7)
	Non-invasive ventilation	5.6 (5.3, 5.9)	1.5 (1.4, 1.6)	3.7 (3.3, 4.1)
	Hemodialysis	4.2 (4, 4.4)	0.8 (0.7, 0.9)	5.4 (4.7, 6.1)
	Thoracentesis	4.1 (3.9, 4.4)	2.3 (2.2, 2.5)	1.8 (1.6, 1.9)
	Cardiopulmonary resuscitation	3.8 (3.6, 4)	0.1 (0.1, 0.2)	31.2 (22.5, 43.3)
	Closed bronchial biopsy	3.5 (3.3, 3.7)	1.1 (1, 1.2)	3.2 (2.9, 3.6)
	Arterial catheterization	3.3 (3.1, 3.5)	0.4 (0.3, 0.4)	8.7 (7.2, 10.5)
Death in facility, % (95% CI)		71.8 (71.3,72.3)	13.1 (12.7,13.5)	5.5 (5.3,5.7)
	Acute care hospital [b]	48 (47.5,48.6)	3 (2.8,3.2)	15.9 (14.9,17)
	Long-term hospital or SNF [c]	23.8 (23.3,24.3)	10.1 (9.7,10.4)	2.4 (2.3,2.5)

eTable 7 shows health care utilization during exposure periods in the last year of life: percent of hospice and non-hospice beneficiaries with an admission, intensive care unit (ICU) stay, procedures, and death in facilities, with 95% confidence intervals. The last column shows the ratio of hospice to non-hospice percentage, calculated as proportion of non-hospice over hospice beneficiaries, with 95% confidence interval (calculated as a relative risk).

[a] Combines ICD codes 518.81 and 518.84

[b] Percent of beneficiaries with an inpatient facility claim on day of death.

[c] Percent of beneficiaries with a claim from a long-term care hospital or skilled nursing facility on day of death. Data on SNFs are incomplete because of Medicare restrictions on the number of SNF days reimbursed per year, so these should be seen as minimum estimates for both groups.
COPD denotes chronic obstructive pulmonary disease
ICD denotes International Classification of Disease codes
ICU denotes Intensive Care Unit
SNF denotes skilled nursing facility

eTable 8. Total Costs in the Last Year of Life, PSM Cohort

			Total cost over last year of life (95% CI)		
Exposure period length (weeks)	**Weeks from diagnosis to death, mean (95 %CI)**	**Matched pairs (n)**	**Non-hospice**	**Hospice**	**Difference**
1	76	10937	**$73,152**	**$62,408**	**$10,744**
	(75, 77)		($71,901, 74,404)	($61,488, 63,329)	($9,213, 12,275)
2	74	5137	**$73,143**	**$59,902**	**$13,241**
	(73, 76)		($71,297, 74,989)	($58,599, 61,205)	($11,023, 15,459)
3-4	76	4670	**$73,890**	**$55,608**	**$18,282**
	(75, 78)		($71,862, 75,918)	($54,333, 56,882)	($15,938, 20,627)
5-8	77	4022	**$72,904**	**$55,519**	**$17,386**
	(75, 78)		($70,691, 75,118)	($54,222, 56,815)	($14,846, 19,926)
9-26	87	4100	**$67,645**	**$56,515**	**$11,129**
	(86, 89)		($65,496, 69,794)	($55,378, 57,653)	($8,721, 13,538)
27-52	98	1108	**$62,734**	**$61,585**	**$1,149**
	(95, 102)		($58,961, 66,506)	($59,946, 63,223)	(-$3,014, 5,312)
> 52	116	664	**$61,301**	**$53,552**	**$7,749**
	(112, 120)		($56,846, 65,755)	($51,824, 55,280)	($2,982, 12,515)
Total	79	30,638	**$71,860**	**$59,037**	**$12,823**
	(78, 80)		($71,094, 72,626)	($58,535, 59,538)	($11,921, 13,726)

eTable 8 shows cumulative total costs for non-hospice and hospice beneficiaries, separated by the length of the exposure period (*i.e.,* period of non-hospice or hospice care before death).