Association Between the Medicare Hospice Benefit and Health Care Utilization and Costs for Patients With Poor-Prognosis Cancer

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Abstract

Importance: More patients with cancer use hospice today than ever before, but there are indications that care intensity outside of hospice is increasing, and length of hospice stay decreasing. Uncertainties regarding how hospice affects health care utilization and costs have hampered efforts to promote it.

Objective: To compare utilization and costs of patients with poor-prognosis cancers enrolled in hospice to similar patients without hospice care.

Design: Matched case–control study of hospice and non-hospice care.

Setting: Nationally-representative 20% sample of Medicare fee-for-service beneficiaries who died in 2011.

Participants: Patients with poor-prognosis cancers (*e.g.*, brain, pancreatic, metastatic malignancies) enrolled in hospice before death, matched to similar patients who died without hospice care. Matched pairs in which either patient received cancer-directed treatment after exposure were excluded.

Exposure: Defined as the time period between hospice enrollment and death for hospice beneficiaries, and the equivalent period of non-hospice care before death for matched controls.

Main Outcomes: Health care utilization including hospitalizations and procedures; place of death; cost trajectories before and after hospice start; and cumulative costs, all over the last year of life.

Results: Among 86,851 patients with poor-prognosis cancers, median time from first poor-prognosis diagnosis to death was 13 months (IQR: 3-34), and 51,924 (60%) entered hospice before death. Matching yielded a cohort balanced on age, sex, region, time from poor-prognosis diagnosis to death, and baseline care utilization, with 18,165 patients in the hospice group and 18,165 in the non-hospice group. After matching, 11% of non-hospice and 1% of hospice beneficiaries who had cancer-directed therapy after exposure were excluded. Median hospice duration was 11 days. Non-hospice beneficiaries had significantly more hospitalizations (65%, 95% CI: 64-66%, vs. hospice: 42%, 95% CI 42-43%, risk ratio: 1.5, 95% CI: 1.5-1.6), intensive care (36%, 95% CI: 35-37%, vs. hospice: 15%, 95% CI: 14-15%, risk ratio: 2.4, 95% CI: 2.3-2.5), and procedures (51%, 95% CI: 50-52%, vs. hospice: 27%, 95% CI: 26-27%, risk ratio: 1.9, 95% CI: 1.9-2.0), largely for acute conditions not directly related to cancer; 74% (95% CI: 74-75) of non-hospice beneficiaries died in hospitals and nursing facilities compared to 14% (95% CI: 14-15%) of hospice. Costs for hospice and non-hospice beneficiaries were not significantly different at baseline, but diverged after hospice start. Total costs over the last year of life were $71,517 (95% CI: $70,543-72,490) for non-hospice and $62,819 (95% CI: $62,082-63,557) for hospice, a statistically-significant difference of $8,697 (95% CI: $7,560-9,835).

Conclusions and Relevance: In this sample of Medicare fee-for-service beneficiaries with poor-prognosis cancer, those receiving hospice care, compared to matched control patients not receiving hospice care, had significantly lower rates of hospitalization, intensive care unit admission, and invasive procedures at the end of life, along with significantly lower total costs during the last year of life.

Introduction

Multiple studies have documented the high intensity of medical care at the end of life,[1,2] and there is increasing consensus that such care can produce poor outcomes[2–4] and conflict with patient preferences.[4,5] The Institute of Medicine report *Dying in America* has drawn attention to the difficulties of promoting palliative care, including Medicare's hospice program,[6] the nation's largest palliative care intervention, which covers all comfort-oriented care related to terminal illnesses, from medications to home care to hospitalizations. While the number of people receiving hospice has increased since the program began in 1982, enrollment length decreased over the same period, and end of life care intensity increased.[7] Patients with cancer, the single largest group of hospice users,[8] have both the highest rates of hospice enrollment and the highest rates of hospice stays under three days.[7]

Several policy factors are cited to explain these trends. First, the Medicare administration monitors and prosecutes hospices with inappropriately long hospice stays, creating a perceived disincentive for providers to make early hospice referrals that are more likely to produce long stays.[9,10] Second, Medicare does not reimburse providers for discussions to elicit patients' preferences for end of life care.[11] Third, Medicare requires patients to formally renounce curative care before enrolling in hospice, which is thought to limit demand.[10,12] This last issue is particularly relevant to cancer care, since patients often wish to continue active treatment irrespective of prognosis—an area of concern to payers as use of costly new targeted therapies, often oral and less toxic, becomes widespread at the end of life.[13]

Indeed, many of these policies are related to concerns that increasing hospice use could increase health care utilization and ultimately costs—while advocates of hospice argue that aggressive end-of-life care outside of hospice is the more pressing cost issue.[10,14] A key input to these

debates is a better understanding of the relationship between hospice and health care utilization, and its implications for costs. To date, however, few studies have described the realities of how hospice affects medical care at the end of life, and attempts to estimate cost savings have produced mixed results, with two recent studies finding only small differences in costs that were inconsistent across different lengths of hospice stays.[10,15] Using data on Medicare beneficiaries with poor-prognosis cancers, we matched those enrolled in hospice before death to those who died without hospice care, and compared utilization and costs at the end of life. We excluded patients who received cancer-directed treatment during hospice, or the equivalent period before death for non-hospice beneficiaries, to compare beneficiaries who may have had similar preferences for no further cancer treatment.

Methods

Study population

In a nationally-representative 20% sample of fee-for-service Medicare beneficiaries (74% of the Medicare population, excluding managed care), we identified those with poor-prognosis malignancies who died in 2011 after a full year of Medicare coverage. By virtue of having died after poor-prognosis diagnoses, these beneficiaries would have been eligible for hospice, available to those with terminal illness and expected survival of under six months. We assumed beneficiaries had enough evidence of advanced disease to make hospice enrollment reasonable.

Data

We created a list of International Classification of Disease (ICD) codes corresponding to poor-prognosis malignancies, derived from a palliative care screening instrument at a major US cancer center, including poor-prognosis primaries (*e.g.*, lung, pancreatic, brain), any metastatic or ill-defined malignancy, and hematologic malignancies designated as relapsed or not in remission (eTable 1).[16] We retained beneficiaries with any of these codes present in claims between 2007-11 in the inpatient, outpatient, and carrier hospice files, excluding potential outpatient 'rule-out' codes.[17] We attributed to hospice all care received by the beneficiary from enrollment (*i.e.*, day of first hospice claim) until death, and assumed beneficiaries remained in hospice until death; 98.6% had a hospice claim within 30 days of death. We excluded those with hospice claims prior to poor-prognosis cancer diagnoses, indicating enrollment for another, prior disease.

Matching

We used a two stage matching approach to create pairs of beneficiaries who were as similar as possible, but made different choices regarding hospice enrollment at the same point in time before death. First, we matched hospice *beneficiaries* to a control group of beneficiaries who did not choose hospice. Second, for each matched pair, we matched the hospice *period* to the equivalent 'exposure period' of non-hospice care before death. By matching hospice beneficiaries to non-hospice beneficiaries, then comparing outcomes before and after hospice enrollment, we attempted to capture what might have happened if the non-hospice beneficiary had instead enrolled in hospice.

To match *beneficiaries*, we split the sample into those who enrolled in hospice at any time before death, and those who did not. Our initial plan was to perform propensity score matching (PSM), but this resulted in multiple significant imbalances between groups, which persisted despite attempts to rematch on different covariates. As a result, we used coarsened exact matching[18]

(CEM); we present these results here, and detailed PSM results in the supplement (eMethods). We matched using four variables: place of residence, age, sex, and time from first poor-prognosis cancer diagnosis to death. We assumed illness duration from diagnosis to death was inversely correlated with disease severity and thus a good proxy measure for it; we also assumed that hospice enrollment did not affect illness duration. We first matched on the finest strata of all variables (home zip code, year of birth, sex, illness duration in months), then iteratively coarsened variables and re-matched beneficiaries unmatched in the first round, to a maximum coarseness of five-year age intervals, four-month illness duration intervals, and home hospital referral region (HRR; see eTable2).

To match *exposure periods*, *i.e.*, 'treatment' period of hospice care to 'control' period of the same length before death, we defined the hospice period as the number of days, d^h, of hospice care prior to death, t^h_{death}, and defined the corresponding exposure period for matched non-hospice beneficiaries as d^h days prior to death. Thus a beneficiary who began hospice on day t^h_0 and died d^h days later on t^h_{death} was matched to a non-hospice beneficiaries who died on t^n_{death}, whose exposure period began d^h days earlier (Figure 1B).

We identified beneficiaries receiving chemotherapy or curative surgery before and after exposure using claims-based codes (eTable 3).[20,21] We excluded pairs where one or both beneficiaries received cancer-directed treatment after exposure, creating a cohort matched on preference for no further treatment, in order to better identify differences in utilization and cost associated with hospice, rather than simply with the decision to abandon cancer treatment.

Statistical analysis

We verified balance between hospice and non-hospice beneficiaries by comparing means or medians for all variables used for matching. We also compared care utilization before hospice enrollment including clinic, emergency, inpatient, home health, and skilled nursing facility (SNF) use; and comorbidity, measured on a scale synthesizing Elixhauser and Charlson indices.[19] We calculated comorbidity over two periods: from the earliest data available (2006) to first poor-prognosis cancer diagnosis (median 4.4 years), and from diagnosis to exposure (median 5.5 months). We could not match on pre-exposure utilization or comorbidity: non-hospice beneficiaries have no intrinsic 'exposure periods'—these could only be defined after matching, with respect to hospice enrollment for matched hospice beneficiaries.

The primary outcome was health care utilization during exposure periods, *i.e.*, hospice care, or the equivalent period for the matched controls, in the last year of life. We measured frequency of hospitalizations, intensive care, inpatient procedures, and death in hospitals or SNFs, ascertained by the presence of a facility claim on the death date. The secondary outcome was total costs, calculated at the beneficiary-week level, starting one year before death or six months before exposure (whichever was earlier). We added amount paid by beneficiaries, Medicare, and third-party payers[22] for all inpatient and outpatient care,[23] including hospice and provider payments, but excluding outpatient medication claims, personal care, and other expenses not covered by Medicare. The Institutional Review Board of the National Bureau of Economic Research approved this study. Statistical analyses were performed using Stata 13 (Stata Corporation, College Station, Tex) and R 3.0.2 (R Foundation, Vienna, Austria).

Results

Study population

In this nationally-representative 20% sample of Medicare fee-for-service beneficiaries with poor-prognosis cancer, median time from first poor-prognosis diagnosis to death was 13 months (IQR: 3-34); 60% received hospice care. Figure 1A shows creation of the matched cohort from this population. Figure 1B shows creation of exposure periods, matching hospice periods to equivalent periods of non-hospice care for matched controls. Of 86,851 deaths with poor-prognosis cancer, we matched 41,224 beneficiaries, or 59% of the smaller non-hospice group. After hospice enrollment, 1% of hospice beneficiaries received cancer-directed therapy, compared to 11% of non-hospice beneficiaries over similar exposure periods before death. Pairs including these beneficiaries were excluded. The final cohort of 36,330 beneficiaries was largely similar to the overall population of 86,851 cancer deaths from which it was drawn (eTable 4), but had shorter median time from diagnosis to death (reflecting fewer exact matches on illness duration among beneficiaries with longer survival times—eFigure 1), and lived in zip codes with mean incomes 1-3% higher than the overall cohort.

Table 1 shows baseline characteristics of the matched cohort. There were no statistically-significant differences between cases and controls in age, sex, region, time from poor-prognosis diagnosis to death, comorbidity before poor-prognosis diagnosis, or daily cost in the year before hospice enrollment. Solid tumors accounted for the majority of diagnoses in both groups (91% hospice, 88% non-hospice). Hospice beneficiaries were more white, and lived in higher-income zip codes. Median hospice duration was 11 days; under 6% of stays exceeded six months. Hospice and non-hospice beneficiaries had similar comorbidity before poor-prognosis diagnosis, but higher comorbidity between diagnosis and hospice enrollment; illness duration from diagnosis to death, however, was the same for both groups (7 months). Before exposure, hospice beneficiaries had similar prevalence of dementia, anemia, fluid/electrolyte disturbances, hemiplegia, and weight loss compared to non-hospice beneficiaries; hospice beneficiaries had

more days of home health assistance (7 vs. 6, difference: 1, 95% CI: 0.4-1.6), but used SNFs less (46.5% vs. 52.6%, difference: 6.2%, 95% CI: 5.1-7.2%). Together, these results indicated similarity between hospice and non-hospice beneficiaries on important aspects of functional status. Finally, hospice beneficiaries had more clinic visits (45 vs. 42, difference: 3, 95% CI: 2-4) and more claims for cancer-directed therapy (44.5% vs. 35.5%, difference: 9%, 95% CI: 8-10%) before hospice start.

Utilization and costs

Table 2 compares health care utilization during hospice with the equivalent period before death for matched non-hospice beneficiaries, in the last year of life. Non-hospice beneficiaries had more hospitalizations, largely for acute conditions (*e.g.*, infections, organ failure) and exacerbations of medical comorbidities. Only one of the ten most frequent primary discharge diagnoses involved cancer. Rates of intensive care and invasive procedures were also higher for non-hospice beneficiaries. Seventy-four percent of non-hospice beneficiaries died in hospitals or SNFs, compared to 14% of hospice.

We compared total costs for hospice and non-hospice beneficiaries before and after hospice start, to capture overall intensity of care utilization, and yield insight into whether differences in utilization were associated with hospice, or with pre-existing patient characteristics or care preferences. Figure 2 shows daily costs for representative groups of beneficiaries, separated by length of hospice enrollment. Over the year before hospice, hospice beneficiaries cost on average $145 daily (95% CI: $143-147) compared to $148 (95% CI: $146-150) for non-hospice (difference: $3, 95% CI: $0-5). In the week before hospice, hospice beneficiaries cost $802 daily, $146 (95% CI: $126-166) more than non-hospice beneficiaries. Costs declined rapidly thereafter, and by the last week of life, hospice beneficiaries cost $556 daily (95% CI: $542-571) compared

to $1,760 (95% CI: $1,718-1,801) for non-hospice, a difference of $1,203 (95% CI: $1,161-1,245).

Table 3 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. Overall, costs over the last year of life were $62,819 (95% CI: $62,082-63,557) for hospice and $71,517 (95% CI: $70,543-72,490) for non-hospice, a difference of $8,697 (95% CI: $7,560-9,835). Beneficiaries enrolled in hospice for 5-8 weeks had cumulative costs of $56,986 (95% CI: $55,098-58,875) compared to $74,890 (95% CI: $71,910-77,869) for non-hospice beneficiaries, a difference of $17,903 (95% CI: $14,543-21,264). Differences in cost for short hospice stays (1-2 weeks) were smaller, but remained statistically significant. For the 2% of beneficiaries with hospice stays over one year, hospice beneficiaries had higher costs (difference: $7,387, 95% CI: $1,485-13,289).

Propensity score analysis

Propensity scores allowed us to match 100% of the smaller non-hospice group (eFigure 2), but produced imbalance on important covariates including baseline cost and geography, with median distance between pairs over 800 miles; only 0.8% of matched pairs lived in the same HRR (eTable 5). There was significant imbalance on time from poor-prognosis diagnosis to death, 436 days for non-hospice and 286 for hospice, which likely contributed to significant differences in costs over the year before exposure ($149 for non-hospice vs. $135 for hospice; eTable 6): this year would have included a median of 79 days before hospice beneficiaries received their poor-prognosis diagnosis, spuriously lowering cost estimates. Despite this, cost trajectories (eFigure 3) were grossly similar to the CEM cohort, and care utilization patterns were nearly identical (eTable 7). Cumulative costs over the last year of life (eTable 8) were $71,860 (95% CI: $71,094-

72,626) for non-hospice and $59,037 (95% CI: $58,353-59,538) for hospice (difference : $12,823, 95% CI: $11,921-13,726).

Discussion

In a matched cohort of Medicare beneficiaries with poor-prognosis cancers, we found large, statistically-significant differences in care utilization between hospice and non-hospice beneficiaries at the end of life. While enrolled in hospice, beneficiaries were hospitalized less, received less intensive care, underwent fewer procedures, and were less likely to die in hospitals and SNFs. Over similar periods before death, one in ten non-hospice beneficiaries received active cancer-directed treatment; among those who did not, most were admitted to hospitals and ICUs for acute conditions not directly related to their poor-prognosis cancer. Such care is unlikely to fit with the preferences of most patients. Our findings highlight the potential importance of honest discussions between doctors and patients about the realities of care at the end of life, an issue of particular importance as the Medicare administration weighs decisions around reimbursing providers for advance care planning.

Differences in care utilization between hospice and non-hospice beneficiaries translated into statistically-significantly lower costs for hospice beneficiaries in the last year of life. Cost trajectories began to diverge in the week after hospice enrollment, implying that baseline differences between hospice and non-hospice beneficiaries were not responsible for cost differences. Hospice enrollment of 5-8 weeks produced the greatest savings; shorter stays produced fewer savings, likely because of both hospice initiation costs, and need for intensive symptom palliation in the days before death.[24] Overall, these results may indicate that efforts to promote broader and earlier hospice uptake are unlikely to produce increases in total costs.

Our study in no way replicates a randomized trial of a hospice intervention, and results depend on the validity of the matching strategy, making it important to highlight key choices involved in the creation of the study cohort. First, CEM achieved excellent balance for matched beneficiaries, but failed to match a substantial number of beneficiaries (41% of the smaller non-hospice group, 53% of the overall cohort). PSM matched 100% of the non-hospice group and 80% of the overall cohort, but at the expense of inferior balance on important covariates. Each method had trade-offs in terms of internal and external validity, but both ultimately produced very similar results. Second, matching on illness duration made two crucial assumptions: that illness duration was a proxy for disease severity, and that it was not affected by hospice enrollment. Matching on duration would bias results if hospice prolonged life: hospice patients with more severe disease at baseline, who improved after hospice treatment, would be matched to controls with less severe baseline disease. Since utilization and severity are usually correlated, our estimates of differences would be biased downward. If hospice beneficiaries had shorter survival, *e.g.*, because of discontinuation of effective anti-cancer treatment, the opposite would be true; but since cancer-directed therapy was *more* common for hospice beneficiaries before enrollment, insufficiently aggressive treatment seems unlikely. Third, hospice beneficiaries had higher comorbidity scores after poor-prognosis diagnoses, which could reflect higher overall utilization, or higher true comorbidity. The latter would have biased downward our estimates of savings, though matching on illness duration should have controlled for overall disease severity in this period. Fourth, our results are unlikely to generalize to this sub-group of 1% of hospice beneficiaries who received cancer-directed treatment after exposure start. Further, we could not determine if other hospice beneficiaries left hospice. If this were widespread, contamination would lead to downward bias in estimates of differences in outcomes. Finally, hospice beneficiaries lived in wealthier areas, potentially giving them increased access to hospice. However, since pairs were matched by HRR, geographic access to hospice should have been similar, except possibly in large-area rural HRRs.

There are other limitations to note. We restricted our analysis to beneficiaries with poor-prognosis cancer, but non-cancer diagnoses are a growing part of the hospice population, and our results may not generalize. We excluded beneficiaries with managed care, for whom claims data were not available, and the entire non-Medicare population. We relied on ICD codes to identify poor-prognosis diagnoses, but claims-based diagnoses can be inaccurate. We determined place of death via same-day facility claims, which did not include inpatient hospice facilities or assisted living; we had incomplete data on SNF, and no data on personal care utilization. We did not include outpatient medication expenses; these were likely lower in the hospice group, since hospice covers medications related to their terminal condition.

Conclusions

In this sample of Medicare fee-for-service beneficiaries with poor-prognosis cancer, those receiving hospice care, compared to matched control patients not receiving hospice care, had significantly lower rates of hospitalization, intensive care unit admission, and invasive procedures at the end of life, along with significantly lower health care expenditures during the last year of life.

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ZO had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis

The funders had no role in the design and conduct of the study, in the collection, analysis, and interpretation of the data, and in the preparation, review, or approval of the manuscript.

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Figure legends

Figure 1. Study population

Panel A shows matching of hospice to non-hospice *beneficiaries*, starting with all fee-for-service beneficiaries who died in 2011, and restricting to those with a poor-prognosis cancer diagnosis. Some beneficiaries were excluded because of missing data, and others because they started hospice prior to cancer diagnosis, likely due to another concurrent terminal illness. Panel B shows matching of *exposure periods* for two hypothetical beneficiaries matched in the first stage. In chronological time, the two beneficiaries are represented as lines spanning from poor-prognosis diagnosis to death; in the exposure time frame used for analysis, dates of death are aligned to create a similar exposure period of hospice or non-hospice care prior to death. Because beneficiaries are matched on time from diagnosis to death, the lengths of the lines are approximately the same. After matching exposure periods, we drop pairs in which one or both beneficiaries received chemotherapy or curative surgery during the periods.

Figure 2. Cost trajectories before and after hospice start

Figure 2 shows mean total daily costs relative to hospice 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 109 groups was not possible, and since aggregation would obscure time trends, we show representative groups with exposure periods of 1, 2, 3, and 4 weeks, which together make up 71% of the entire cohort; every 2 weeks from 6 to 12 weeks (8% of the cohort); and every 4 weeks from 16 to 28 (2%). "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 show the 95% confidence interval (CI) for the mean; lower CI bounds of

less than zero were censored at zero. Week zero is defined as the week before the first day of hospice.

Tables

Table 1. Baseline characteristics of the matched cohort

Variable	Non-hospice (N=18,165)	Hospice (N=18,165)	Difference	Std. Diff. [d]
Variables used for matching				
Age in years, mean (95% CI) [a]	80 (79.9, 80.1)	80 (79.9, 80.1)	0 (-0.2, 0.2)	0.00
Male, % (95% CI)[a]	48 (47.3, 48.8)	48 (47.3, 48.8)	0 (-1, 1)	0.00
Days from poor-prognosis cancer diagnosis to death, median (25th, 75th percentile) [b]	213 (43, 818)	210 (48, 822)	3 (-10, 16)	0.00
Distance between pair home zip codes in miles, median (25th, 75th percentile) [b]		24.5 (10.2, 51.8)		-
Demographics				
White, % (95% CI) [a]	84.7 (84.1, 85.2)	87.8 (87.3, 88.2)	-3.1 (-3.8, -2.4)	-0.09
Income of beneficiary home zip code in thousands, median (25th, 75th percentile) [b]	62.9 (51.5, 83.1)	64.9 (52.7, 86.6)	-2 (-2.6, -1.4)	-0.08
Region, % (95% CI) [a]				
Northeast	22.7 (22.1, 23.4)	22.8 (22.2, 23.4)	0 (-0.9, 0.8)	0.00
Midwest	23.6 (23, 24.3)	23.8 (23.2, 24.4)	-0.1 (-1, 0.7)	0.00
South	37.8 (37.1, 38.5)	37.6 (36.9, 38.3)	0.2 (-0.8, 1.2)	0.00
West	15.9 (15.3, 16.4)	15.9 (15.4, 16.4)	0 (-0.8, 0.7)	0.00
First poor-prognosis malignancy diagnosis, % (95% CI) [a]				
Solid tumor	88.2 (87.7, 88.7)	91 (90.6, 91.5)	-2.9 (-3.5, -2.2)	-0.09
Hematological	12.2 (11.7, 12.7)	9.4 (9, 9.8)	2.8 (2.2, 3.4)	0.09
Illness and hospice course, median (25th, 75th percentile) [b]				
Poor-prognosis cancer diagnosis to exposure start, days	166 (24, 757)	165 (25, 758)	1 (-13.3, 11.3)	0.00
Exposure start to death, days	11 (4, 35)	11 (4, 35)	0 (-0.4, 0.4)	0.00
2006 to poor prognosis cancer diagnosis, days	1767 (1185, 1942)	1770 (1181, 1941)	-3 (-14.4, 8.4)	0.00
Comorbidity index, median (25th, 75th percentile) [b c]				
2006 to poor-prognosis cancer diagnosis	3 (1, 6)	3 (1, 6)	0 (-0.1, 0.1)	- [e]
Poor-prognosis diagnosis to exposure start	6 (2, 9)	7 (4, 9)	-1 (-1.1, -0.9)	- [e]

Table 1. Baseline characteristics of the matched cohort

Variable	Non-hospice (N=18,165)	Hospice (N=18,165)	Difference	Std. Diff. [d]
Presence of selected individual comorbidities related to functional status, 2006 to exposure start, % (95% CI) [a]				
Anemia	68.5 (67.8, 69.2)	68.3 (67.6, 69)	0.2 (-0.7, 1.2)	0.00
Dementia	18 (17.5, 18.6)	18 (17.5, 18.6)	0 (-0.8, 0.8)	0.00
Fluid and electrolyte disorders	71.7 (71, 72.3)	71.2 (70.5, 71.9)	0.5 (-0.5, 1.4)	0.01
Hemiplegia	6.7 (6.4, 7.1)	6.8 (6.4, 7.1)	0.0 (-0.5, 0.5)	0.00
Weight loss	26.2 (25.6, 26.8)	25.8 (25.2, 26.5)	0.4 (-0.5, 1.3)	0.01
Healthcare utilization, 2006 to exposure start				
Inpatient admissions, median (25th, 75th percentile) [b]	3 (1, 6)	3 (2, 5)	0 (0, 0)	- [e]
Emergency visits, median (25th, 75th percentile) [b]	4 (2, 7)	4 (2, 7)	0 (0, 0)	- [e]
Clinic visits, median (25th, 75th percentile) [b]	42 (21, 70)	45 (24, 73)	-3 (-4, -2)	- [e]
Home health days , median (25th, 75th percentile) [b]	6 (0, 31)	7 (0, 30)	-1 (-1.6, -0.4)	0.04
Use of SNF, % (95% CI) [a]	52.6 (51.9, 53.3)	46.5 (45.7, 47.2)	6.2 (5.1, 7.2)	0.12
Active cancer treatment, % (95% CI) [a f]	35.5 (34.8, 36.2)	44.5 (43.8, 45.2)	-9 (-10, -8)	-0.18
Daily expenses, year prior to exposure start, $ (95% CI) [a]	$148 (146, 150)	$145 (143, 147)	$3 (0, 5)	0.02

Table 1 shows variables used for coarsened exact matching and other measures of health and care utilization in the baseline period before exposure start, *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.

[b] For non-normally-distributed variables, we report medians, with inter-quartile range in parentheses. Differences 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

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Table 2. Care utilization during exposure periods in the last year of life

		Matched cohort		
		Non-hospice (N=18,165)	Hospice (N=18,165)	Risk ratio
Hospital admission, % (95% CI)		**65.1 (64.4, 65.8)**	**42.3 (41.5, 43.0)**	**1.5 (1.5, 1.6)**
Primary ICD code (discharge)	Sepsis	10 (9.5, 10.4)	3.4 (3.1, 3.7)	2.9 (2.7, 3.2)
	Pneumonia	4.4 (4.1, 4.7)	2.1 (1.9, 2.3)	2.1 (1.8, 2.3)
	Acute/chronic respiratory failure [a]	3.9 (3.6, 4.2)	1.1 (1, 1.3)	3.5 (3, 4.1)
	Pneumonitis (aspiration)	2.3 (2.1, 2.5)	1.0 (0.8, 1.1)	2.3 (1.9, 2.7)
	Acute kidney failure	2.2 (2, 2.5)	1.6 (1.4, 1.8)	1.4 (1.2, 1.6)
	Neoplasm of bronchus and lung	2.1 (1.9, 2.3)	1.5 (1.4, 1.7)	1.3 (1.1, 1.6)
	COPD exacerbation	1.4 (1.2, 1.6)	0.6 (0.5, 0.7)	2.5 (2, 3.1)
	Subendocardial infarction	1.3 (1.2, 1.5)	0.4 (0.3, 0.5)	3.6 (2.8, 4.7)
	Urinary tract infection	1.2 (1.1, 1.4)	0.6 (0.5, 0.8)	1.9 (1.5, 2.3)
	Cerebral artery occlusion (stroke)	1.0 (0.9, 1.2)	0.8 (0.6, 0.9)	1.4 (1.2, 1.8)
ICU admission, % (95% CI)		**35.8 (35.1, 36.5)**	**14.8 (14.3, 15.3)**	**2.4 (2.3, 2.5)**
	ICU	27 (26.4, 27.7)	8.4 (8, 8.8)	3.2 (3, 3.4)
	Step-down or intermediate	10.1 (9.6, 10.5)	6.5 (6.1, 6.8)	1.6 (1.5, 1.7)
Invasive procedures, % (95% CI)		**51.0 (50.3, 51.7)**	**26.7 (26.1, 27.4)**	**1.9 (1.9, 2.0)**
	Insertion of venous catheter	21.4 (20.8, 22.0)	7 (6.6, 7.4)	3.1 (2.9, 3.3)
	Endotracheal intubation	19.3 (18.8, 19.9)	2.7 (2.4, 2.9)	7.3 (6.6, 8.0)
	Packed cell transfusion	15.6 (15.1, 16.2)	8.7 (8.3, 9.1)	1.8 (1.7, 1.9)
	Platelet or plasma transfusion	6.3 (5.9, 6.6)	2.9 (2.6, 3.1)	2.2 (2, 2.4)
	Non-invasive ventilation	5.9 (5.6, 6.3)	1.7 (1.5, 1.9)	3.4 (3, 3.9)
	Thoracentesis	4.3 (4, 4.6)	2.5 (2.3, 2.8)	1.7 (1.5, 1.9)
	Hemodialysis	4.1 (3.8, 4.4)	1.2 (1, 1.3)	3.6 (3.1, 4.2)
	Cardiopulmonary resuscitation	4.0 (3.7, 4.2)	0.2 (0.1, 0.2)	21.8 (15.4, 30.8)
	Closed bronchial biopsy	3.8 (3.5, 4.1)	1.2 (1, 1.3)	3.3 (2.8, 3.9)
	Arterial catheterization	3.5 (3.2, 3.8)	0.4 (0.3, 0.5)	8.8 (6.9, 11.1)
Death in hospital or SNF, % (95% CI)		**74.1 (73.5, 74.8)**	**14 (13.5, 14.5)**	**5.3 (5.1, 5.5)**
	Acute care hospital [b]	50.2 (49.5, 51)	3.4 (3.2, 3.7)	14.6 (13.5, 15.8)
	Long-term hospital or SNF [c]	23.9 (23.3, 24.5)	10.5 (10.1, 11.0)	2.3 (2.2, 2.4)

Table 2 shows health care utilization during exposure periods (*i.e.*, hospice care, or the equivalent period before death for non-hospice beneficiaries) in the last year of life: percent of beneficiaries with hospital admission, ICU stay, procedure, and place of death, 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

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Table 3. Total costs in the last year of life

Exposure period length (weeks)	Weeks from diagnosis to death (95% CI)	Matched pairs (n)	Total costs, last year of life, mean (95 % CI)		
			Non-hospice	Hospice	Difference
1	58	6922	$71,582	$66,779	$4,803
	(57, 60)		($70,027, 73,137)	($65,470, 68,087)	($2,933, 6,674)
2	57	3138	$70,987	$63,139	$7,848
	(55, 58)		($68,680, 73,294)	($61,322, 64,955)	($5,141, 10,555)
3-4	62	2783	$72,660	$59,595	$13,065
	(60, 64)		($70,177, 75,144)	($57,719, 61,471)	($10,201, 15,930)
5-8	67	2231	$74,890	$56,986	$17,903
	(65, 69)		($71,910, 77,869)	($55,098, 58,875)	($14,543, 21,264)
9-26	91	2161	$72,432	$60,326	$12,106
	(88, 93)		($69,504, 75,360)	($58,518, 62,134)	($8,821, 15,392)
27-52	118	556	$66,035	$65,300	$735
	(114, 122)		($60,718, 71,352)	($62,687, 67,913)	(-$5,131, 6,601)
> 52	152	374	$48,981	$56,368	-$7,387
	(148, 157)		($44,206, 53,755)	($52,931, 59,805)	(-$13,289, -1,485)
Total	67	18,165	$71,517	$62,819	$8,697
	(67, 68)		($70,543, 72,490)	($62,082, 63,557)	($7,560, 9,835)

Table 3 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).

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Matching stage A: Beneficiaries

314,095
Deaths in 2011

303,163
Coverage for >1y

87,741
Poor-prognosis cancer

257
Not in continental US

6
Missing or invalid zip

616
Hospice before diagnosis

11
Missing or invalid dates

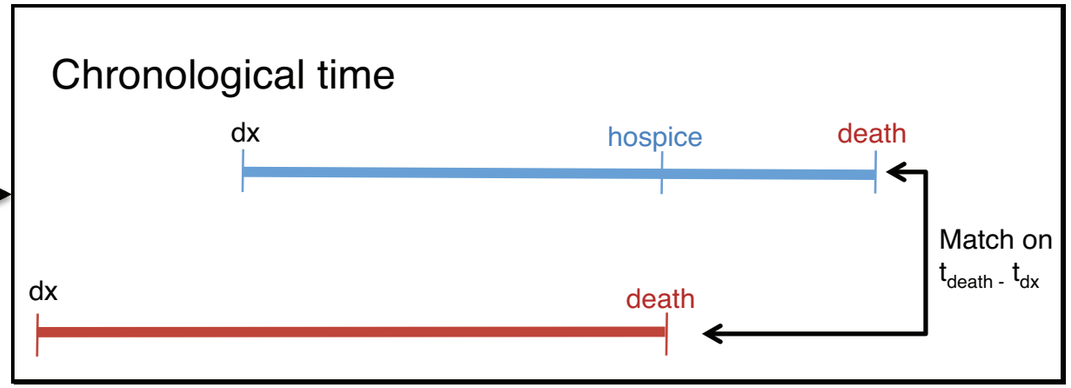
51,924
Hospice

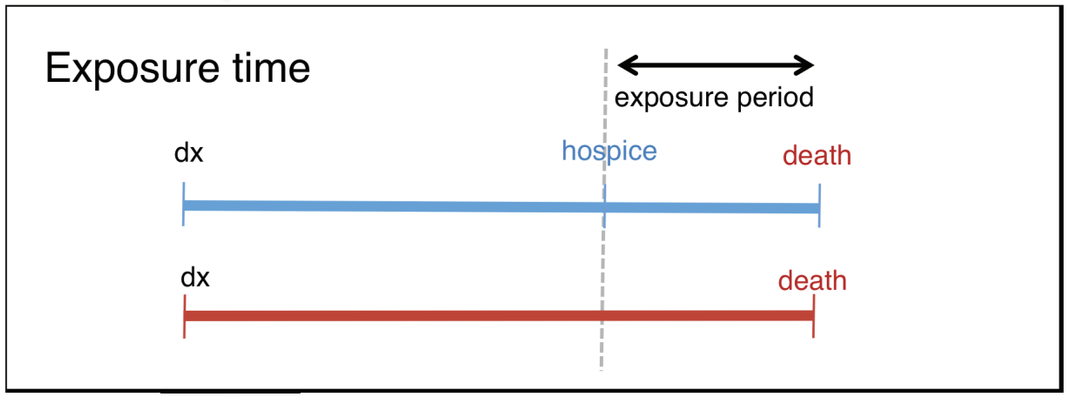
34,927
Non-hospice

Unmatched:
14,315 non-hospice
31,312 hospice

20,612
Matched pairs

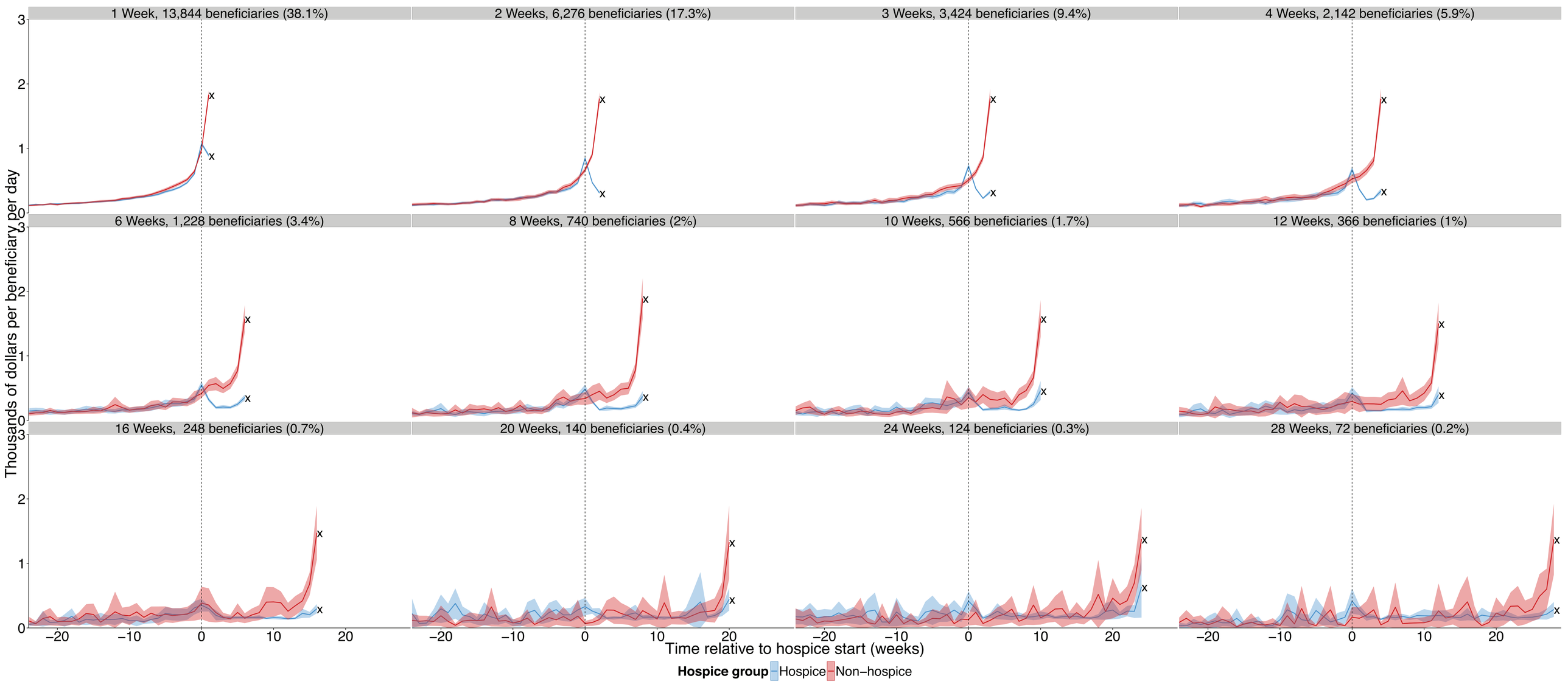
Matching stage B: Exposure periods





2,447 pairs
Cancer-directed treatment
during exposure period
- Non-hospice: 2,298 (11.1%)
- Hospice: 227 (1.1%)

18,165
Matched pairs


1 Week, 13,844 beneficiaries (38.1%)
2 Weeks, 6,276 beneficiaries (17.3%)
3 Weeks, 3,424 beneficiaries (9.4%)
4 Weeks, 2,142 beneficiaries (5.9%)
6 Weeks, 1,228 beneficiaries (3.4%)
8 Weeks, 740 beneficiaries (2%)
10 Weeks, 566 beneficiaries (1.7%)
12 Weeks, 366 beneficiaries (1%)
16 Weeks, 248 beneficiaries (0.7%)
20 Weeks, 140 beneficiaries (0.4%)
24 Weeks, 124 beneficiaries (0.3%)
28 Weeks, 72 beneficiaries (0.2%)
Thousands of dollars per beneficiary per day
0
1
2
3
−20
−10
0
10
20
Time relative to hospice start (weeks)
Hospice group
Hospice
Non−hospice