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.

96 **Introduction**

97

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

108

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

118

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

122 debates is a better understanding of the relationship between hospice and health care utilization,
123 and its implications for costs. To date, however, few studies have described the realities of how
124 hospice affects medical care at the end of life, and attempts to estimate cost savings have
125 produced mixed results, with two recent studies finding only small differences in costs that were
126 inconsistent across different lengths of hospice stays.[10,15] Using data on Medicare beneficiaries
127 with poor-prognosis cancers, we matched those enrolled in hospice before death to those who
128 died without hospice care, and compared utilization and costs at the end of life. We excluded
129 patients who received cancer-directed treatment during hospice, or the equivalent period before
130 death for non-hospice beneficiaries, to compare beneficiaries who may have had similar
131 preferences for no further cancer treatment.
132
133
134 **Methods**
135
136 *Study population*
137
138 In a nationally-representative 20% sample of fee-for-service Medicare beneficiaries (74% of the
139 Medicare population, excluding managed care), we identified those with poor-prognosis
140 malignancies who died in 2011 after a full year of Medicare coverage. By virtue of having died
141 after poor-prognosis diagnoses, these beneficiaries would have been eligible for hospice,
142 available to those with terminal illness and expected survival of under six months. We assumed
143 beneficiaries had enough evidence of advanced disease to make hospice enrollment reasonable.
144
145 *Data*
146

147 We created a list of International Classification of Disease (ICD) codes corresponding to poor-
148 prognosis malignancies, derived from a palliative care screening instrument at a major US cancer
149 center, including poor-prognosis primaries (*e.g.*, lung, pancreatic, brain), any metastatic or ill-
150 defined malignancy, and hematologic malignancies designated as relapsed or not in remission
151 (eTable 1).[16] We retained beneficiaries with any of these codes present in claims between 2007-
152 11 in the inpatient, outpatient, and carrier hospice files, excluding potential outpatient 'rule-out'
153 codes.[17] We attributed to hospice all care received by the beneficiary from enrollment (*i.e.*, day of
154 first hospice claim) until death, and assumed beneficiaries remained in hospice until death; 98.6%
155 had a hospice claim within 30 days of death. We excluded those with hospice claims prior to
156 poor-prognosis cancer diagnoses, indicating enrollment for another, prior disease.
157
158 *Matching*
159
160 We used a two stage matching approach to create pairs of beneficiaries who were as similar as
161 possible, but made different choices regarding hospice enrollment at the same point in time
162 before death. First, we matched hospice *beneficiaries* to a control group of beneficiaries who did
163 not choose hospice. Second, for each matched pair, we matched the hospice *period* to the
164 equivalent 'exposure period' of non-hospice care before death. By matching hospice beneficiaries
165 to non-hospice beneficiaries, then comparing outcomes before and after hospice enrollment, we
166 attempted to capture what might have happened if the non-hospice beneficiary had instead
167 enrolled in hospice.
168
169 To match *beneficiaries*, we split the sample into those who enrolled in hospice at any time before
170 death, and those who did not. Our initial plan was to perform propensity score matching (PSM),
171 but this resulted in multiple significant imbalances between groups, which persisted despite
172 attempts to rematch on different covariates. As a result, we used coarsened exact matching[18]

173 (CEM); we present these results here, and detailed PSM results in the supplement (eMethods).
174 We matched using four variables: place of residence, age, sex, and time from first poor-prognosis
175 cancer diagnosis to death. We assumed illness duration from diagnosis to death was inversely
176 correlated with disease severity and thus a good proxy measure for it; we also assumed that
177 hospice enrollment did not affect illness duration. We first matched on the finest strata of all
178 variables (home zip code, year of birth, sex, illness duration in months), then iteratively coarsened
179 variables and re-matched beneficiaries unmatched in the first round, to a maximum coarseness of
180 five-year age intervals, four-month illness duration intervals, and home hospital referral region
181 (HRR; see eTable2).
182
183 To match *exposure periods*, *i.e.*, 'treatment' period of hospice care to 'control' period of the same
184 length before death, we defined the hospice period as the number of days, d^h, of hospice care
185 prior to death, t^h_{death}, and defined the corresponding exposure period for matched non-hospice
186 beneficiaries as d^h days prior to death. Thus a beneficiary who began hospice on day t^h_0 and died
187 d^h days later on t^h_{death} was matched to a non-hospice beneficiaries who died on t^n_{death}, whose
188 exposure period began d^h days earlier (Figure 1B).
189
190 We identified beneficiaries receiving chemotherapy or curative surgery before and after exposure
191 using claims-based codes (eTable 3).[20,21] We excluded pairs where one or both beneficiaries
192 received cancer-directed treatment after exposure, creating a cohort matched on preference for no
193 further treatment, in order to better identify differences in utilization and cost associated with
194 hospice, rather than simply with the decision to abandon cancer treatment.
195
196 *Statistical analysis*
197

198 We verified balance between hospice and non-hospice beneficiaries by comparing means or
199 medians for all variables used for matching. We also compared care utilization before hospice
200 enrollment including clinic, emergency, inpatient, home health, and skilled nursing facility (SNF)
201 use; and comorbidity, measured on a scale synthesizing Elixhauser and Charlson indices.[19] We
202 calculated comorbidity over two periods: from the earliest data available (2006) to first poor-
203 prognosis cancer diagnosis (median 4.4 years), and from diagnosis to exposure (median 5.5
204 months). We could not match on pre-exposure utilization or comorbidity: non-hospice
205 beneficiaries have no intrinsic 'exposure periods'—these could only be defined after matching,
206 with respect to hospice enrollment for matched hospice beneficiaries.
207
208 The primary outcome was health care utilization during exposure periods, *i.e.*, hospice care, or
209 the equivalent period for the matched controls, in the last year of life. We measured frequency of
210 hospitalizations, intensive care, inpatient procedures, and death in hospitals or SNFs, ascertained
211 by the presence of a facility claim on the death date. The secondary outcome was total costs,
212 calculated at the beneficiary-week level, starting one year before death or six months before
213 exposure (whichever was earlier). We added amount paid by beneficiaries, Medicare, and third-
214 party payers[22] for all inpatient and outpatient care,[23] including hospice and provider payments, but
215 excluding outpatient medication claims, personal care, and other expenses not covered by
216 Medicare. The Institutional Review Board of the National Bureau of Economic Research
217 approved this study. Statistical analyses were performed using Stata 13 (Stata Corporation,
218 College Station, Tex) and R 3.0.2 (R Foundation, Vienna, Austria).
219
220
221 **Results**
222
223 *Study population*

224

225 In this nationally-representative 20% sample of Medicare fee-for-service beneficiaries with poor-
226 prognosis cancer, median time from first poor-prognosis diagnosis to death was 13 months (IQR:
227 3-34); 60% received hospice care. Figure 1A shows creation of the matched cohort from this
228 population. Figure 1B shows creation of exposure periods, matching hospice periods to
229 equivalent periods of non-hospice care for matched controls. Of 86,851 deaths with poor-
230 prognosis cancer, we matched 41,224 beneficiaries, or 59% of the smaller non-hospice group.
231 After hospice enrollment, 1% of hospice beneficiaries received cancer-directed therapy,
232 compared to 11% of non-hospice beneficiaries over similar exposure periods before death. Pairs
233 including these beneficiaries were excluded. The final cohort of 36,330 beneficiaries was largely
234 similar to the overall population of 86,851 cancer deaths from which it was drawn (eTable 4), but
235 had shorter median time from diagnosis to death (reflecting fewer exact matches on illness
236 duration among beneficiaries with longer survival times—eFigure 1), and lived in zip codes with
237 mean incomes 1-3% higher than the overall cohort.

238

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

250 more days of home health assistance (7 vs. 6, difference: 1, 95% CI: 0.4-1.6), but used SNFs less
251 (46.5% vs. 52.6%, difference: 6.2%, 95% CI: 5.1-7.2%). Together, these results indicated
252 similarity between hospice and non-hospice beneficiaries on important aspects of functional
253 status. Finally, hospice beneficiaries had more clinic visits (45 vs. 42, difference: 3, 95% CI: 2-4)
254 and more claims for cancer-directed therapy (44.5% vs. 35.5%, difference: 9%, 95% CI: 8-10%)
255 before hospice start.
256
257 *Utilization and costs*
258
259 Table 2 compares health care utilization during hospice with the equivalent period before death
260 for matched non-hospice beneficiaries, in the last year of life. Non-hospice beneficiaries had
261 more hospitalizations, largely for acute conditions (*e.g.*, infections, organ failure) and
262 exacerbations of medical comorbidities. Only one of the ten most frequent primary discharge
263 diagnoses involved cancer. Rates of intensive care and invasive procedures were also higher for
264 non-hospice beneficiaries. Seventy-four percent of non-hospice beneficiaries died in hospitals or
265 SNFs, compared to 14% of hospice.
266
267 We compared total costs for hospice and non-hospice beneficiaries before and after hospice start,
268 to capture overall intensity of care utilization, and yield insight into whether differences in
269 utilization were associated with hospice, or with pre-existing patient characteristics or care
270 preferences. Figure 2 shows daily costs for representative groups of beneficiaries, separated by
271 length of hospice enrollment. Over the year before hospice, hospice beneficiaries cost on average
272 $145 daily (95% CI: $143-147) compared to $148 (95% CI: $146-150) for non-hospice
273 (difference: $3, 95% CI: $0-5). In the week before hospice, hospice beneficiaries cost $802 daily,
274 $146 (95% CI: $126-166) more than non-hospice beneficiaries. Costs declined rapidly thereafter,
275 and by the last week of life, hospice beneficiaries cost $556 daily (95% CI: $542-571) compared

276 to $1,760 (95% CI: $1,718-1,801) for non-hospice, a difference of $1,203 (95% CI: $1,161-
277 1,245).
278
279 Table 3 shows cumulative total costs over the last year of life, by length of hospice enrollment;
280 we calculated total costs over the last year, irrespective of exposure period start, for comparability
281 to other studies. Overall, costs over the last year of life were $62,819 (95% CI: $62,082-63,557)
282 for hospice and $71,517 (95% CI: $70,543-72,490) for non-hospice, a difference of $8,697 (95%
283 CI: $7,560-9,835). Beneficiaries enrolled in hospice for 5-8 weeks had cumulative costs of
284 $56,986 (95% CI: $55,098-58,875) compared to $74,890 (95% CI: $71,910-77,869) for non-
285 hospice beneficiaries, a difference of $17,903 (95% CI: $14,543-21,264). Differences in cost for
286 short hospice stays (1-2 weeks) were smaller, but remained statistically significant. For the 2% of
287 beneficiaries with hospice stays over one year, hospice beneficiaries had higher costs (difference:
288 $7,387, 95% CI: $1,485-13,289).
289
290 *Propensity score analysis*
291
292 Propensity scores allowed us to match 100% of the smaller non-hospice group (eFigure 2), but
293 produced imbalance on important covariates including baseline cost and geography, with median
294 distance between pairs over 800 miles; only 0.8% of matched pairs lived in the same HRR
295 (eTable 5). There was significant imbalance on time from poor-prognosis diagnosis to death, 436
296 days for non-hospice and 286 for hospice, which likely contributed to significant differences in
297 costs over the year before exposure ($149 for non-hospice vs. $135 for hospice; eTable 6): this
298 year would have included a median of 79 days before hospice beneficiaries received their poor-
299 prognosis diagnosis, spuriously lowering cost estimates. Despite this, cost trajectories (eFigure 3)
300 were grossly similar to the CEM cohort, and care utilization patterns were nearly identical
301 (eTable 7). Cumulative costs over the last year of life (eTable 8) were $71,860 (95% CI: $71,094-

302 72,626) for non-hospice and $59,037 (95% CI: $58,353-59,538) for hospice (difference : $12,823,
303 95% CI: $11,921-13,726).
304
305 **Discussion**
306
307 In a matched cohort of Medicare beneficiaries with poor-prognosis cancers, we found large,
308 statistically-significant differences in care utilization between hospice and non-hospice
309 beneficiaries at the end of life. While enrolled in hospice, beneficiaries were hospitalized less,
310 received less intensive care, underwent fewer procedures, and were less likely to die in hospitals
311 and SNFs. Over similar periods before death, one in ten non-hospice beneficiaries received active
312 cancer-directed treatment; among those who did not, most were admitted to hospitals and ICUs
313 for acute conditions not directly related to their poor-prognosis cancer. Such care is unlikely to fit
314 with the preferences of most patients. Our findings highlight the potential importance of honest
315 discussions between doctors and patients about the realities of care at the end of life, an issue of
316 particular importance as the Medicare administration weighs decisions around reimbursing
317 providers for advance care planning.
318
319 Differences in care utilization between hospice and non-hospice beneficiaries translated into
320 statistically-significantly lower costs for hospice beneficiaries in the last year of life. Cost
321 trajectories began to diverge in the week after hospice enrollment, implying that baseline
322 differences between hospice and non-hospice beneficiaries were not responsible for cost
323 differences. Hospice enrollment of 5-8 weeks produced the greatest savings; shorter stays
324 produced fewer savings, likely because of both hospice initiation costs, and need for intensive
325 symptom palliation in the days before death.[24] Overall, these results may indicate that efforts to
326 promote broader and earlier hospice uptake are unlikely to produce increases in total costs.
327

328 Our study in no way replicates a randomized trial of a hospice intervention, and results depend on
329 the validity of the matching strategy, making it important to highlight key choices involved in the
330 creation of the study cohort. First, CEM achieved excellent balance for matched beneficiaries, but
331 failed to match a substantial number of beneficiaries (41% of the smaller non-hospice group, 53%
332 of the overall cohort). PSM matched 100% of the non-hospice group and 80% of the overall
333 cohort, but at the expense of inferior balance on important covariates. Each method had trade-offs
334 in terms of internal and external validity, but both ultimately produced very similar results.
335 Second, matching on illness duration made two crucial assumptions: that illness duration was a
336 proxy for disease severity, and that it was not affected by hospice enrollment. Matching on
337 duration would bias results if hospice prolonged life: hospice patients with more severe disease at
338 baseline, who improved after hospice treatment, would be matched to controls with less severe
339 baseline disease. Since utilization and severity are usually correlated, our estimates of differences
340 would be biased downward. If hospice beneficiaries had shorter survival, *e.g.*, because of
341 discontinuation of effective anti-cancer treatment, the opposite would be true; but since cancer-
342 directed therapy was *more* common for hospice beneficiaries before enrollment, insufficiently
343 aggressive treatment seems unlikely. Third, hospice beneficiaries had higher comorbidity scores
344 after poor-prognosis diagnoses, which could reflect higher overall utilization, or higher true
345 comorbidity. The latter would have biased downward our estimates of savings, though matching
346 on illness duration should have controlled for overall disease severity in this period. Fourth, our
347 results are unlikely to generalize to this sub-group of 1% of hospice beneficiaries who received
348 cancer-directed treatment after exposure start. Further, we could not determine if other hospice
349 beneficiaries left hospice. If this were widespread, contamination would lead to downward bias in
350 estimates of differences in outcomes. Finally, hospice beneficiaries lived in wealthier areas,
351 potentially giving them increased access to hospice. However, since pairs were matched by HRR,
352 geographic access to hospice should have been similar, except possibly in large-area rural HRRs.
353

354 There are other limitations to note. We restricted our analysis to beneficiaries with poor-prognosis
355 cancer, but non-cancer diagnoses are a growing part of the hospice population, and our results
356 may not generalize. We excluded beneficiaries with managed care, for whom claims data were
357 not available, and the entire non-Medicare population. We relied on ICD codes to identify poor-
358 prognosis diagnoses, but claims-based diagnoses can be inaccurate. We determined place of death
359 via same-day facility claims, which did not include inpatient hospice facilities or assisted living;
360 we had incomplete data on SNF, and no data on personal care utilization. We did not include
361 outpatient medication expenses; these were likely lower in the hospice group, since hospice
362 covers medications related to their terminal condition.
363
364 **Conclusions**
365
366 In this sample of Medicare fee-for-service beneficiaries with poor-prognosis cancer, those
367 receiving hospice care, compared to matched control patients not receiving hospice care, had
368 significantly lower rates of hospitalization, intensive care unit admission, and invasive procedures
369 at the end of life, along with significantly lower health care expenditures during the last year of
370 life.
371
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373
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377
378 ZO had full access to all of the data in the study and takes responsibility for the integrity of the
379 data and the accuracy of the data analysis

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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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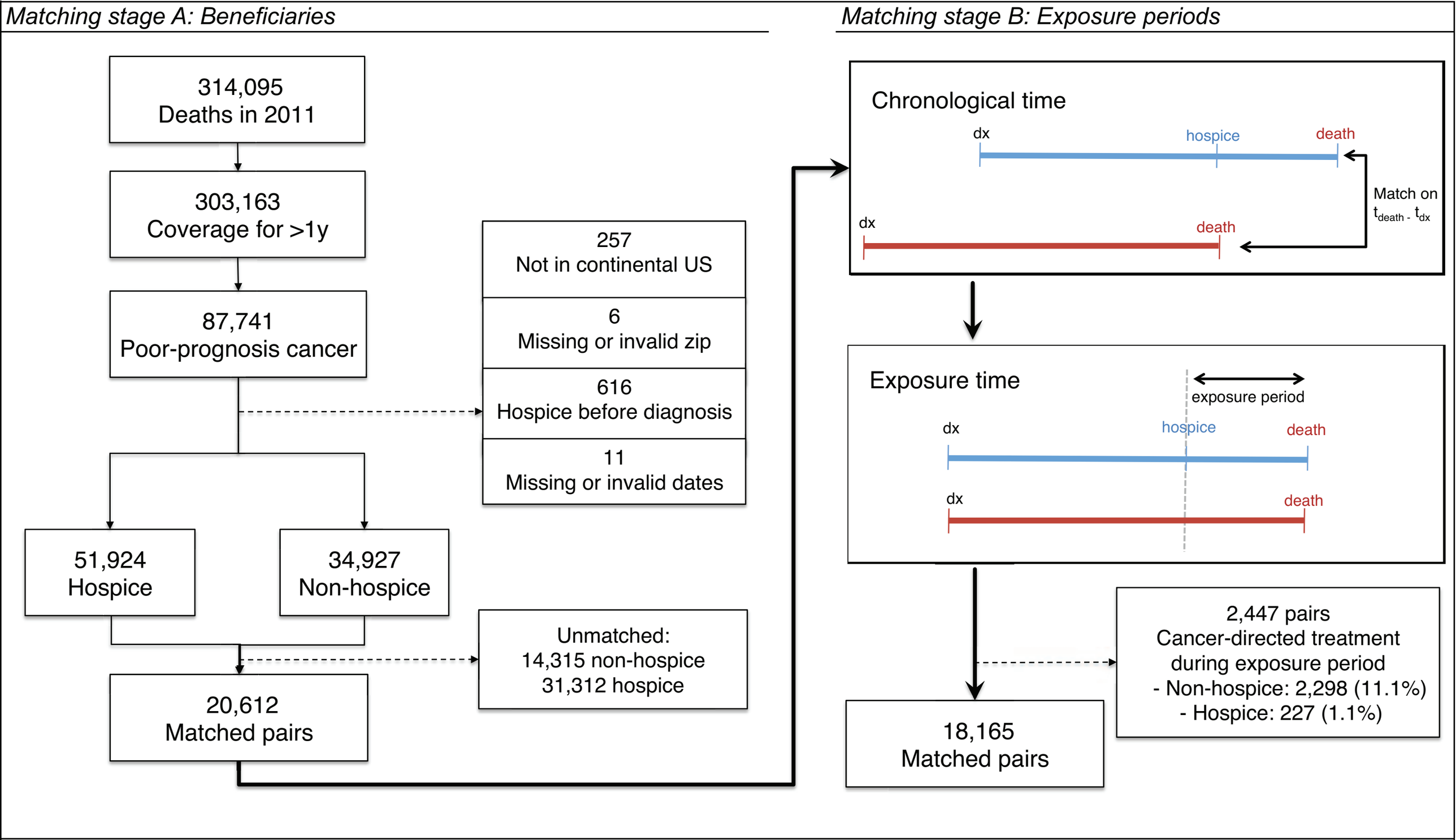
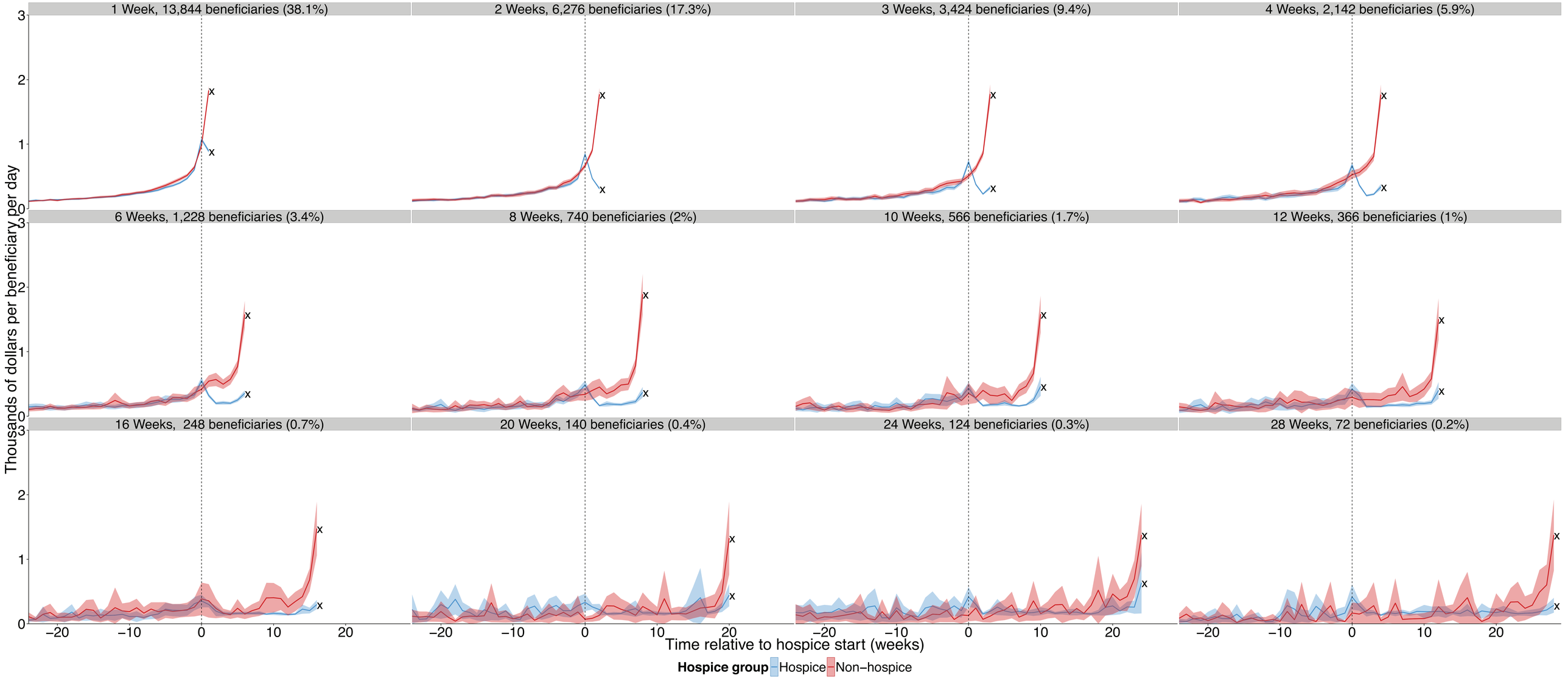

Matching stage A: Beneficiaries
314,095
Deaths in 2011
303,163
Coverage for >1y
87,741
Poor-prognosis cancer
257
Not in continental US
6
Missing or invalid zip
616
Hospice before diagnosis
11
Missing or invalid dates
51,924
Hospice
34,927
Non-hospice
Unmatched:
14,315 non-hospice
31,312 hospice
20,612
Matched pairs
Matching stage B: Exposure periods
Chronological time
dx
hospice
death
Match on
$t_{death} - t_{dx}$
dx
death
Exposure time
exposure period
dx
hospice
death
dx
death
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
Time relative to hospice start (weeks)
Hospice group
Hospice
Non−hospice