



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

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1 **Association between the Medicare hospice benefit and health care utilization and costs for**  
2 **patients with poor-prognosis cancer**

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47 **Abstract**

48

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

53

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

56

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

58

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

61

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

66

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

69

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

73

74 **Results:** Among 86,851 patients with poor-prognosis cancers, median time from first poor-  
75 prognosis diagnosis to death was 13 months (IQR: 3-34), and 51,924 (60%) entered hospice  
76 before death. Matching yielded a cohort balanced on age, sex, region, time from poor-prognosis  
77 diagnosis to death, and baseline care utilization, with 18,165 patients in the hospice group and  
78 18,165 in the non-hospice group. After matching, 11% of non-hospice and 1% of hospice  
79 beneficiaries who had cancer-directed therapy after exposure were excluded. Median hospice  
80 duration was 11 days. Non-hospice beneficiaries had significantly more hospitalizations (65%,  
81 95% CI: 64-66%, vs. hospice: 42%, 95% CI 42-43%, risk ratio: 1.5, 95% CI: 1.5-1.6), intensive  
82 care (36%, 95% CI: 35-37%, vs. hospice: 15%, 95% CI: 14-15%, risk ratio: 2.4, 95% CI: 2.3-2.5),  
83 and procedures (51%, 95% CI: 50-52%, vs. hospice: 27%, 95% CI: 26-27%, risk ratio: 1.9, 95%  
84 CI: 1.9-2.0), largely for acute conditions not directly related to cancer; 74% (95% CI: 74-75) of  
85 non-hospice beneficiaries died in hospitals and nursing facilities compared to 14% (95% CI: 14-  
86 15%) of hospice. Costs for hospice and non-hospice beneficiaries were not significantly different  
87 at baseline, but diverged after hospice start. Total costs over the last year of life were \$71,517  
88 (95% CI: \$70,543-72,490) for non-hospice and \$62,819 (95% CI: \$62,082-63,557) for hospice, a  
89 statistically-significant difference of \$8,697 (95% CI: \$7,560-9,835).

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

95

96 **Introduction**

97

98 Multiple studies have documented the high intensity of medical care at the end of life,<sup>1,2</sup> and there  
99 is increasing consensus that such care can produce poor outcomes<sup>2-4</sup> and conflict with patient  
100 preferences.<sup>4,5</sup> The Institute of Medicine report *Dying in America* has drawn attention to the  
101 difficulties of promoting palliative care, including Medicare's hospice program,<sup>6</sup> 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.<sup>7</sup> Patients with cancer, the single  
106 largest group of hospice users,<sup>8</sup> have both the highest rates of hospice enrollment and the highest  
107 rates of hospice stays under three days.<sup>7</sup>

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.<sup>9,10</sup> Second, Medicare does not reimburse providers for discussions to elicit patients'  
113 preferences for end of life care.<sup>11</sup> Third, Medicare requires patients to formally renounce curative  
114 care before enrolling in hospice, which is thought to limit demand.<sup>10,12</sup> 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.<sup>13</sup>

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.<sup>10,14</sup> 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.<sup>10,15</sup> 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).<sup>16</sup> 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.<sup>17</sup> 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<sup>18</sup>

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,  $t_{death}^h$ , 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  $t_0^h$  and died  
187  $d^h$  days later on  $t_{death}^h$  was matched to a non-hospice beneficiaries who died on  $t_{death}^n$ , 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).<sup>20,21</sup> 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.<sup>19</sup> 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<sup>22</sup> for all inpatient and outpatient care,<sup>23</sup> 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.<sup>24</sup> 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

380

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383

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388

### 389 **Figure legends**

390

#### 391 **Figure 1. Study population**

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

404

#### 405 **Figure 2. Cost trajectories before and after hospice start**

406 Figure 2 shows mean total daily costs relative to hospice start, with beneficiaries  
407 separated into groups based on the length of the exposure period (i.e., the length of  
408 hospice or non-hospice care before death). Since showing all 109 groups was not  
409 possible, and since aggregation would obscure time trends, we show representative  
410 groups with exposure periods of 1, 2, 3, and 4 weeks, which together make up 71% of  
411 the entire cohort; every 2 weeks from 6 to 12 weeks (8% of the cohort); and every 4  
412 weeks from 16 to 28 (2%). "X" marks week of death for each group of beneficiaries. The  
413 panel title shows the length of the exposure period in weeks, the number of beneficiaries,  
414 and the percentage of the overall matched cohort they make up. The shaded area  
415 around the lines show the 95% confidence interval (CI) for the mean; lower CI bounds of

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

418



## Tables

**Table 1.** Baseline characteristics of the matched cohort

Variable	Non-hospice (N=18,165)	Hospice (N=18,165)	Difference	Std. Diff. <sup>d</sup>
<b>Variables used for matching</b>				
Age in years, mean (95% CI) <sup>a</sup>	80 (79.9, 80.1)	80 (79.9, 80.1)	0 (-0.2, 0.2)	0.00
Male, % (95% CI) <sup>a</sup>	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) <sup>b</sup>	213 (43, 818)	210 (48, 822)	3 (-10, 16)	0.00
Distance between pair home zip codes in miles, median (25th, 75th percentile) <sup>b</sup>		24.5 (10.2, 51.8)		-
<b>Demographics</b>				
White, % (95% CI) <sup>a</sup>	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) <sup>b</sup>	62.9 (51.5, 83.1)	64.9 (52.7, 86.6)	-2 (-2.6, -1.4)	-0.08
Region, % (95% CI) <sup>a</sup>				
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
<b>First poor-prognosis malignancy diagnosis, % (95% CI) <sup>a</sup></b>				
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
<b>Illness and hospice course, median (25th, 75th percentile) <sup>b</sup></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
<b>Comorbidity index, median (25th, 75th percentile) <sup>b,c</sup></b>				
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. <sup>d</sup>
<b>Presence of selected individual comorbidities related to functional status, 2006 to exposure start, % (95% CI) <sup>a</sup></b>				
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
<b>Healthcare utilization, 2006 to exposure start</b>				
Inpatient admissions, median (25th, 75th percentile) <sup>b</sup>	3 (1, 6)	3 (2, 5)	0 (0, 0)	- <sup>e</sup>
Emergency visits, median (25th, 75th percentile) <sup>b</sup>	4 (2, 7)	4 (2, 7)	0 (0, 0)	- <sup>e</sup>
Clinic visits, median (25th, 75th percentile) <sup>b</sup>	42 (21, 70)	45 (24, 73)	-3 (-4, -2)	- <sup>e</sup>
Home health days, median (25th, 75th percentile) <sup>b</sup>	6 (0, 31)	7 (0, 30)	-1 (-1.6, -0.4)	0.04
Use of SNF, % (95% CI) <sup>a</sup>	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) <sup>a,f</sup>	35.5 (34.8, 36.2)	44.5 (43.8, 45.2)	-9 (-10, -8)	-0.18
<b>Daily expenses, year prior to exposure start, \$ (95% CI) <sup>a</sup></b>	\$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.

<sup>a</sup> 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.

<sup>b</sup> For non-normally-distributed variables, we report medians, with inter-quartile range in parentheses. Differences are calculated by quantile regression.

<sup>c</sup> Gagne comorbidity score, measured on a composite scale synthesizing Elixhauser and Charlson indices; scale ranges from -2 to 26.

<sup>d</sup> Standardized difference is the difference in group means divided by the common standard deviation.

<sup>e</sup> Standardized difference cannot be calculated for count variables.

<sup>f</sup> Active cancer treatment refers to chemotherapy or surgery

**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
<b>Hospital admission, % (95% CI)</b>	<b>65.1 (64.4, 65.8)</b>	<b>42.3 (41.5, 43.0)</b>	<b>1.5 (1.5, 1.6)</b>
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 <sup>a</sup>	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)
<b>ICU admission, % (95% CI)</b>	<b>35.8 (35.1, 36.5)</b>	<b>14.8 (14.3, 15.3)</b>	<b>2.4 (2.3, 2.5)</b>
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)
<b>Invasive procedures, % (95% CI)</b>	<b>51.0 (50.3, 51.7)</b>	<b>26.7 (26.1, 27.4)</b>	<b>1.9 (1.9, 2.0)</b>
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)
<b>Death in hospital or SNF, % (95% CI)</b>	<b>74.1 (73.5, 74.8)</b>	<b>14 (13.5, 14.5)</b>	<b>5.3 (5.1, 5.5)</b>
Acute care hospital <sup>b</sup>	50.2 (49.5, 51)	3.4 (3.2, 3.7)	14.6 (13.5, 15.8)
Long-term hospital or SNF <sup>c</sup>	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).

<sup>a</sup> Combines ICD codes 518.81 and 518.84

<sup>b</sup> Percent of beneficiaries with an inpatient facility claim on day of death.

<sup>c</sup> 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

**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 (57, 60)	6922	\$71,582 (\$70,027, 73,137)	\$66,779 (\$65,470, 68,087)	\$4,803 (\$2,933, 6,674)
2	57 (55, 58)	3138	\$70,987 (\$68,680, 73,294)	\$63,139 (\$61,322, 64,955)	\$7,848 (\$5,141, 10,555)
3-4	62 (60, 64)	2783	\$72,660 (\$70,177, 75,144)	\$59,595 (\$57,719, 61,471)	\$13,065 (\$10,201, 15,930)
5-8	67 (65, 69)	2231	\$74,890 (\$71,910, 77,869)	\$56,986 (\$55,098, 58,875)	\$17,903 (\$14,543, 21,264)
9-26	91 (88, 93)	2161	\$72,432 (\$69,504, 75,360)	\$60,326 (\$58,518, 62,134)	\$12,106 (\$8,821, 15,392)
27-52	118 (114, 122)	556	\$66,035 (\$60,718, 71,352)	\$65,300 (\$62,687, 67,913)	\$735 (-\$5,131, 6,601)
> 52	152 (148, 157)	374	\$48,981 (\$44,206, 53,755)	\$56,368 (\$52,931, 59,805)	-\$7,387 (-\$13,289, -1,485)
Total	67 (67, 68)	18,165	\$71,517 (\$70,543, 72,490)	\$62,819 (\$62,082, 63,557)	\$8,697 (\$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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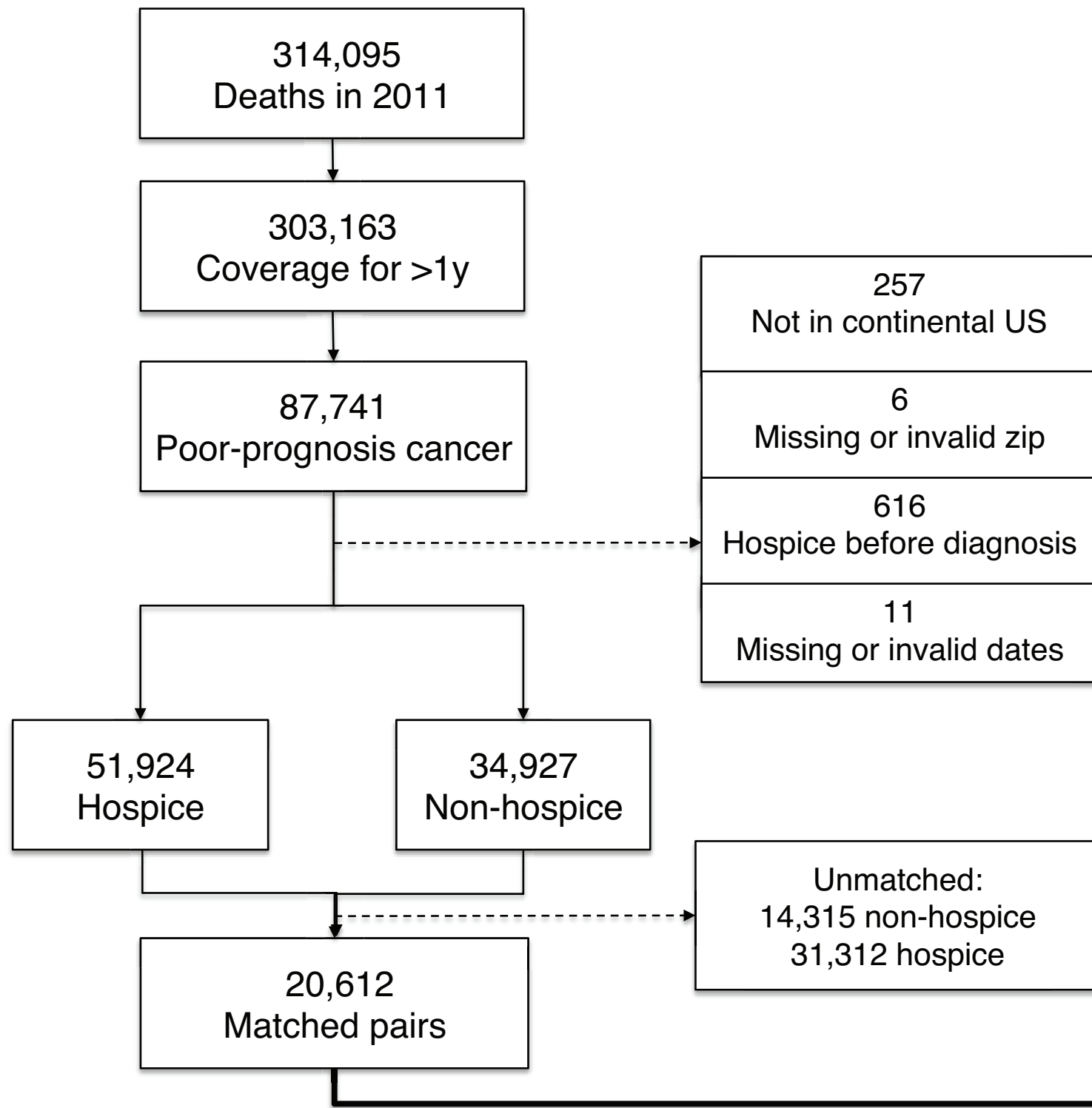
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### Matching stage A: Beneficiaries



### Matching stage B: Exposure periods

