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Meaningful changes in end-of-life care among patients with myeloma

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ABSTRACT

Patients with advanced myeloma experience a high symptom burden particularly near the end of life, making timely hospice use crucial. Little is known about the quality and determinants of end-of-life care for this population, including whether potential increases in hospice use are also accompanied by “late” enrollment (≤ 3 days before death). Using the Surveillance, Epidemiology, and End-Results-Medicare database, we identified patients ≥ 65 years diagnosed with myeloma between 2000 and 2013 who died by December 31, 2013. We assessed prevalence and trends in hospice use, including late enrollment. We also examined six established measures of potentially aggressive medical care at the end of life. Independent predictors of late hospice enrollment and aggressive end-of-life care were assessed using multivariable logistic regression analyses. Of 12,686 myeloma decedents, 48.2% enrolled in hospice. Among the 6111 who enrolled, 17.2% spent ≤ 3 days there. There was a significant trend in increasing hospice use, from 28.5% in 2000 to 56.5% by 2013 ($P_{\text{trend}} < 0.001$), no significant rise in late enrollment (12.2% in 2000 to 16.3% in 2013, $P_{\text{trend}} = 0.19$), and a slight decrease in aggressive end-of-life care (59.2% in 2000 to 56.7% in 2013, $P_{\text{trend}} = 0.01$). Patients who were transfusion-dependent, on dialysis, or survived for less than one year were more likely to enroll late in hospice and experience aggressive medical care at the end of life. Gains in hospice use for myeloma decedents were not accompanied by increases in late enrollment or aggressive medical care. These findings suggest meaningful improvements in end-of-life care for this population.

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Introduction

Multiple myeloma is a hematologic cancer diagnosed in over 30,000 individuals each year in the USA.¹ It is predominantly a disease of older adults, with a median age of diagnosis at 69 years.² Although there has been a rapid adoption of novel treatments leading to improvements in survival, myeloma remains an incurable disease.³⁻⁶ Moreover, affected patients experience substantial symptom burden throughout the disease trajectory, which intensifies near the end of life (EOL).^{7,8} Accordingly, high-quality EOL care is crucial for this population.

Hospice is a model of care that has been demonstrated to be effective in alleviating patient suffering and improving quality of life for patients near the EOL, through the provision of expert symptom-directed care.^{9,10} Although hospice enrollment in the USA typically involves discontinuation of chemotherapy and transfusions, this is not the case for many hospice programs in European countries.¹¹ Despite these differences in hospice care delivery in various locations, the central focus is to improve patient quality of life through expert symptom-directed care. In contrast to hospice, medically aggressive care near the EOL is associated with worse patient quality of life.¹² Moreover, bereaved caregivers of patients who receive aggressive medical care close to death are less likely to report that their loved ones received “excellent” care, and are also at heightened risk of poor mental health outcomes.^{9,13} Timely hospice enrollment and avoidance of aggressive medical care near death (e.g., multiple hospitalizations or intensive care

unit [ICU] admission) are thus endorsed as indicators of high quality EOL care.^{14,15}

Although little is known about EOL care for patients with myeloma, several studies have demonstrated that patients with hematologic cancers have low rates of hospice enrollment and high rates of aggressive medical care at the EOL compared to patients with solid malignancies.¹⁶⁻¹⁹ Rates of hospice use have increased for patients with blood cancers in the past decade; however, there have also been concomitant rises in “late” enrollment (generally defined as ≤ 3 days before death) and aggressive EOL care.²⁰⁻²² Growth in hospice use that is largely driven by late enrollment is less meaningful, as patients are being admitted to hospice primarily to manage their death, rather than to obtain palliative benefits.²³

These trends may not apply to patients with myeloma. Myeloma shares many characteristics with other blood cancers (e.g., bone marrow failure leading to transfusion dependence), has other features that are similar to advanced solid malignancies (e.g., high prevalence of pain, incurability), and still others that are unique (high likelihood of renal disease and dialysis). In this context, we aimed to characterize EOL care among older patients with myeloma. We hypothesized that there would be an increase in hospice use over time; however, given the traditional palliative needs of this population at the EOL and the known incurability of myeloma, we also hypothesized that we would not see increases in late enrollment.

Methods

Data Source

We used the National Cancer Institute’s Surveillance, Epidemiology, and End Results cancer registry linked to Medicare healthcare claims (SEER-Medicare). This database provides cancer registry data from 18 geographic areas, representing 28% of the population of the USA, linked to billing claims for Medicare beneficiaries.²⁴ At the time of this analysis, the database included diagnoses through 2013 and billing claims through 2014. The Dana-Farber/Harvard Cancer Center Office for Human Research Studies deemed the study exempt from review.

Cohort Assembly

We identified patients ≥ 65 years diagnosed with myeloma or plasmacytoma between 2000 and 2013, who were deceased by December 31, 2013. We excluded patients who died within 30 days of diagnosis. To ascertain complete claims history, patients had to have been continuously enrolled in Medicare Parts A and B with no health maintenance organization enrollment during the twelve months before death. We excluded patients diagnosed with myeloma at death or autopsy, and those who had end-stage renal disease or disability at diagnosis.²⁵ Figure 1 and the *Online Supplementary Methods* detail the cohort assembly.

Outcomes

Hospice use: was defined as the presence of at least one hospice claim (outpatient or inpatient). We defined “late” enrollment as enrollment ≤ 3 days before death.

Aggressive EOL care: was defined as the occurrence of at least one of the following indicators: 1) chemotherapy use within 14 days of death, 2) ≥ 2 emergency department (ED) visits within 30 days of death, 3) ≥ 2 hospitalizations within 30 days of death, 4) hospital stay >14 days within 30 days of death, 5) at least one ICU admission within 30 days of death, and 6) death in a hospital.^{12,21}

These measures are well-established indicators of potentially sub-optimal EOL care.

Covariates

In addition to sociodemographic characteristics, we examined comorbidity using the Deyo adaptation of the Charlson Comorbidity Index²⁶ in the twelve months before death, transfusion-dependence (presence of two or more claims for transfusions in the last 30 days of life),²⁰ and dialysis-dependence (presence of two or more claims for dialysis in the last 30 days of life).

Statistical Analyses

We assessed univariable associations of patient characteristics with outcomes of late hospice enrollment and experiencing at least one indicator of aggressive care using Chi-square tests. We then fit multivariable logistic regression models to characterize factors independently associated with the two aforementioned outcomes. Only covariates with $P < 0.05$ in univariable analysis were included in the models. Trends in overall hospice use, late enrollment, and receipt of at least one indicator of aggressive EOL care were depicted visually using locally weighted scatterplot smoothing, where the day of death was the unit of analysis for the plot. We assessed significant trends over time using the Cochran-Armitage test, which tested for a monotonic change (i.e., increase or decrease) across the ordered years of death. In a separate multivariable logistic regression model that included hospice use as a covariate, we examined the relationship between hospice enrollment and medically aggressive EOL care. Two-sided P values < 0.05 were considered statistically significant. All analyses were performed using SAS version 9.4 (Cary, NC).

Results

Patient Characteristics

This study cohort included 12,686 myeloma decedents. The median age at diagnosis was 77 years. About half of the cohort was male (49.5%) and most were white (80.6%; Table 1). Of the total cohort, 7.3% were transfusion-dependent in the last 30 days of life, and 10.5% were dialysis-dependent. Median survival was 17.6 months (interquartile range [IQR] 5.2 to 39.1 months).

Hospice Use

Among the entire cohort, 6111 (48.2%) received hospice care. The median length of stay in hospice was 13 days (IQR 5 to 45 days). The majority (79.6%) used outpatient/home hospice services, while 19.4% used inpatient hospice services, and 1.0% used both. Among those who enrolled, 17.2% spent ≤ 3 days in hospice. In univariable analysis, patients who were transfusion-dependent were more likely to enroll in hospice ≤ 3 days before death compared to those who were not transfusion-dependent (36.5% vs. 16.0%, $P < 0.001$; Table 2). Dialysis-dependence was also associated with late hospice enrollment (32.3% vs. 16.0%; $P < 0.001$). These findings remained consistent in multivariable analysis: patients who were transfusion-dependent were more likely to enroll in hospice late (odds ratio [OR] 3.02, 95% confidence interval [CI] 2.39 – 3.82). Similarly, patients on dialysis were also more likely to enroll late (OR 2.22, 95% CI 1.79 – 2.76). Other factors significantly associated with enrolling late in hospice included male sex, living in urban areas, higher comorbidity scores, and surviving less than a year after myeloma diagnosis (Table 3). There was a significant increase in

hospice use over the study period, with rates rising from 28.5% in 2000 to 56.5% by 2013 ($P_{\text{trend}} < 0.001$); however, there was no significant increase in late enrollment (12.2% in 2000 to 16.3% in 2013, $P_{\text{trend}} = 0.19$; Figure 2).

Aggressive EOL Care

Slightly over half of the cohort (55.8%) had at least one indicator of aggressive EOL care. Nineteen percent of patients received only one indicator of aggressive medical care, 16.0% received two, and only 0.1% received all six indicators of aggressive EOL care. Univariable associations between patient characteristics and aggressive EOL care are displayed in Table 4. In multivariable logistic regression analysis, year of death was a significant determinant of aggressive EOL care. Specifically, we found significantly

lower odds of experiencing any indicator of aggressive care in more recent years compared to earlier years (Table 5). Patients who were transfusion-dependent (OR 3.40, 95% CI 2.87 – 4.04) or dialysis-dependent (OR 2.32, 95% CI 2.01 – 2.68) had significantly higher odds of having at least one indicator of medically aggressive care. We also found that age, sex, race, marital status, geographic region, comorbidity, and survival were significantly associated with having one or more indicators of medically aggressive EOL care (Table 5).

In univariable analysis examining the relationship between hospice use and medically aggressive care at the EOL, we found that 35.7% of patients who enrolled in a hospice experienced aggressive care compared to 74.5% among those who did not enroll. In a separate multivari-

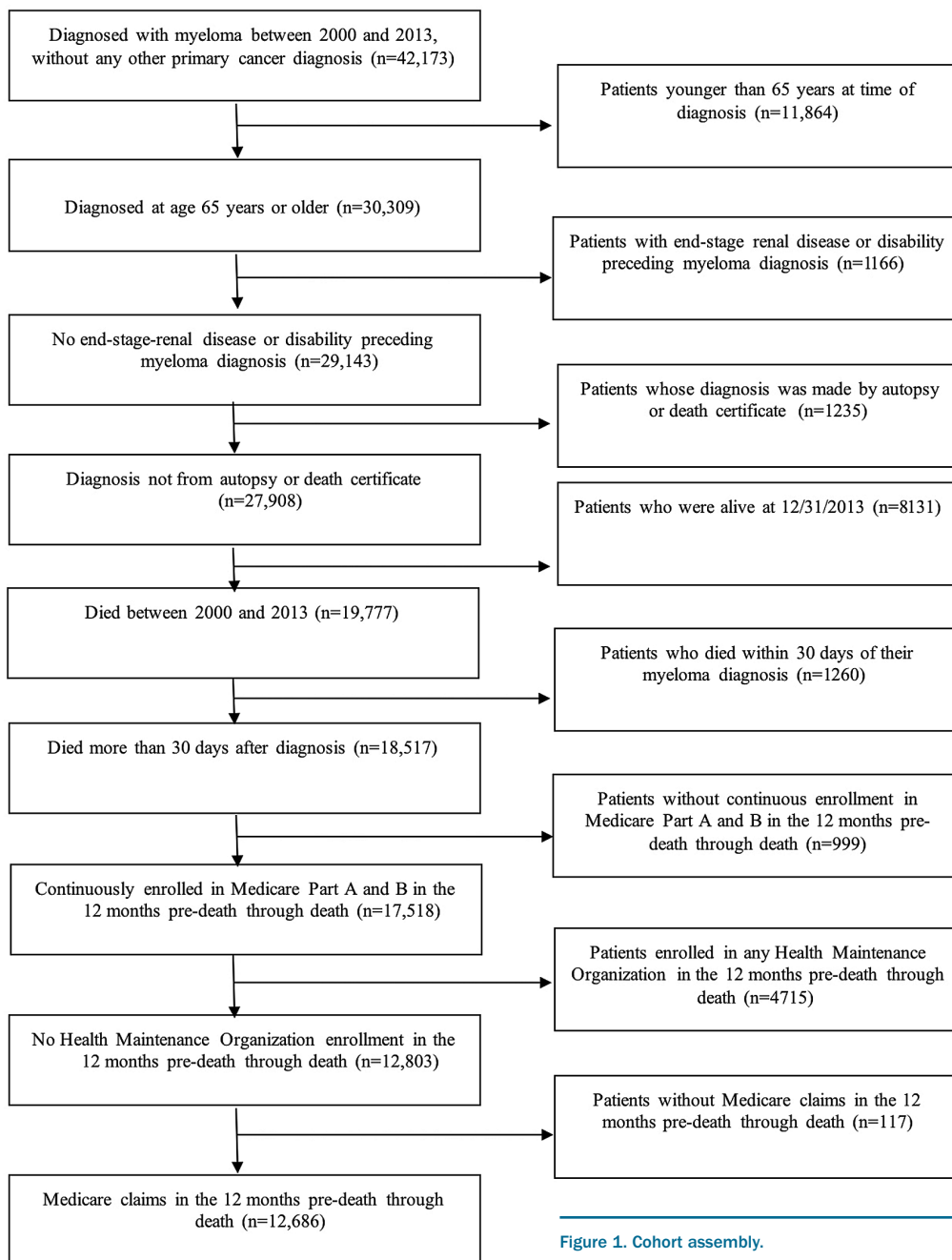


Figure 1. Cohort assembly.

able model that assessed the relationship between hospice use and aggressive EOL care, patients who enrolled in hospice were significantly less likely to experience any measure of aggressive care at the EOL (OR 0.20, 95% CI 0.18 – 0.22). There was also a slight decrease in experiencing any aggressive EOL care during the study period (59.2% in 2000 to 56.7% in 2013, $P_{\text{trend}}=0.01$).

Discussion

In this large cohort of older patients with myeloma, almost half enrolled in hospice, and among these, approx-

imately 17% enrolled within 3 days of death. Although hospice enrollment significantly increased between 2000 and 2013, with rates almost doubling, there was no significant rise in late enrollment, suggesting that the increase in hospice use was meaningful. While slightly more than half of the myeloma decedents experienced at least one indicator of medically aggressive care in the last month of life, there was a significant decline in the overall intensity of healthcare utilization during the study period. Moreover, patients who enrolled in a hospice had substantially lower odds of experiencing medically aggressive care at the end of life. Taken together, these data suggest improvements in EOL care for patients with myeloma, which could be

Table 1. Characteristics of patients diagnosed with myeloma who died between 2000 and 2013 (n=12,686).

Characteristic		Number	%
Sex	Male	6275	49.5
	Female	6411	50.5
Age at diagnosis (yrs)	65-69	2215	17.5
	70-74	2727	21.5
	75-79	2862	22.5
	≥ 80	4882	38.5
Race	White	10225	80.6
	Nonwhite	2461	19.4
Marital status at diagnosis	Married	6390	50.4
	Other	6296	49.6
Residency	Urban	11271	88.9
	Rural	1413	11.1
College education (census tract quintile)	1 (lowest)	2471	19.5
	2	2463	19.4
	3	2796	22.0
	4	2477	19.5
	5 (highest)	2479	19.6
Median income (census tract quintile)	1 (lowest)	2459	19.4
	2	2472	19.5
	3	2796	22.0
	4	2478	19.5
	5 (highest)	2481	19.6
Region	Northeast	2629	20.7
	South	3426	27.0
	Midwest	1695	13.4
	West	4936	38.9
Time from diagnosis to death*	< 1 year	5198	41.0
	≥ 1 year	7488	59.0
Modified Charlson comorbidity score	0-1	4240	33.4
	2+	8446	66.6
Dialysis-dependent	No	11,350	89.5
	Yes	1336	10.5
Transfusion-dependent	No	11,759	92.7
	Yes	927	7.3
Year of death	2000 – 2003	2407	19.0
	2004 – 2008	5047	39.8
	2009 – 2013	5232	41.2

*Median duration of disease (from myeloma diagnosis to death) in the cohort was 17.6 months (interquartile range 5.2 to 39.1 months).

further augmented by promoting timely hospice use.

The rise in hospice use among myeloma decedents is consistent with prior studies among patients with various malignancies in the USA.^{16,22,27} Such trends may reflect a greater awareness of the benefits of hospice care, especially as professional oncology organizations have released statements on the importance of hospice.^{28,29} Moreover, there has also been a substantial growth in the number of hospice organizations serving various locations in the USA over the past two decades.³⁰ Unlike many other

hematologic cancers,^{21,22} gains in hospice use for patients with myeloma were not accompanied by increases in late enrollment. Distinct features of myeloma compared to other blood cancers, such as incurability and a high prevalence of pain, may make the need for hospice services at the EOL clearer and thus encourage timely enrollment. Indeed, in a prior study examining symptom burden of patients with hematologic malignancies, those with myeloma had the highest number and severity of symptoms, such as pain, fatigue, and constipation.³¹ A combination of this population's severe symptom burden and the

Table 2. Univariable analysis of factors associated with hospice enrollment ≤ 3 days before death among myeloma decedents that enrolled in hospice (n=6111).

Characteristic		Hospice stay ≤ 3 days (n=1054) n (%)	Hospice stay > 3 days (n=5057) n (%)	P
Sex	Male	551 (20.0)	2214 (80.0)	<0.001
	Female	503 (15.0)	2843 (85.0)	
Age at diagnosis (yrs)	65- 69	177 (19.0)	754 (81.0)	0.05
	70-74	234 (19.1)	993 (80.9)	
	75- 79	227 (16.6)	1142 (83.4)	
	≥ 80	416 (16.1)	2168 (83.9)	
Race	White	906 (17.6)	4255 (82.4)	0.14
	Nonwhite	148 (15.6)	802 (84.4)	
Marital status at diagnosis	Married	572 (18.8)	2470 (81.2)	0.0014
	Other	482 (15.7)	2587 (84.3)	
Residency	Rural	82 (12.7)	562 (87.3)	0.0013
	Urban	972 (17.8)	4494 (82.2)	
College education (census tract quintile)	1 (lowest)	166 (15.2)	929 (84.8)	0.34
	2	202 (17.1)	977 (82.9)	
	3	243 (17.6)	1137 (82.4)	
	4	221 (17.9)	1012 (82.1)	
	5 (highest)	222 (18.1)	1002 (81.9)	
Median income (census tract quintile)	1 (lowest)	156 (14.6)	911 (85.4)	0.02
	2	196 (16.6)	988 (83.4)	
	3	252 (17.4)	1199 (82.6)	
	4	210 (17.5)	993 (82.5)	
	5 (highest)	240 (19.9)	966 (80.1)	
Region	Northeast	272 (23.7)	876 (76.3)	<0.001
	South	228 (12.9)	1543 (87.1)	
	Midwest	184 (19.6)	757 (80.4)	
	West	370 (16.4)	1881 (83.6)	
Time from diagnosis to death	< 1 year	426 (18.7)	1848 (81.3)	0.02
	≥ 1 year	628 (16.4)	3209 (83.6)	
Modified Charlson comorbidity score	0-1	301 (13.1)	2001 (86.9)	<0.001
	2+	753 (19.8)	3056 (80.2)	
Dialysis-dependent	No	904 (16.0)	4743 (84.0)	<0.001
	Yes	150 (32.3)	314 (67.7)	
Transfusion-dependent	No	922 (16.0)	4827 (84.0)	<0.001
	Yes	132 (36.5)	230 (63.5)	
Year of death	2000 – 2003	147 (15.7)	788 (84.3)	0.33
	2004 – 2008	396 (17.2)	1913 (82.8)	
	2009 – 2013	511 (17.8)	2356 (82.2)	

All percentages are row percentages.

fact that the hospice model is known to be especially effective in pain management may promote increased enrollment. Additionally, the known incurability of myeloma may temper prognostic uncertainty and encourage earlier EOL discussions compared to blood cancers that are potentially curable.³²

The current analysis allowed us to explore potential unique barriers to timely enrollment, such as transfusion-

and dialysis-dependence. Our finding that patients who were transfusion-dependent had three times the odds of enrolling late is provocative, and suggests that transfusion-dependence is not only associated with lack of hospice use for patients with blood cancers,^{20,22} but also impacts the timeliness of enrollment. Although transfusions are palliative, only very few hospices in the USA provide this resource due to reimbursement constraints.³³ In some

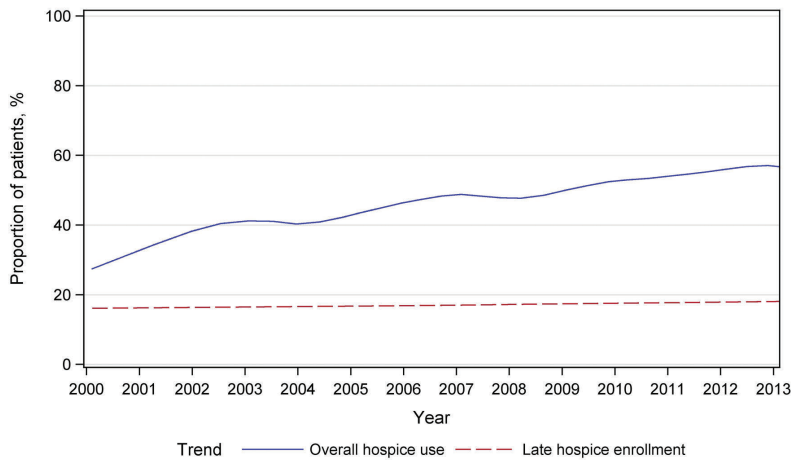


Figure 2. Trends in overall hospice use and late enrollment (≤ 3 days before death) from 2000 to 2013. Trends in hospice use for myeloma decedents significantly increased from 2000 to 2013 ($P_{\text{trend}} < 0.001$). Trends in late hospice enrollment (≤ 3 days before death) for myeloma decedents did not significantly increase from 2000 to 2013 ($P_{\text{trend}} = 0.19$).

Table 3. Multivariable analysis of factors associated with hospice enrollment ≤ 3 days before death among myeloma decedents that enrolled in hospice.

Characteristic		Odds Ratio	95% Confidence Interval
Sex	Male	Ref	
	Female	0.75	0.64 – 0.86
Marital status at diagnosis	Married	Ref	
	Other	0.88	0.76 – 1.02
Residency	Rural	Ref	
	Urban	1.34	1.03 – 1.75
Median income (census tract quintile)	1 (lowest)	Ref	
	2	1.06	0.84 – 1.35
	3	1.06	0.84 – 1.33
	4	1.00	0.76 – 1.24
	5 (highest)	1.04	0.81 – 1.34
Region	Northeast	Ref	
	South	0.49	0.40 – 0.62
	Midwest	0.80	0.63 – 1.01
	West	0.64	0.53 – 0.77
Time from diagnosis to death	< 1 year	Ref	
	≥ 1 year	0.76	0.66 – 0.87
Modified Charlson comorbidity score	0-1	Ref	
	2+	1.41	1.22 – 1.65
Dialysis-dependent	No	Ref	
	Yes	2.22	1.79 – 2.76
Transfusion-dependent	No	Ref	
	Yes	3.02	2.39 – 3.82

Only variables with $P < 0.05$ in univariable analysis, specifically sex, marital status, urban/rural residency, median income census tract quintile, region, modified Charlson comorbidity score, time from diagnosis to death, dialysis, and transfusion-dependence, were included in the multivariable logistic regression model to generate odds ratios. Odds ratio > 1 indicate increased odds of enrolling in hospice late.

health care systems in Europe, where access to transfusion is available in hospice settings, the relationship we observed between transfusion-dependence and late enrollment may not be present. Modifying the current hospice reimbursement structure in the USA to liberalize the use of palliative transfusions would likely improve timely hospice use for patients with myeloma and other hematologic cancers. Indeed, in a national survey of hematologic oncologists, the majority reported that they would refer more

patients to hospice if transfusions were readily available.³⁴ Although providing transfusions necessitates additional costs, our finding that hospice enrollment was associated with a 38.8% absolute reduction in receiving any high-cost medically aggressive care at the EOL suggests that this strategy could be overall financially equivalent, at least from the societal perspective.

The lack of access to dialysis services in most hospices may contribute to refusals or delays in enrollment among

Table 4. Univariable analysis of factors associated with receipt of at least one indicator of medically aggressive care at the end of life among entire cohort of myeloma decedents from 2000 to 2013 (n=12,686).

Characteristic		Received any aggressive care (n=7079) n (%)	Did not receive any aggressive care (n=5607) n (%)	P
Sex	Male	3670 (58.5)	2605 (41.5)	<0.001
	Female	3409 (53.2)	3002 (46.8)	
Age at diagnosis (yrs)	65-69	1415 (63.9)	800 (36.1)	<0.001
	70-74	1689 (61.9)	1038 (38.1)	
	75-79	1629 (56.9)	1233 (43.1)	
	≥ 80	2346 (48.1)	2536 (51.9)	
Race	White	5514 (53.9)	4711 (46.1)	<0.001
	Nonwhite	1565 (63.6)	896 (36.4)	
Marital status at diagnosis	Married	3717 (58.2)	2673 (41.8)	<0.001
	Other	3362 (53.4)	2934 (46.6)	
Residency	Rural	778 (55.1)	635 (44.9)	0.55
	Urban	6301 (55.9)	4970 (44.1)	
College education (census tract quintile)	1 (lowest)	1486 (60.1)	985 (39.9)	<0.001
	2	1356 (55.1)	1107 (44.9)	
	3	1528 (54.7)	1268 (45.3)	
	4	1368 (55.2)	1109 (44.8)	
	5 (highest)	1341 (54.1)	1138 (45.9)	
Median income (census tract quintile)	1 (lowest)	1460 (59.4)	999 (40.6)	<0.001
	2	1370 (55.4)	1102 (44.6)	
	3	1450 (51.9)	1346 (48.1)	
	4	1371 (55.3)	1107 (44.7)	
	5 (highest)	1428 (57.6)	1053 (42.4)	
Region	Northeast	1627 (61.9)	1002 (38.1)	<0.001
	South	1869 (54.6)	1557 (45.4)	
	Midwest	917 (54.1)	778 (45.9)	
	West	2666 (54.0)	2270 (46.0)	
Modified Charlson comorbidity score	0-1	1776 (41.9)	2464 (58.1)	<0.001
	2+	5303 (62.8)	3143 (37.2)	
Time from diagnosis to death	< 1 year	3135 (60.3)	2063 (39.7)	<0.001
	≥ 1 year	3944 (52.7)	3544 (47.3)	
Dialysis-dependent	No	6026 (53.1)	5324 (46.9)	<0.001
	Yes	1053 (78.8)	283 (21.2)	
Transfusion-dependent	No	6338 (53.9)	5421 (46.1)	<0.001
	Yes	741 (79.9)	186 (20.1)	
Year of death	2000 – 2003	1417 (58.9)	990 (41.1)	0.003
	2004 – 2008	2781 (55.1)	2266 (44.9)	
	2009 – 2013	2881 (55.1)	2351 (44.9)	

All percentages are row percentages.

dialysis-dependent myeloma patients. This may partially explain our finding that myeloma patients who were dialysis-dependent were significantly more likely to enroll late. Unlike transfusions, dialysis itself is unlikely to be palliative.³⁵ Accordingly, rather than incorporating dialysis into hospice care, this group of patients may benefit from bridge programs that provide palliative care services before choosing to discontinue dialysis and transition to hospice. Although the rate of medically aggressive care at the EOL for this myeloma cohort (56%) was substantially lower than a prior analysis that included patients with various types of hematologic cancers (78%),¹⁹ it is higher than

that described for patients with solid malignancies in both single-institution and population-based studies (30–35%).^{16,19} This intermediate rate supports the hypothesis that the complex features of myeloma that are similar to solid malignancies (e.g., incurability, pain) may ease the transition from more aggressive medical care toward symptom-directed care as compared to other blood cancers. In a qualitative study of hematologic oncologists, physicians who focused on myeloma noted that the incurability of the disease made it less challenging to transition from disease-directed to symptom-focused therapies near the EOL.³⁶ Moreover, in a population-based study of blood

Table 5. Multivariable analysis of factors associated with receipt of at least one indicator of medically aggressive care at the end of life among entire cohort of myeloma decedents from 2000 to 2013 (n=12,686).

Characteristic		Odds Ratio	95% Confidence Interval
Sex	Male	Ref	
	Female	0.90	0.83 – 0.97
Age at diagnosis (yrs)	65-69	Ref	
	70-74	0.91	0.81 – 1.03
	75-79	0.76	0.68 – 0.86
	≥ 80	0.55	0.49 – 0.61
Race	White	Ref	
	Nonwhite	1.36	1.23 – 1.50
Marital status at diagnosis	Married	Ref	
	Other	0.88	0.81 – 0.95
College education (census tract quintile)	1 (lowest)	Ref	
	2	0.86	0.76 – 0.98
	3	0.86	0.75 – 0.98
	4	0.85	0.73 – 0.99
	5 (highest)	0.78	0.66 – 0.92
Median income (census tract quintile)	1 (lowest)	Ref	
	2	0.97	0.86 – 1.10
	3	0.85	0.74 – 0.98
	4	1.00	0.85 – 1.17
	5 (highest)	1.09	0.91 – 1.31
Region	Northeast	Ref	
	South	0.68	0.60 – 0.77
	Midwest	0.71	0.62 – 0.81
	West	0.73	0.66 – 0.82
Time from diagnosis to death	< 1 year	Ref	
	≥ 1 year	0.62	0.58 – 0.68
Modified Charlson comorbidity score	0-1	Ref	
	2+	2.11	1.95 – 2.29
Dialysis-dependent	No	Ref	
	Yes	2.32	2.01 – 2.68
Transfusion-dependent	No	Ref	
	Yes	3.40	2.87 – 4.04
Year of death	2000 – 2003	Ref	
	2004 – 2008	0.85	0.77 – 0.95
	2009 – 2013	0.81	0.73 – 0.90

Only variables with $P < 0.05$ in univariable analysis, specifically sex, age, race, marital status, median income census tract, college education census tract, region, modified Charlson comorbidity score, time from diagnosis to death, dialysis-dependence, transfusion-dependence, and year of death, were included in the multivariable logistic regression model to generate odds ratios. Odds ratio >1 indicate higher odds of receiving at least one indicator of aggressive care at the end of life.

cancer patients in the UK, those with myeloma (n=887) were significantly more likely to be referred to palliative care and less likely to die in acute care settings.^{37,38}

Patients who survived more than a year after their diagnosis were more likely to use hospice in a timely fashion and were also less likely to receive aggressive medical care close to death. This is consistent with prior data showing that survival duration is an important determinant of having a home *versus* hospital death.³⁹ The relationship between survival time and EOL care may reflect increased patient experience with—and thus the desire to avoid—the burden of additional intensive treatments. Moreover, a longer time between diagnosis and death offers more opportunities to engage in advance care planning. Importantly, clear and consistent discussions regarding prognosis and EOL decision-making early in the disease trajectory are necessary if we are going to improve the quality of EOL care across all survival ranges.

We acknowledge limitations to our study. First, our cohort was restricted to patients 65 years and older who were enrolled in Medicare, which may limit the generalizability of our findings. Nonetheless, we are reassured that the median diagnostic age for myeloma is well over 65 years. Second, we relied on claims to assess EOL care, which may have variable sensitivity in capturing outcomes of interest. Third, we did not have access to patients' preferences, which are also a significant determinant of the quality of EOL care received. Next, we did not have access to Revised-International Staging System (R-ISS) stage for patients in this study, and thus could not determine if any association exists between R-ISS and EOL care. Finally, while each indicator of medically aggressive care near the EOL was equally weighted in our analysis as in previous studies,^{16,19,39} various stakeholders

(patients, hematologic oncologists, policy makers) may assign different levels of importance to each of the indicators.

In conclusion, our data suggest that along with vast improvements in treatment and survival, there has also been meaningful progress in EOL care for patients with myeloma in the USA. These patients are not only enrolling more often in hospice, but the increase in use is not driven by late enrollment. Still, there remains ample opportunity for further improvement, particularly among patients who survive less than one year, are dialysis-dependent, or transfusion-dependent. Possible solutions include earlier goals of care discussions, bridge palliative care services, and modification of the hospice model to enable transfusion support.

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