Influence of Treating Facility, Provider Volume, and Patient-Sharing on Survival of Patients With Multiple Myeloma

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ABSTRACT

Background: Population-based studies suggest that patients with multiple myeloma (MM) have better outcomes when treated at high-volume facilities, but the relative contribution of provider expertise and hospital resources to improved outcomes is unknown. This study explored how treating facility, individual provider volume, and patient-sharing between MM specialists and community providers influenced outcomes for patients with MM. **Patients and Methods:** A state cancer registry linked to public and private insurance claims was used to identify a cohort of patients diagnosed with MM in 2006 through 2012. Three multivariable Cox models were used to examine how the following factors impacted overall survival: (1) evaluation at an NCI-designated Comprehensive Cancer Center (NCICCC), (2) the primary oncologist's volume of patients with MM, and (3) patient-sharing between MM specialists and community oncologists. **Results:** A total of 1,029 patients diagnosed with MM in 2006 through 2012 were identified. Patients who were not evaluated at an NCICCC had an increased risk of mortality compared with those evaluated at an NCICCC (hazard ratio [HR], 1.50; 95% CI, 1.21–1.86; $P<.001$). Compared with patients treated by NCICCC MM specialists, those treated by both low-volume community providers (HR, 1.47; 95% CI, 1.14–1.90; $P<.01$) and high-volume community providers (HR, 1.29; 95% CI, 1.04–1.61; $P<.05$) had a higher risk of mortality. No difference in mortality was seen between patients treated by NCICCC MM specialists and those treated by the highest-volume community oncologists in the ninth and tenth deciles (HR, 1.08; 95% CI, 0.84–1.37; $P=.5591$). Patients treated by community oncologists had a higher risk of mortality regardless of patient-sharing compared with patients treated by MM specialists (eg, community oncologist with a history of sharing vs NCICCC MM specialist: HR, 1.49; 95% CI, 1.10–2.02; $P<.05$). **Conclusions:** Findings of this study add to the accumulating evidence showing that patients with MM benefit from care at high-volume facilities, and suggest that similar outcomes can be achieved by the highest-volume providers in the community.

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Background

Population-based studies suggest that patients with hematologic malignancies benefit from treatment at specialized facilities, which have been identified in claims-based studies based on NCI Comprehensive Cancer Center (NCICCC) designation, university affiliation, or high patient volume. For example, treatment at an NCICCC has been shown to attenuate survival disparities among young adults with hematologic malignancies,[1] and treatment by a university-based oncologist has been associated with lower mortality for patients with lymphoma.[2] Similarly, patients with acute myeloid leukemia[3] or non-Hodgkin's lymphoma[4] receiving chemotherapy at high-volume facilities have been found to have a lower mortality rate than those treated at low-volume facilities. Superior survival has also been reported for patients with chronic lymphocytic leukemia (CLL) treated by a CLL specialist compared with other hematologists within a single NCICCC.[5] Recently, Go et al[6] identified a volume–outcome relationship in multiple myeloma (MM) showing that patients treated at low-volume facilities had a 22% increased risk of death compared with those treated at high-volume facilities.

Provider expertise and hospital volume are overlapping, but both these distinct concepts may affect outcomes for patients. However, most studies reporting volume–outcome relationships have not been able to elucidate the underlying mechanisms driving better outcomes.[7] Studying the relative impact of provider expertise and hospital volume on patient outcomes may help inform referral practices. A common practice is to refer patients to an MM specialist for treatment recommendations, but to perform most care in the community. The impact on survival of patient-sharing among MM treatment providers has not been studied.

Objectives

The primary objective was to determine the factors predicting NCICCC evaluation and to examine the impact of NCICCC evaluation on overall survival (OS) of patients with MM. We hypothesized that patients

evaluated at an NCICCC would have longer OS than those who were not. The secondary objective was to determine whether individual provider volume or patient-sharing between NCICCC MM specialists and community oncologists were associated with OS. We hypothesized that treatment by either high- or low-volume providers who share patients with NCICCC MM specialists would be associated with improved survival.

Patients and Methods

Study Population

A retrospective cohort of patients with MM was identified using the University of North Carolina Cancer Information and Population Health Resource (CIPHR). The CIPHR data comprise a nationally unique, state-based dataset representing linkage of the North Carolina Central Cancer Registry (NC CCR; >400,000 patients) to >6 million unique beneficiaries of Medicare, Medicaid, and private insurance plans across the state.

We included all patients aged >18 years in the NC CCR diagnosed with MM from 2006 through 2012 (n=4,603). This date range was chosen because 2006 was the first year Medicare Part D was available, which allowed oral chemotherapy to be captured, and 2012 was the most recent complete year of data available at the time of analysis. Patients were excluded if they were diagnosed on death certificate or autopsy (n=215), had additional cancer diagnoses (n=722), or lacked confirmatory laboratory studies (n=256). Patients were also excluded if they had incomplete information in the database related to home (n=9) or provider (n=49) ZIP code. To ensure capture of patient comorbidities and observation of complete healthcare use, patients were excluded if they did not have continuous insurance enrollment for 6 months before and 12 months after diagnosis (n=2,031). Although this criterion resulted in the exclusion of a significant number of patients, it was important to ensure an accurate representation of the interactions between patients and physicians. To avoid including patients with smoldering MM, patients who did not receive chemotherapy within 12 months of diagnosis were excluded (n=279). Although most patients received treatment in North Carolina (>99%), those who were treated out of state were not specifically excluded. Finally, 13 patients were excluded who were simultaneously enrolled in Medicare, Medicaid, and a private insurance plan for 18 months because this was unlikely and believed to be erroneous. A total of 1,029 individuals met all inclusion criteria (Figure 1).

Exposure and Outcome Measurement

Logistic regression was used to identify factors associated with increased odds of undergoing evaluation at an NCICCC within 12 months of diagnosis, and then 3 separate multivariable analyses were conducted. The first analysis explored the impact on OS of at least one outpatient visit to an NCICCC oncologist within 12 months of MM diagnosis. NCICCCs were identified by ZIP code. Among all institutions in North Carolina, there are 3 NCICCCs, and these constituted the highest quartile of volume when all treating facilities in North Carolina were classified according to average annual volume of patients with MM.

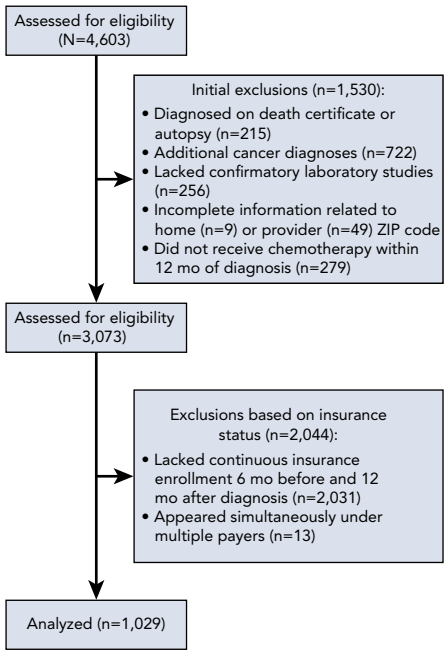

Figure 1. CONSORT diagram of study population.

The second analysis explored the impact on OS of the primary oncologist's volume of patients with MM. The primary oncologist was defined as the patient's most visited oncologist. Provider volume was defined by the number of prevalent patients with MM per provider over a 2-year period before the date of diagnosis. We restricted the oncologists to North Carolina physicians and measured the number of patients these oncologists encountered, regardless of the patients' state of residence. This model included the following 3 mutually exclusive patient categories based on type of primary oncologist: (1) NCICCC MM specialists, (2) high-volume community oncologists, and (3) low-volume community oncologists. The NCICCC MM specialists were defined a priori through consensus among myeloma specialists at the 3 NCICCCs. These providers tended to see the largest volume of patients (mean, 50 patients per 2-year period). High-volume community providers consisted of oncologists in the sixth to tenth deciles of MM patient volume (≥9 patients per 2-year period), and low-volume

community providers comprised oncologists in the first to fifth deciles (<9 patients per 2-year period).

The third multivariable analysis explored how patient-sharing between NCICCC MM specialists and community oncologists impacted OS. To be considered as having a sharing relationship, 2 oncologists must have had at least 1 patient with MM in common during the 2 years before diagnosis. This is the same threshold that has been used in other settings to define relationships among providers.[8–12] To be considered a "sharing" community oncologist, we further required that a community oncologist share at least 10% of their patients with MM with an NCICCC MM specialist. The following 3 mutually exclusive categories based on type of primary oncologist were included in this model: (1) NCICCC MM specialists, (2) community oncologists with a history of sharing patients with MM with NCICCC MM specialists, and (3) community oncologists with no history of sharing.

Covariates

Covariates for all models included patient demographic factors, socioeconomic indicators, Charlson comorbidity index score, and patient frailty. Autologous hematopoietic stem cell transplantation (AHCT) was only available at the 3 NCICCCs during the study period, resulting in a high degree of correlation between receiving AHCT and evaluation at an NCICCC. Thus, AHCT was not included in the final survival analyses. Unfortunately, we could not reliably characterize specific treatment regimens in the database, because the sensitivity and specificity of claims data to identify receipt of specific agents can vary considerably.

Information from the NC CCR was used to identify each patient's age, sex, race (non-Hispanic white vs other), marital status, and year of diagnosis. Insurance enrollment data were used to categorize patients according to type of insurance coverage. Insurance claims for patient comorbidities and durable medical equipment were used to calculate the Charlson comorbidity index score and activities of daily living (ADL) dependency score as a proxy for patient frailty.[13] Insurance claims were also used to identify receipt of chemotherapy and AHCT.

Sociodemographic covariates, which were defined using census tract information from the American Community Survey (2005–2009),[14] included quartiles of median household income, percentage of population unemployed, and percentage of population with college degree. Rural versus urban residence was also included (defined from rural-urban commuting area [RUCA] codes[15] using the ZIP code approximation). The ZIP code RUCA was selected to provide a second level of geographic detail. The Rural Health Research Center indicates that the agreement between ZIP code and census tract RUCA is 99%.[16] In addition, we computed the straight-line distance between each patients' home ZIP code and the nearest NCICCC clinic. Finally, using patients' home ZIP codes, we identified the hospital referral region for each patient at the time of cancer diagnosis.

Statistical Analysis

A logistic regression was used to identify factors associated with increased odds of undergoing evaluation at an NCICCC within 12 months of diagnosis. For the NCICCC evaluation, provider volume, and patient-sharing models, Cox proportional hazards modeling was applied to estimate predictors associated with survival. Model assumptions regarding proportional hazards were met. Covariates for all models included age, sex, race, marital status, insurance type, distance between home and NCICCC clinic, hospital referral region, ADL dependency score, rural versus urban ZIP code, and the sociodemographic variables discussed earlier. Multicollinearity between the main exposure variables was tested by examining a variance inflation factor (<10). All analyses were conducted using SAS 9.4 (SAS Institute Inc.).

Results

Cohort Demographics

A total of 1,029 patients with a diagnosis of MM in 2006 through 2012 met eligibility criteria (Table 1). The mean age was 68 years (range, 25–98 years), and 48% of the final cohort were men. Most patients were non-Hispanic white (65%) and 44% had private health insurance. The highest education quartile was overrepresented in this cohort (28%) relative to national census tract data. Only 17% of patients underwent AHCT within 1 year of diagnosis.

Factors Predicting NCICCC Evaluation

The following factors were associated with a decreased likelihood of NCICCC evaluation: older age (eg, 65–69 vs <65 years; odds ratio [OR], 0.44; 95% CI, 0.27–0.72; $P<.01$), nonprivate health insurance (eg, Medicaid vs private; OR, 0.49; 95% CI, 0.30–0.80; $P<.01$), not being married (OR, 0.46; 95% CI, 0.30–0.69; $P<.001$), and increasing distance from home address to NCICCC (eg, highest quartile of distance vs lowest; OR, 0.24; 95% CI, 0.13–0.47; $P<.001$) (Table 2).

Survival Analysis for NCICCC Evaluation

Patients who were not evaluated at an NCICCC had an increased risk of mortality compared with those who were (HR, 1.50; 95% CI, 1.21–1.86; $P<.001$) (Table 3;

Table 1. Cohort Demographics

Variable	n (%)
Sex	
Male	496 (48)
Age, y	
Mean (SD)	67.8 (11.2)
Range	25–98
Race	
Non-Hispanic white	665 (65)
Other	364 (35)
Marital status	
Married	476 (46%)
Insurance type	
Any private	456 (44)
Medicare only	389 (38)
Any Medicaid	184 (18)
Rural home address	
No	659 (64)
Quartile of distance between home and NCICCC (mean)	
Q1 (17 miles)	285 (28)
Q2 (67 miles)	247 (24)
Q3 (76 miles)	270 (26)
Q4 (129 miles)	227 (22)
Quartile of % population aged ≥25 years with college degree	
Not available	15 (1)
Q1	224 (24)
Q2	240 (23)
Q3	240 (23)
Q4 (highest)	290 (28)
Quartile of % unemployment	
Not available	15 (1)
Q1	260 (25)
Q2	227 (22)
Q3	260 (25)
Q4 (highest)	267 (26)
Quartile of median household income	
Not available	15 (1)
Q1	286 (28)
Q2	230 (22)
Q3	212 (21)
Q4 (highest)	286 (28)
ADL dependency score quartile	
Q1	319 (31)
Q2	283 (28)
Q3	247 (24)
Q4 (highest)	180 (17)
AHCT within 12 months of diagnosis	
Yes	179 (17)

Abbreviations: ADL, activities of daily living; AHCT, autologous hematopoietic stem cell transplantation; NCICCC, NCI-designated Comprehensive Cancer Center.

Figure 2). As expected, the risk of mortality was higher in the overall cohort with advancing age (eg, >80 years vs <65 years; HR, 1.99; 95% CI, 1.47–2.69; $P<.001$), higher Charlson comorbidity index score (≥3 vs 0; HR, 1.67; 95% CI, 1.30–2.16; $P<.001$), and frailty (highest vs lowest quartile of ADL dependency; HR, 1.95; 95% CI, 1.48–2.56; $P<.001$). Having a primary ZIP code of residence corresponding to the highest quartiles of unemployment was associated with increased mortality (highest vs lowest quartile; HR, 1.55; 95% CI, 1.16–2.09; $P<.01$), but the other socioeconomic indicators (education and median income) were not significantly associated with survival. Race other than non-Hispanic white was associated with a decreased risk of mortality in this analysis (HR, 0.71; 95% CI, 0.59–0.86; $P<.001$) (Table 3).

Survival Analysis for Provider Volume

Compared with patients treated primarily by an NCICCC MM specialist, those treated by a community provider had a higher risk of mortality regardless of high-volume (HR, 1.29; 95% CI, 1.04–1.61; $P<.05$) or low-volume (HR, 1.47; 95% CI, 1.14–1.90; $P<.01$) status (Table 3; Figure 3). In addition, we compared patients treated by high-volume versus low-volume community oncologists and found no difference in risk of mortality (HR, 1.15; 95% CI, 0.92–1.43; $P=.2227$). To determine whether outcomes are different for patients treated by the highest-volume community providers, we reran the analysis to compare patients treated by NCICCC MM specialists and those treated by the highest-volume community providers in the ninth and tenth deciles and found no difference in mortality (HR, 1.08; 95% CI, 0.84–1.37; $P=.5591$).

Survival Analysis for Patient-Sharing

Patients treated primarily by community oncologists regardless of patient-sharing history had a higher risk of mortality compared with those treated primarily by NCICCC MM specialists (sharing community oncologist vs NCICCC MM specialist: HR, 1.49; 95% CI, 1.10–2.02;

Table 2. Factors Associated With Evaluation at an NCICCC

Variable	Odds Ratio (95% CI)
Sex	
Female	1.23 (0.87–1.74)
Marital status	
Not married	0.46 (0.30–0.69)***
Age, y	
<65	Ref
65–69	0.44 (0.27–0.72)**
70–74	0.16 (0.10–0.27)***
75–80	0.14 (0.08–0.25)***
>80	0.10 (0.05–0.19)***
Race	
Non-Hispanic white	Ref
Other	0.91 (0.61–1.34)
Insurance type	
Any private	Ref
Medicare only	0.42 (0.28–0.63)***
Any Medicaid	0.49 (0.30–0.80)**
Rural home address	
Yes	1.33 (0.88–2.01)
Quartile of distance between home and NCICCC	
Q1	Ref
Q2	0.72 (0.42–1.22)
Q3	0.32 (0.18–0.56)***
Q4 (longest)	0.24 (0.13–0.47)***
Quartile of % population aged ≥25 years with college degree	
Q4 (highest)	Ref
Q3	0.50 (0.28–0.87)*
Q2	0.57 (0.31–1.05)
Q1	0.57 (0.30–1.10)
Quartile of % unemployment	
Q1 (lowest)	Ref
Q2	0.94 (0.57–1.55)
Q3	1.51 (0.89–2.58)
Q4	1.28 (0.71–2.29)
Quartile of median household income	
Q4 (highest)	Ref
Q3	1.12 (0.66–1.90)
Q2	0.83 (0.47–1.47)
Q1	0.74 (0.40–1.38)
ADL dependency score quartile	
Q1	Ref
Q2	0.56 (0.37–0.87)**
Q3	0.70 (0.43–1.13)
Q4 (highest)	0.55 (0.31–0.95)*
Charlson comorbidity index score	
0	Ref
1–2	0.75 (0.52–1.08)
≥3	0.53 (0.32–0.89)*

(continued)

Model was adjusted for year of diagnosis and hospital referral region (not shown).
Abbreviations: ADL, activities of daily living; NCICCC, NCI-designated Comprehensive Cancer Center.
*P<.05; **P<.01; ***P<.001.

P<.05; nonsharing community oncologist vs NCICCC MM specialist: HR, 1.31; 95% CI, 1.06–1.61; P<.05) (Table 3; Figure 4). Of note, there was no significant difference in the proportion of high- and low-volume providers in the sharing vs nonsharing community oncologist categories.

Discussion

Using the University of North Carolina CIPHR database, we observed that patients with MM evaluated at an NCICCC or those treated primarily by NCICCC MM specialists had a lower mortality risk compared with patients treated by community oncologists. This survival benefit persisted after controlling for patient variables (age, sex, race, insurance, comorbidities, and frailty) and regional socioeconomic indicators (education, poverty level, unemployment rate, and income). The 3 NCICCCs in North Carolina were also the highest-volume facilities during the study period. Thus, our data are consistent with the findings of Go et al,[6] which showed that patients treated by facilities in the lowest quartile of volume (<4 new patients with MM per year) had a 22% increased risk of death compared with those treated by facilities in the highest quartile (≥10 new patients with MM per year). Our study builds on these data by introducing 2 novel variables—provider volume and patient-sharing—to better understand the impact of individual provider experience and collaboration between MM specialists and community oncologists.

We found that patients treated by community oncologists as opposed to NCICCC MM specialists had higher mortality. Most of the highest-volume providers were also the NCICCC MM specialists; thus, our data did not allow us to evaluate provider volume independent of NCICCC affiliation at the highest levels of provider

Table 3. Survival Models Showing Risk of Mortality

Variable	Hazard Ratio (95% CI)		
	NCICCC Evaluation	Provider Volume	Patient-Sharing
NCICCC evaluation			
No	1.50 (1.21–1.86)***	—	—
Provider volume			
NCICCC MM specialist	—	Ref	—
High-volume community oncologist	—	1.29 (1.04–1.61)*	—
Low-volume community oncologist	—	1.47 (1.14–1.90)**	—
Patient-sharing			
NCICCC MM specialist	—	—	Ref
Community oncologist with history of sharing	—	—	1.49 (1.10–2.02)*
Community oncologist with no history of sharing	—	—	1.31 (1.06–1.61)*
Sex			
Female	0.85 (0.71–1.02)	0.82 (0.69–0.98)*	0.82 (0.69–0.98)*
Marital status			
Not married	1.02 (0.83–1.25)	1.05 (0.85–1.29)	1.04 (0.85–1.28)
Age, y			
<65	Ref	Ref	Ref
65–69	1.18 (0.89–1.56)	1.19 (0.90–1.58)	1.18 (0.89–1.56)
70–74	1.48 (1.12–1.96)**	1.57 (1.19–2.07)**	1.55 (1.18–2.04)**
75–80	1.63 (1.23–2.15)***	1.61 (1.22–2.14)***	1.66 (1.25–2.19)***
>80	1.99 (1.47–2.69)***	2.05 (1.52–2.78)***	2.05 (1.52–2.77)***
Race			
Non-Hispanic white	Ref	Ref	Ref
Other	0.71 (0.59–0.86)***	0.68 (0.56–0.83)***	0.69 (0.57–0.84)***
Insurance type			
Any private	Ref	Ref	Ref
Medicare only	1.06 (0.85–1.33)	1.16 (0.93–1.45)	1.13 (0.91–1.41)
Any Medicaid	1.26 (0.98–1.61)	1.33 (1.04–1.71)*	1.29 (1.01–1.66)*
Rural home address			
Yes	0.94 (0.78–1.14)	0.94 (0.76–1.15)	0.93 (0.77–1.13)
Quartile of % population aged ≥25 years with college degree			
Q4 (highest)	Ref	Ref	Ref
Q3	1.13 (0.87–1.48)	1.19 (0.91–1.56)	1.18 (0.90–1.54)
Q2	1.24 (0.94–1.63)	1.36 (1.02–1.80)*	1.30 (0.99–1.72)
Q1	1.01 (0.74–1.38)	1.08 (0.79–1.49)	1.05 (0.77–1.43)
Quartile of % unemployment			
Q1 (lowest)	Ref	Ref	Ref
Q2	1.17 (0.90–1.52)	1.15 (0.88–1.50)	1.12 (0.87–1.46)
Q3	1.70 (1.30–2.24)***	1.66 (1.26–2.18)***	1.63 (1.24–2.14)***
Q4	1.55 (1.16–2.09)**	1.54 (1.14–2.07)**	1.51 (1.12–2.03)**

(continued on next page)

Model was adjusted for year of diagnosis and hospital referral region (not shown).
Abbreviations: ADL, activities of daily living; MM, multiple myeloma; NCICCC, NCI-designated Comprehensive Cancer Center.
*$P<.05$; **$P<.01$; ***$P<.001$.

Table 3. Survival Models Showing Risk of Mortality (cont.)

Variable	Hazard Ratio (95% CI)		
	NCICCC Evaluation	Provider Volume	Patient-Sharing
Quartile of median household income			
Q4 (highest)	Ref	Ref	Ref
Q3	0.87 (0.67–1.13)	0.88 (0.67–1.14)	0.87 (0.67–1.14)
Q2	0.84 (0.63–1.12)	0.90 (0.67–1.21)	0.87 (0.65–1.16)
Q1	0.86 (0.64–1.18)	0.93 (0.68–1.27)	0.90 (0.67–1.23)
ADL dependency score quartile			
Q1 (lowest)	Ref	Ref	Ref
Q2	1.01 (0.80–1.28)	1.04 (0.83–1.32)	1.03 (0.82–1.30)
Q3	1.50 (1.18–1.92)***	1.53 (1.20–1.96)***	1.52 (1.19–1.94)***
Q4	1.95 (1.48–2.56)***	2.01 (1.53–2.65)***	2.01 (1.53–2.64)***
Charlson comorbidity index score			
0	Ref	Ref	Ref
1–2	1.52 (1.26–1.83)***	1.55 (1.29–1.87)***	1.54 (1.28–1.85)***
≥3	1.67 (1.30–2.16)***	1.68 (1.30–2.16)***	1.70 (1.32–2.19)***

Model was adjusted for year of diagnosis and hospital referral region (not shown).
Abbreviations: ADL, activities of daily living; MM, multiple myeloma; NCICCC, NCI-designated Comprehensive Cancer Center.
*P<.05; **P<.01; ***P<.001.

volume. Community oncologist volume was analyzed in 2 categories corresponding to the first to fifth and sixth to tenth deciles of volume because of the small number of patients in lower-volume groups (n=168 for first to fifth decile and n=483 in sixth to tenth deciles). It is possible that survival for patients treated by the highest-volume community providers (eg, ninth and tenth deciles of volume) would be similar to that for patients treated by NCICCC MM specialists. To test this hypothesis, we reran the provider volume multivariate survival analysis to compare patients treated by NCICCC MM specialists and those treated by the highest volume community providers in the ninth and tenth deciles, and confirmed that there was no difference in mortality (HR, 1.08; 95% CI, 0.84–1.37; P=.5591). This finding suggests that provider experience at NCICCCs, and not just resource availability, is an important predictor of outcome. Several possible mechanisms exist through which greater provider experience can improve outcomes, including earlier adoption of new drugs, earlier recognition of complications and progressive disease, and quick access

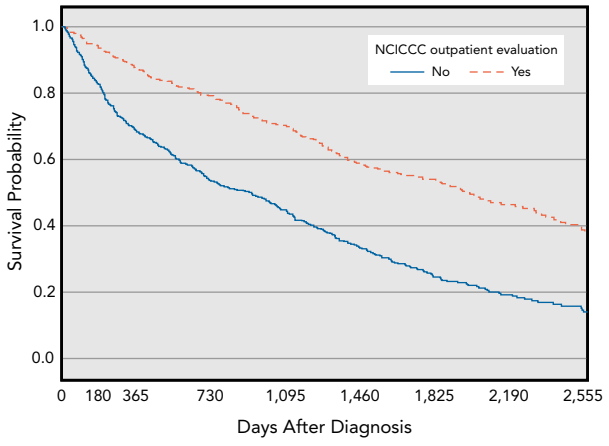

Figure 2. Overall survival curves for patients with multiple myeloma according to evaluation at an NCICCC within 12 months of diagnosis.
Abbreviation: NCICCC, NCI-designated Comprehensive Cancer Center.

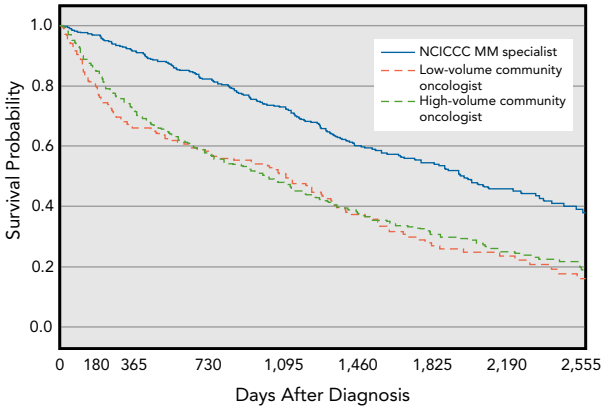

Figure 3. Overall survival curves for patients with MM according to provider volume.
Abbreviations: MM, multiple myeloma; NCICCC, NCI-designated Comprehensive Cancer Center.

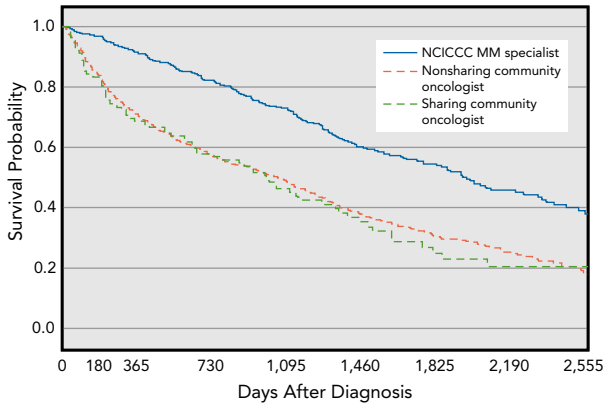

Figure 4. Overall survival curves for patients with MM according to patient-sharing relationships between primary oncologist and MM specialists.
Abbreviations: MM, multiple myeloma; NCICCC, NCI-designated Comprehensive Cancer Center.

to non-oncology specialties, such as orthopedics or nephrology. Several other factors could affect survival that were not able to be accounted for in this study, such as disease stage, cytogenetics, and participation in clinical trials. Unfortunately, we could not reliably characterize specific treatment regimens in the database. The sensitivity and specificity of claims data to identify receipt of specific agents can vary considerably, resulting in misclassification of type of treatment received. Furthermore, generic rather than specific codes are sometimes used. For example, we may identify a code for "intravenous chemotherapy administration," making it impossible to know exactly what therapy was used for a portion of the population. Given these limitations, we decided not to include less-than-perfect information on treatment regimens.

Because it is not feasible for all patients with MM to be treated at an NCICCC, a common practice among community oncologists is to refer a patient to an MM specialist for initial treatment recommendations or transplant evaluation, but to perform most care in the community. This study introduced a novel variable in an initial attempt to evaluate the impact of patient-sharing, and found that such sharing had no impact on the higher mortality rate observed for community oncologists. Again, this could reflect the importance of NCICCC-associated resources discussed earlier or the lack of data regarding disease stage, clinical trial participation, or specific treatments. Alternatively, our definition of patient-sharing, which was limited by the claims-based nature of the study, may not accurately reflect the quality of sharing relationships. To be considered as having a sharing relationship, we required that an MM specialist and a community oncologist have at least one patient with MM in common in the 2 years before diagnosis. We selected this threshold based on previous studies that have used the same threshold to define relationships among providers.[8–12] Furthermore, MM is a rare malignancy; it is estimated that a general community oncologist could see as few as 2 new patients with MM annually.[17] Therefore, we felt that any patient-sharing with an MM specialist could be meaningful. Although we did not find a relationship between patient-sharing and survival, the methodology used in this study could be applied to larger databases to explore the impact of provider networks in MM.

During the study period, AHCT in NC was only available at the 3 NCICCCs; therefore, referral to an NCICCC was a necessary first step in receiving an AHCT. Patients in our cohort were less likely to be evaluated at an NCICCC if they did not have private insurance or were aged >65 years, suggesting missed opportunities in the care of these patients. Despite the fact that AHCT is covered by both Medicare and Medicaid, a decreased rate of AHCT for patients with MM with nonprivate insurance has been reported previously and may be related to socioeconomic barriers limiting access to transplant services.[18] The decreased likelihood of referral to a transplant center for patients aged >65 years is concerning, given that AHCT is safe in patients up to 75 or even 80 years of age and the greatest increase in frequency of upfront AHCT in the United States has been in the 65- to 75-year age group.[19,20] Although we controlled for comorbidities and patient frailty using a claims-based ADL dependency score,[13] a detailed analysis of factors contributing to nonreferral of older patients was not possible.

Conclusions

Overall, our data demonstrating improved survival among patients with MM who are evaluated at an NCICCC or treated by NCICCC MM specialists add to accumulating evidence showing that these patients benefit from care at high-volume facilities, and suggest that similar outcomes can be achieved by the highest-volume providers in the community.

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