

Incidence and Clinical Complications of Myelodysplastic Syndromes Among United States Medicare Beneficiaries

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A B S T R A C T

Purpose

To determine the incidence and complications of myelodysplastic syndromes (MDS) among Medicare beneficiaries.

Methods

Retrospective review of 2003 Medicare Standard Analytic Files utilizing International Classification of Diseases for Oncology ninth edition CM code 238.7 to identify new MDS patients, with 3-year follow-up.

Results

Among 1,394,343 individuals in Medicare Standard Analytic Files age ≥ 65 years, 162 per 100,000 were coded as newly diagnosed MDS during 2003 yielding a calculated 45,000 new cases in the United States Medicare ≥ 65 years population. Patients with MDS were older (median age, 77 years), and over-represented by males. Among patients with MDS diagnosed during first quarter of 2003, 73.2% suffered cardiac-related events during 3-year follow-up, which exceeded the Medicare population (54.5%; $P < .01$) even when age adjusted (odds ratio, 2.10; $P < .01$). Significant increases in prevalence of diabetes (40.0% v 33.1%), dyspnea (49.4% v 28.5%), hepatic diseases (0.8% v 0.2%), and infections (sepsis: 22.5% v 6.1%) were noted in MDS (all $P < .01$) compared with the Medicare population. Patients with MDS requiring RBC transfusions had greater prevalence of these comorbidities. Acute myeloid leukemia developed within 3 years in 9.6%, with increased transformation among transfused (24.6%; $P < .001$). The 3-year Kaplan-Meier age-adjusted survival for MDS was 60.0%, which was significantly lower than the Medicare population (84.7%; hazard ratio, 3.08; $P < .001$), and mortality was further increased among transfused MDS ($P < .01$). In 2003, median payment for MDS was \$16,181, compared to \$1,575 for the Medicare population ($P < .001$).

Conclusion

MDS is a common hematologic malignancy of the elderly, which places patients at risk for comorbid conditions. Transfusion dependency identifies patients with MDS at additional increased risk of organ impairment and shortened survival.

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INTRODUCTION

Myelodysplastic syndromes (MDS) are a heterogeneous group of clonal hematopoietic stem-cell disorders, characterized by ineffective hematopoiesis in one or more cell lines leading to peripheral cytopenias. The symptoms of MDS reflect these peripheral cytopenias. In addition, up to 30% of patients with MDS progress to acute leukemia.^{1,2} For most patients with MDS, supportive care with blood transfusions is the mainstay of treatment, although newer low-intensity strategies, such as hypomethylating, immunomodulatory, and iron chelating agents are being introduced into therapeutic algorithms.^{3,4}

Until recently, the epidemiology and clinical consequences of MDS in the United States remained largely speculative, derived primarily from hospital-based statistics or regional cancer surveys. These databases are often limited by small and poorly defined reference populations, the inability to detect regional changes in incidence, and the potential for bias in the patient referral process, especially in an older population that may not be evaluated at tertiary care centers performing epidemiologic research. The third National Health and Nutrition Examination Survey (1988 to 1994) identified 11.0% of men and 10.2% of women ≥ 65 years to be anemic, with 5.8% of the anemic population having peripheral blood features suggestive of MDS.⁵ With

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the WHO reclassification of MDS as a neoplastic disease, MDS became reportable to the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) program in 2001.⁶ Using this population-based database, approximately 10,300 incident cases of MDS were diagnosed in the United States during 2003, with an observed 3-year survival rate of only 35%.⁷ An expanded review from the North American Association of Central Cancer Registries (NAACCR), encompassing 82% of the US population, estimated approximately 9,700 new patients with MDS in 2004.⁸ However, only 4% of patients with MDS in NAACCR were reported by physicians' offices. Given the older age at diagnosis, it is possible that many affected individuals may not be referred for hematologic evaluation for their vague anemias and even if referred, many may not undergo the bone marrow examinations required for capture in the cancer registries, thereby underestimating MDS incidence.

Since MDS is a hematologic neoplasm primarily of the elderly, with 86% of MDS cases diagnosed in individuals age ≥ 60 years (median age at diagnosis, 76 years), according to the SEER database, we hypothesized that a review of the US Medicare claims encompassing most US older individuals might provide instructive information, independent of the biases of pathologically based cancer registries.⁷ By reviewing data from 2003, before the widespread adoption of newer low-intensity treatments, we could follow the natural history and economic impact of MDS and provide direct comparisons with recently published SEER data for the same timeframe. Given newer information that RBC transfusion dependency might negatively affect outcomes in MDS, we also reviewed the development of comorbid conditions and possible association with transfusional support.⁹⁻¹¹

METHODS

Data Source

A retrospective review of US Medicare claims was performed to determine the incidence, clinical and economic consequences of MDS, focusing on those beneficiaries age ≥ 65 years. Medicare covers hospital, physician, and other medical services for more than 97% of all US citizens age ≥ 65 years, those eligible for disability, and/or those with end-stage renal disease. The Medicare Standard Analytic Files (SAF) is a nationally representative claims database comprised of randomly selected, 5% sample of US Medicare beneficiaries. It includes claims across various care settings, including inpatient, outpatient, skilled nursing, home health, and hospice, and durable medical equipment. A denominator file provides Medicare enrollment status, beneficiaries' demographics and date of death. Our analysis included SAF files from 2003 to 2005; the 2002 Carrier (Physician/Supplier Part B) file was used for exclusion criteria. The data set is fully de-identified and compliant with Health Insurance Portability and Accountability Act regulations.

Study Populations

The International Classification of Diseases for Oncology ninth edition CM (ICD-9-CM) code 238.7 was used to identify patients with a new diagnosis of MDS in calendar year 2003. Patients with anemias of known causes (ICD-9-CM codes 281, 282, 283, and 284) or myeloid leukemia (ICD-9-CM codes 205.0, 205.1) diagnosed in the previous year (2002) were excluded. ICD-9-CM codes are generated by physicians at the time of billing for services and are the treating physician's impression of the diagnosis rather than a confirmed pathologic diagnosis. Performance of a bone marrow aspirate or bone marrow biopsy were noted and presumed as a measure of pathologic confirmation; no attempt to obtain marrow reports or to review microscopy was undertaken. A retrospective review of clinical and economic consequences of MDS was performed on the subset of patients with ICD-9-CM 238.7 identified during the first quarter 2003, linked across different care settings via encrypted identifiers

and followed through the fourth quarter of 2005 or death, and compared to the Medicare population SAF file who were enrolled before the completion of the first quarter 2003 (to permit similar follow-up times). ICD codes for comorbid conditions were captured during the 3-year follow-up. Total health care costs (measured by Medicare payment) across all care settings were identified by Healthcare Common Procedure Coding System/Current Procedural Terminology codes. Outpatient prescription drug data are not included in the SAF data or in our analyses.

Data Analysis

Hypothesis tests for continuous variables were conducted using *t*-tests. χ^2 was used to analyze categorical variables. Nonparametric Wilcoxon tests were used to compare differences in Medicare payments. Kaplan-Meier survival estimation was used. The hazard ratio for death occurring during the 3-year follow-up period was estimated using the Cox proportional hazards regression model, adjusted for age. The overall level of α significance for each statistical test was set at .05. Analyses were performed using the SAS Statistical software system (SAS Institute, Cary, NC).

RESULTS

Incidence of MDS

Among 1,394,343 patients age ≥ 65 enrolled in the Medicare SAF in 2003; 2,253 patients with newly diagnosed MDS (ICD-9-CM code 238.7) were identified (excluding patients with prior MDS history, anemias of known causes, or myeloid leukemia in 2002), yielding an

Table 1. Demographic and Clinical Characteristics in Patients With Newly Diagnosed MDS and Overall SAF Medicare Population

Demographic and Clinical Characteristics	MDS		Overall SAF Medicare Population		P
	No.	%	No.	%	
No. of subjects	2,253		1,394,343		NA
Mean age, years	77		76		< .001
SD	7.2		7.4		
Median age, years	77		75		
Age, years					
65-69	405	18.0	353,979	25.4	< .001
70-74	488	21.7	333,232	23.9	
75-79	526	23.3	299,043	21.4	
80+	834	37.0	408,089	29.3	
Sex					
Male	1,048	46.5	560,597	40.2	< .001
Female	1,205	53.5	833,746	59.8	
Race					
White	1,996	88.6	1,218,811	87.4	.24
African American	165	7.3	106,370	7.6	
Hispanic/Latino	37	1.6	27,123	1.9	
Other	55	2.4	42,039	3.0	
Reason for MDS					
Prior anemia of unknown causes	1	0.0	—		NA
Prior chemo/radiation therapy	112	5.0	—		NA
De novo	2,140	95	—		NA
Diagnosis					NA
Bone marrow biopsy	1,837	81.5	—		NA
Clinical impression	416	18.5	—		NA

NOTE. P values were obtained from Student t tests for continuous variables and χ^2 tests for categorical variables.

Abbreviations: MDS, myelodysplastic syndromes; SAF, Medicare Standard Analytic Files; SD, standard deviation; NA, not applicable.

Table 2. Myelodysplastic Syndromes Incidence in Medicare Population

Characteristic	Myelodysplastic Syndromes Incidence per 100,000	95% CI
Age, years		
65-69	114	103 to 126
70-74	146	133 to 159
75-79	176	161 to 191
80+	204	191 to 218
Sex		
Male	187	176 to 198
Female	145	136 to 153
Race		
White	164	157 to 171
African American	155	131 to 179
Hispanic/Latino	136	92 to 180
Other	131	96 to 165
Overall incidence	162	155 to 168

incidence of 162 per 100,000. Of the identified cases, 1,837 (81.5%) had undergone a bone marrow study during 2002 or the first quarter 2003, with 416 (18.5%) obtaining the ICD-9-CM code on clinical impression. The median age at diagnosis was 77 years. The MDS population was older ($P < .001$), and over-represented by males ($P < .001$) compared with the general Medicare population (Table 1). Incidence rates varied by age and sex (Table 2). Patients with MDS with a clinical diagnosis were older (median age 79 v 76; $P < .001$), and were more likely to be female (65.6% v 50.7%; $P < .001$), but had similar race distributions ($P = .77$) compared with those diagnosed via bone marrow evaluations.

Applying the MDS incidence rate to the entire Medicare population age ≥ 65 in 2003 calculated a total of approximately 45,000 newly diagnosed cases. Additional cases in younger populations would raise national figures slightly since most patients with MDS are elderly.

Clinical and Economic Consequences of MDS

Demographics of subpopulation. Of approximately 1.4 million patients in the Medicare SAF age ≥ 65 , 512 developed MDS in the first quarter of 2003. Among them, 21 (4.1%) had received chemotherapy or radiotherapy in 2002 for another disorder, and 491 (95.9%) had no identified cause in the prior year. This cohort of MDS patients was older than the overall Medicare SAF population (median age 77 v 75; $P < .001$); and over-represented by males (46.1% v 40.2%; $P < .001$), but had similar race distributions ($P = .44$). Of this subset, 400 (78%) had undergone bone marrow studies, and 112 (22%) were based on clinical impression. Similar to the incidence population, patients diagnosed by clinical impression were older (median age 79 v 77; $P < .001$) and were more likely to be female (63.4% v 51.3%; $P < .001$), but had similar race distributions ($P = .77$) compared with marrow diagnosed patients.

Increased prevalence of comorbid conditions developing within 3 years among MDS cohort. During the 3-year follow-up, 375 (73.2%) of 512 MDS patients suffered cardiac-related events: 99 myocardial infarctions (19.3%); 247 congestive heart failure (48.2%); 262 arrhythmias (51.2%); and 201 less common events (39.3%). Of the 512 patients, 303 (59.2%) had no prior history of cardiac disease in 2002, and yet 188 (62.0%) of these developed cardiac disease. For compari-

son, significantly fewer (54.5%) of the 1.379 million in the 2003 Medicare SAF database as of the first quarter 2003 had cardiac disease during a similar 3-year follow-up ($P < .001$). Since the MDS cohort was older than the overall Medicare population, and age is a risk factor for cardiac disease, we performed an age-adjusted assessment, which demonstrated that MDS was associated with an increased risk for cardiac-related events (odds ratio [OR], 2.10; 95% CI, 1.72 to 2.57; $P < .01$). Similarly, increased prevalence of diabetes ($P < .001$), dyspnea ($P < .001$), hepatic diseases ($P = .011$), and infectious complications ($P < .001$) were noted among patients with MDS compared with the general Medicare population (Table 3).

Table 3. Comorbidities in the MDS Follow-Up Cohort and Overall Medicare Population From 2003 to 2005

Characteristic	MDS		Overall SAF Medicare Population		P
	No.	%	No.	%	
No. of subjects	512		1,379,185		NA
Cardiac events					
Prevalence of cardiac events					
MI	99	19.3	167,571	12.2	< .001
CHF	247	48.2	356,266	25.8	< .001
Arrhythmias	262	51.2	496,580	36.0	< .001
Other	201	39.3	419,968	30.5	< .001
Any cardiac events*	375	73.2	751,259	54.5	< .001
Incidence of cardiac events					
Without cardiac events in 2002	303		—		NA
With cardiac events in 2003-2005	188	62.0			
Diabetes					
Prevalence of diabetes					
	205	40.0	457,085	33.1	< .001
Incidence of diabetes					
Without diabetes in 2002	380		—		NA
With diabetes in 2003 to 2005	82	21.6			
Dyspnea					
Prevalence of dyspnea					
	253	49.4	392,933	28.5	< .001
Incidence of dyspnea					
Without dyspnea in 2002	442		—		NA
With dyspnea in 2003-2005	203	45.9			
Hepatic events					
Prevalence of hepatic events					
	4	0.8	3,248	0.2	.0108
Incidence of hepatic events					
Without hepatic events in 2002	512		—		NA
With hepatic events in 2003 to 2005	4	0.8			
Infectious complications					
Prevalence of infectious complications					
Sepsis	115	22.5	84,530	6.1	< .001
Bacteremia	80	15.6	110,904	8.0	< .001
Fungal infection	49	9.6	66,129	4.8	< .001
Cellulitis	158	30.9	269,615	19.5	< .001
Renal kidney infections	18	3.5	19,860	1.4	< .001
Intestinal infections	38	7.4	47,833	3.5	< .001
Pneumonia	204	39.8	272,487	19.8	< .001

NOTE. P values were obtained via χ^2 tests.

Abbreviations: MDS, myelodysplastic syndromes; SAF, Medicare Standard Analytic Files; MI, myocardial infarction; CHF, congestive heart failure; NA, not applicable.

*Age-adjusted odds ratio = 2.10 (95% CI, 1.72 to 2.57).

Blood transfusions and development of comorbid conditions. Blood transfusions were administered to 205 (40.0%) of the 512 patients with MDS. One hundred seventy-three incurred fewer than 10 transfusion sessions and 32 had ≥ 10 sessions. Similar percentages received transfusional support regardless of method of diagnosis (bone marrow 41.8% v clinical 33.9%; $P = .13$). Among patients with MDS receiving transfusions, 169 (82.4%) were diagnosed with a cardiac event during the 3-year follow-up, compared with 206 (67.1%) that did not receive transfusions ($P < .001$). Both cohorts experienced a higher prevalence of cardiac events compared to the overall MDS population (54.5%; both analyses $P < .01$). Patients with MDS receiving transfusions had higher prevalence of diabetes mellitus (44.4% v 37.1; $P = .10$), dyspnea (62.9% v 40.4%; $P < .001$), hepatic disease (1% v 0.7%; $P = .68$), and infectious diseases (81% v 55.7%; $P < .001$) compared with nontransfused patients with MDS during the 3-year follow-up (Fig 1).

Development of acute myeloid leukemia. During the 3-year study period, a total of 49 patients with MDS developed acute myeloid leukemia (AML; 9.6%): 33 patients developed AML in 2003; 11 in 2004 and five in 2005. More transfused patients with MDS (37; 18.0%) developed AML compared with nontransfused patients with MDS (13; 3.9%; $P < .001$). The Kaplan-Meier 3-year age-adjusted projections were 24.6% versus 4.3%, respectively. This however may be an underestimate of risk as those dying from cytopenias before AML are censored (Fig 2).

Mortality among MDS cohort. Patients with MDS had significantly higher 3-year mortality compared with the overall Medicare population. The 3-year age-adjusted Kaplan-Meier projected survival for MDS patients was 60.0% compared to 84.7% for the overall Medicare population. Since patients with MDS were older, multivariate Cox models confirmed increased mortality with an age-adjusted haz-

ard ratio of 3.08 (95% CI, 2.70 to 3.51; $P < .001$). Deaths occurred in 222 (43.4%) of the 512 patients: 106 (47.7%) patients died in 2003; 70 (31.5%) in 2004 and 46 (20.7%) in 2005. Patients with MDS diagnosed by bone marrow had similar 3-year survival profiles as those diagnosed by clinical impression, after adjusting for age (HR, 0.91; 95% CI, 0.67 to 1.24). Nontransfused patients with MDS had a higher 3-year age-adjusted survival rate compared to transfused patients with MDS (69.0% v 40.9%). After adjusting for age, transfusion was associated with an increased risk of death among patients with MDS (HR, 2.41; 95% CI, 1.84 to 3.15; $P < .001$; Fig 2).

Health care use and costs. Over the 3-year follow-up period, 76.8% of the patients with MDS were hospitalized, 79.5% had at least one emergency room visit, and 39.6% received growth factor treatments. Blood transfusions were administered to 40.0%, and 2.3% were coded with hemochromatosis.

In 2003, the median Medicare payment for a patient with MDS ($n = 512$) was \$16,181, compared to \$1,575 for a non-MDS Medicare beneficiary (mean: \$25,834 v \$6,810; $P < .001$). In 2004, the median Medicare payment for patients with MDS ($n = 406$) was \$9,703 compared to \$1,772 for the overall Medicare population (mean: \$19,180 v \$7,438; $P < .001$). In 2005, the median Medicare payment for MDS patients ($n = 336$) was \$6,872, compared to \$1,912 for the overall Medicare population (mean: \$18,759 v \$7,910; $P < .001$).

DISCUSSION

This retrospective review of Medicare SAF, a large national claims database covering 97% of persons ≥ 65 years in the US, calculated an incidence of MDS of 45,000 in 2003. This represents a four- to five-fold increase in incidence compared to recent SEER and NAACCR reports.^{7,8} By using Medicare claims representing services provided across specialties and delivery sites, this analysis avoided some of the potential biases of cancer registry reports. In the SEER database only 4% of MDS cases were from physician offices. Of our identified cases, 81.5% had undergone a bone marrow study during 2002 or the first quarter 2003 and should have been included in the cancer registries, highlighting the discrepancy in reporting of pathologically determined cases. We also identified 18.5% additional cases who obtained the ICD-9-CM code for MDS on the clinical impression of the treating physician alone. Even if these cases were eliminated our incidence would be three-fold greater than registry reports. Our clinical impression cases were older and had more rapid mortality than bone marrow diagnosed cases, indicating clinical judgment to defer the biopsy procedure among this population, although when adjusted for age the clinical cases fared similar to those undergoing biopsies.

The use of a claims database however has some limitations. Clinical information contained in claims data is less detailed and tends to be less accurate than medical charts in identifying patients with specific conditions. Due to the potential for coding errors, claims data may potentially lead to over- and/or under-reporting.^{12,13} Our study used ICD-9-CM codes to identify MDS cases, whereas the SEER and NAACCR reports used the bone marrow pathologically derived International Classification of Diseases for Oncology third edition codes.¹⁴ Thus, differences in coding and naming systems may account for some of the discrepancies in our findings.¹⁵ In addition, ICD-9-CM codes in use during our study period did not discriminate among the various subtypes of MDS and did not permit detailed epidemiologic

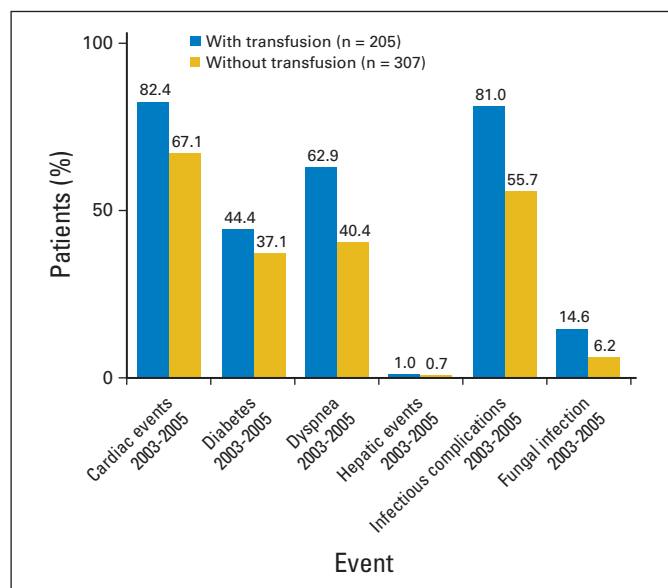


Fig 1. Prevalence of comorbid conditions among transfused and nontransfused patients with myelodysplastic syndromes (MDS). Patients with MDS experienced higher prevalence of comorbid conditions compared with the general US Medicare population ($P < .001$ for all conditions shown). Transfused patients with MDS experienced greater prevalence of comorbid conditions compared with nontransfused MDS patients ($P < .001$ for all conditions except diabetes [$P = .10$] and hepatic diseases [$P = .68$]).

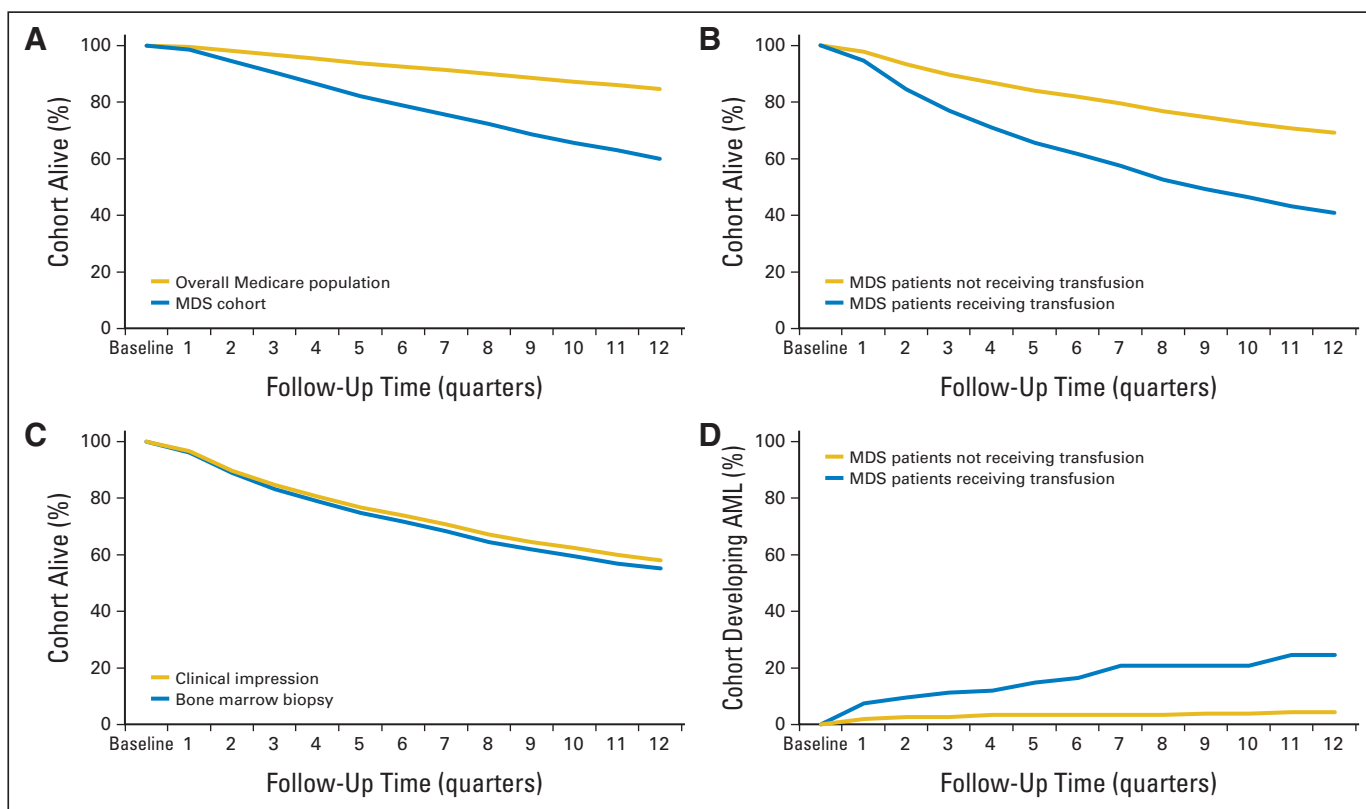


Fig 2. Kaplan-Meier survival analysis: (A) patients with myelodysplastic syndromes (MDS) and overall Medicare population, adjusted for age ($P < .0001$); (B) patients by transfusion status, adjusted for age ($P < .001$); (C) patients by method of diagnosis, adjusted for age ($P = .55$); (D) development of acute myeloid leukemia (AML) in patients with MDS by transfusion status ($P < .001$).

subanalyses. The new ICD-9-CM codes introduced in October 2006 that stratify MDS subtypes (238.72: low-grade MDS; 238.73: high-grade MDS; 238.74: MDS with 5q deletion; 238.75: MDS, unspecified) will facilitate future epidemiologic studies evaluating MDS incidence patterns, although these newer codes do not match the WHO nomenclature for MDS and therefore coding confusion will continue.

Despite differences in incidence rates, our findings confirmed the age and sex effects reported in the SEER and NAACR data: incidence increases with age, MDS is over-represented in men, although more women have the disease. Similar trends have been noted in international epidemiologic studies of MDS.¹⁶ As the US population continues to age, MDS will become a more prominent medical problem with a significant impact on the health care system. As shown in our study, caring for elderly patients with MDS costs more than \$16,000 in the first year after diagnosis (excluding outpatient prescription costs), which is more than 10-fold higher than expenditures for the general Medicare population. The introduction of newer low intensity therapies, such as 5-azacitidine, decitabine, and lenalidomide, supportive care medications including the oral iron chelator deferasirox, as well as reduced-intensity allogeneic transplantation techniques that extend eligibility age limits, will increase costs dramatically.

This study also noted better 3-year survival rates, and lower transformation rates to acute leukemia, when compared with the tumor registry-based studies, with a Kaplan-Meier projected survival of 60% in our series compared to 3-year survival rates of 35%, 45%, and 31% in SEER, NAACR, and a recently published Veterans' Administration MDS report, respectively.^{7,8,17} This difference does not

appear to be a result of our inclusion of clinical impression cases as these patients had similar 3-year overall survival rates to cases who underwent bone marrow evaluations. Instead, the differences in survival between series might emphasize referral and reporting biases with healthier cases being treated in community settings where under-reporting may be more common. Supporting this notion is the finding that only 40% of the patients with MDS in our series required blood transfusions during the 3-year follow-up, a transfusion rate lower than expected among higher-risk patients with MDS.^{18,19}

The marked increase in the development of comorbid conditions among patients with MDS during the 3-year follow-up period was a striking finding. Cardiac events were particularly common in the MDS population, occurring in 73.2% and were even more common among MDS patients receiving transfusions. Recent data has suggested that patients with MDS who become transfusion dependent experience increased morbidity and mortality. A review of 467 patients with MDS treated at the University of Pavia between 1992 and 2002 noted that transfusion-dependent patients had significantly shorter survival than those not requiring transfusions ($P < .001$) with cardiac-related deaths as the leading cause, resulting in a proposal to include transfusion dependency in the WHO classification-based prognostic scoring system.^{9,20} A Spanish review of 902 patients with MDS confirmed that development of iron overload (hazard ratio [HR], 52.4; $P < .001$) and transfusion dependency (HR, 8.8; $P < .001$) were strongly associated with overall survival and AML transformation risk (HR, 6.6; $P < .001$ and HR, 3.5; $P = .003$, respectively).¹⁰ A retrospective

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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nested case-control study from a US health insurance claims database also found an increased risk of cardiac complications, diabetes, and hepatic disease among patients with MDS receiving transfusions. Receipt of transfusions was significantly associated with risk of potential iron overload complications (OR, 2.90; $P < .001$), with increased rates of cardiomyopathy/heart failure (OR, 1.62; $P = .29$), conduction/rhythm disorders (OR, 4.18; $P < .001$), diabetes (OR, 5.06; $P < .001$), and liver disease (OR, 3.31; $P < .001$).¹¹ In our study, we noted that transfused patients with MDS experienced higher rates of cardiac events, diabetes, infections, and transformation to acute leukemia, leading to a decreased overall survival rate when compared with nontransfused patients with MDS and decreased survival compared to an age-matched Medicare population. Although some of this effect may be related to an increased need for transfusions among patients with more advanced disease, the possibility of direct organ damage through transfusional iron overload cannot be ignored. Recent studies have suggested improvement of survival with the availability of treatment options for iron overload.^{21,22}

MDS represents an important hematologic malignancy of the elderly population, contributing to serious comorbidities, increased health care use and costs. We conclude that MDS occurs much more commonly than previously expected. Given the high prevalence of cardiac and other comorbidities in this patient population, and the strong association between comorbidities, transfusional support, and iron overload, strategies to improve anemia and maintain adequate iron balance are critical in managing patients with MDS.

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