Cureus
Part of SPRINGER NATURE

Open Access Original Article

Sociodemographic Disparities in Access to Allogeneic Stem Cell Transplantation Among Patients Hospitalized With Relapsed Acute Myeloid Leukemia

Review began 09/24/2026
Review ended 11/07/2026
Published 11/10/2026

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DOI: 10.7759/cureus.119427

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Abstract

Background: Acute myeloid leukemia (AML) is the most common acute leukemia in adults, and allogeneic stem cell transplantation (allo-SCT) remains a potentially curative treatment option for patients with relapsed disease. In addition to disease-specific factors such as cytogenetic and molecular risk, sociodemographic and socioeconomic characteristics may influence access to transplantation. We evaluated the association between these factors and receipt of allo-SCT among hospitalized patients with relapsed AML.

Methodology: We conducted a retrospective analysis using the National Inpatient Sample (NIS) database from 2016 to 2022. Adult hospitalizations for relapsed AML were identified using ICD-10 codes. Multivariable logistic regression was performed to evaluate factors associated with allo-SCT, adjusting for demographic, socioeconomic, and clinical variables.

Results: Among 90,605 hospitalizations for relapsed AML, 33,605 (37.1%) involved allo-SCT. Hospitalizations involving female patients were associated with lower odds of allo-SCT than those involving male patients (adjusted odds ratio (aOR), 0.94; $P = 0.008$). Notably, despite previously documented racial disparities in donor availability and transplantation access, hospitalizations involving Black patients had higher odds of allo-SCT than those involving White patients (aOR, 1.23; 95% confidence interval (CI), 1.13-1.34; $P < 0.001$). Hospitalizations involving Hispanic patients also had numerically higher odds, although the association did not reach statistical significance (aOR, 1.12; $P = 0.054$). Compared with the lowest-income quartile, the low- and high-income quartiles were associated with lower odds of allo-SCT (aORs, 0.89 and 0.83, respectively), whereas the highest quartile was associated with higher odds (aOR, 1.10; $P = 0.005$). Geographically, hospitalizations in the New England states were associated with higher odds of allo-SCT than those in other regions.

Conclusions: Sociodemographic and socioeconomic factors are significantly associated with the receipt of allo-SCT among patients hospitalized with relapsed AML. These findings demonstrate sociodemographic differences in inpatient allo-SCT utilization among hospitalizations for relapsed AML. Further studies are needed to determine whether these differences reflect disparities in transplant eligibility, referral, or access.

Categories: Hematology, Oncology
Keywords: acute myeloid leukemia, allogeneic stem cell transplantation, national inpatient sample database, sociodemographic disparities, socioeconomic disparities

Introduction

Acute myeloid leukemia (AML) is the most common type of acute leukemia in adults, representing approximately 1% of all adult cancers and accounting for roughly 2% of cancer-related mortality in the United States [1]. Although advances in leukemia biology have led to the development of targeted therapies, the disease remains highly aggressive, with substantial relapse rates and mortality. Allogeneic stem cell transplantation (allo-SCT) remains an important therapeutic modality in AML, owing to its potential for curative outcomes [2]. It is considered the preferred consolidation therapy for individuals with intermediate- and high-risk AML and an important potentially curative treatment option for selected patients with primary refractory disease and for those who relapse after initial chemotherapy [3-5].

Eligibility for transplant is also influenced by patient age, functional status, comorbidity burden, donor availability, and patient preferences [6]. Beyond disease-specific biology and clinical considerations, social determinants of health may also significantly influence access to transplant. Socioeconomic factors contribute to disparities throughout the cancer care continuum, from diagnosis and initiation of treatment to access to treatment and overall survival, particularly among vulnerable populations [7,8]. Poverty and ethnic and racial disparities have been associated with worse survival outcomes among patients with AML

[9]. Allo-SCT is a highly resource-intensive intervention that requires caregiver support, adequate insurance coverage, and access to specialized transplant centers; hence, socioeconomic and demographic factors may systematically disadvantage certain patient populations [10]. A prospective multicenter study among patients with AML showed reduced receipt of allo-SCT among those with lower educational status and those from low-income households [11]. If such disparities influence the likelihood of receiving allo-SCT, they will perpetuate survival inequities in a disease where timely access to curative therapy is paramount.

Among patients with relapsed AML, for whom allo-SCT is often considered a potentially curative therapeutic option, research on how sociodemographic and socioeconomic factors influence access to transplantation at the national level is limited. Therefore, this study aimed to evaluate the associations between sociodemographic and socioeconomic characteristics and receipt of allo-SCT among hospitalizations involving patients with relapsed AML.

Materials And Methods

Study design and population

This was a retrospective cross-sectional study. We obtained our data from the National Inpatient Sample (NIS), part of the Healthcare Cost and Utilization Project's (HCUP) collection of databases and tools. It is the largest publicly available all-payer inpatient care database in the United States, containing more than seven million hospitalizations [12]. Researchers and health policymakers depend on the NIS to produce nationwide data on healthcare utilization, costs, quality, and outcomes. The NIS is a discharge-level database and may include multiple hospitalizations for the same individual. The NIS protects patient confidentiality by not including state and hospital identifiers. Data from 2016 to 2022 were used for this analysis.

Adult patients aged 18 years or older with relapsed AML were identified using the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) diagnosis code C92.02 [13]. Receipt of allo-SCT was identified using the International Classification of Diseases, Tenth Revision, Procedure Coding System (ICD-10-PCS) procedure codes. The code set (ICD-10-PCS 30233Y2, ICD-10-PCS 30233Y3, and ICD-10-PCS 30233Y4) was selected to identify patients with allogeneic transplantation from related, unrelated, and unspecified donor sources, respectively [14].

We examined sociodemographic, socioeconomic, and hospital-level variables, including age, sex, race/ethnicity, primary payer, and comorbidity burden. Neighborhood socioeconomic status was assessed using the NIS variable ZIPINC_QRTL, which categorizes the median household income of the patient's ZIP code of residence into four income quartiles: lowest (quartile 1), low (quartile 2), high (quartile 3), and highest (quartile 4), using the corresponding NIS definitions for each study year (2016-2022). Because the income thresholds vary across years, quartiles were analyzed as categorical variables without applying fixed dollar cutoffs across the pooled study period. The lowest-income quartile served as the reference category in multivariable regression analyses. Hospital geographic location was defined using the HCUP variable HOSP_DIVISION: New England, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific. Secondary outcomes, including mortality, length of stay, and total cost of hospitalization, were also examined.

Statistical analysis

The primary objective was to identify hospitalizations involving patients with relapsed AML in which allo-SCT was recorded and to evaluate sociodemographic, socioeconomic, and hospital-level factors associated with receipt of allo-SCT. Categorical variables, including receipt of allo-SCT and patient- and hospital-level characteristics, were summarized using frequencies and percentages.

Comorbidity burden was assessed using an Elixhauser-derived comorbidity count based on ICD-10-CM diagnosis codes. Individual comorbid conditions were identified using the Elixhauser comorbidity framework, and the total number of conditions was calculated for each hospitalization. Comorbidity burden was categorized as mild (no comorbidity), moderate (1-2 comorbidities), or severe (⩾3 comorbidities) [15].

Multivariable logistic regression was performed to evaluate factors associated with allo-SCT recorded during hospitalization. The model adjusted for age category, sex, race/ethnicity, comorbidity burden, primary insurance payer, neighborhood median household income quartile, and hospital census division. Multicollinearity among independent variables was assessed using variance inflation factors (VIFs) and tolerance statistics. VIF values greater than 5 were considered indicative of potentially concerning multicollinearity.

Discharge weights were applied to obtain nationally representative hospitalization estimates, and hospital-level clustering was accounted for when estimating standard errors, 95% confidence intervals (CIs), and *P* values.

Hospitalizations with missing or unavailable information on covariates included in the multivariable regression model were excluded from the adjusted analysis using a complete-case approach. The extent of

missing data was assessed for relevant sociodemographic, socioeconomic, and clinical variables, including race/ethnicity, primary insurance payer, neighborhood median household income quartile, and comorbidity burden.

All statistical analyses were performed using IBM SPSS Statistics, version 31 (IBM Corp., Armonk, NY). Two-sided *P* values < 0.05 were considered statistically significant.

Results

Sociodemographic and hospital-level characteristics

Between 2016 and 2022, a total of 18,121 hospitalizations for relapsed AML were identified in the National Inpatient Sample, representing an estimated 90,605 hospitalizations nationally after applying discharge weights. Of these, 6,721 hospitalizations, corresponding to a weighted national estimate of 33,605 (37.1%), were associated with allo-SCT. Table *1* summarizes the sociodemographic and clinical characteristics of these patients, while Figure *1* illustrates annual hospitalization trends, with the highest number observed in 2018 (*n* = 6,475) and the lowest in 2020 (*n* = 2,475).

Sociodemographic factors	*n*	Percentage
Age (median, IQR)	60, 44-69	
<70 years	25,480	75.8
>=70 years	8,125	24.2
Sex		
Male	18,340	54.6
Female	15,265	45.4
Race		
White	20,620	63.0
Black	3,785	11.6
Hispanic	3,860	11.8
Asian/Pacific Islander	1,595	4.8
Native American	105	0.3
Other races	2,785	8.5
Type of insurance		
Medicare	13,375	39.8
Medicaid	5,430	16.2
Private insurance	12,915	38.4
Self-pay	745	2.2
No charge	100	0.3
Other	1,030	3.1
Median quartile incomes		
Lowest: <$50,000	7,615	23.2
Low: $50,000-$64,999	7,495	22.7
High: $65,000-$85,000	7,930	24.1
Highest: >$86,000	9,835	30.0
Hospital region		
New England	2,665	7.9
Middle Atlantic	6,710	20.0

East North Central	3,955	11.8
West North Central	1,250	3.7
South Atlantic	7,505	22.3
East South Central	2,135	6.4
West South Central	4,210	12.5
Mountain	1,065	3.2
Pacific	4,110	12.2
Comorbidity burden severity index		
Mild	1,870	6.0
Moderate	26,355	84.6
Severe	2,905	9.3
Mortality		
Alive	29,620	88.1
Dead	3,985	11.9
Length of stay in days (median, IQR)	12 (5-27)	
Total Hospital charge in dollars (median, IQR)	132,879 (54,284-332,279)	

TABLE 1: Baseline sociodemographic, economic, and hospital-level characteristics of the study population.

n, number of hospitalizations associated with allogeneic stem cell transplantation; IQR, interquartile range

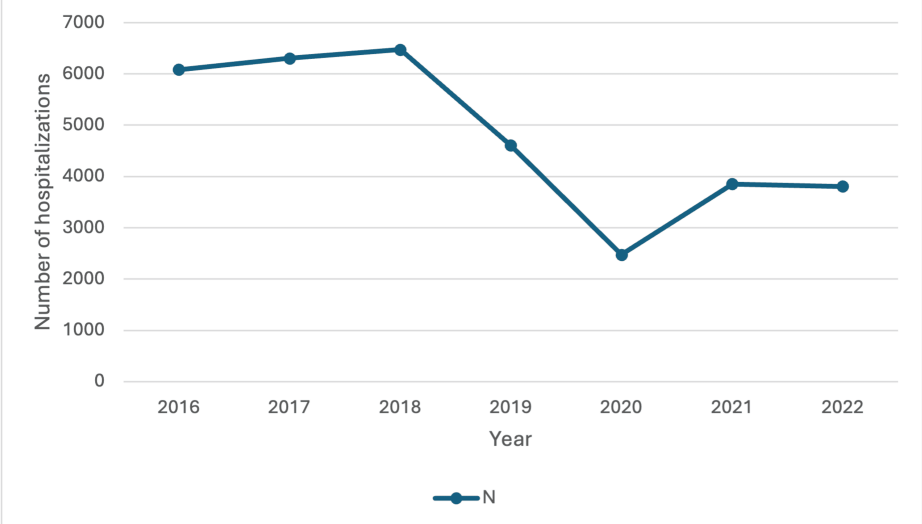


FIGURE 1: Line chart representing the number of relapsed acute myeloid leukemia (AML) hospitalizations per year.

The median age of the cohort was 60 years, and males comprised a slight majority (*n* = 18,340, 54.6%). White patients represented the largest racial group (*n* = 20,620, 63.0%), followed by Black (*n* = 3,785, 11.6%) and Hispanic patients (*n* = 3,860, 11.8%), who were similarly represented.

With respect to insurance status, most hospitalizations were covered by Medicare (*n* = 13,375, 39.8%) or private insurance (*n* = 12,915, 38.4%). Patients were relatively evenly distributed across median household income quartiles. Geographically, a substantial proportion of hospitalizations occurred in the South Atlantic

census division (*n* = 7,505, 22.3%). Most patients had a mild-to-moderate comorbidity burden (*n* = 28,225, 90.6%), while a smaller proportion had high comorbidity severity (*n* = 2,905, 9.3%). The overall in-hospital mortality rate was 11.9% (*n* = 3,985).

Multivariable analysis of factors associated with receipt of allo-SCT

In the multivariable logistic regression analysis, several sociodemographic, clinical, and hospital-level characteristics were associated with allo-SCT recorded during hospitalization (Table *2*, Figure *2*). Multicollinearity diagnostics did not identify substantial collinearity among the independent variables included in the multivariable regression model, with all VIFs below 5.

Sociodemographic factor	Adjusted OR	95% confidence interval	*P* value
Age category (<70 vs. ≥70 years)	1.03	0.97-1.10	0.292
Female sex	0.94	0.90-0.98	0.008*
Race (Reference: White)			
Black	1.23	1.13-1.34	<0.001**
Hispanic	1.12	1.00-1.24	0.054
Asian/Pacific	0.86	0.67-1.10	0.539
Native American	0.86	0.67-1.10	0.539
Other	1.5	1.36-1.65	<0.001**
Comorbidity severity (Reference: mild)			
Moderate	1.03	0.98-1.09	0.256
Severe	1.13	1.05-1.23	0.001**
Insurance (Reference: Medicare)			
Medicaid	0.99	0.92-1.07	0.879
Private	1.02	0.96-1.09	0.534
Self-pay	1.06	0.90-1.25	0.473
No-charge	0.48	0.29-0.80	0.006*
Other	0.85	0.74-0.98	0.029*
Median household income (Reference: lowest quartile: <$50,000)			
Low quartile: $50,000-$64,999	0.89	0.83-0.96	<0.001**
High quartile: $65,000-$85,999	0.83	0.77-0.89	<0.001**
Highest quartile: >$86,000	1.1	1.03-1.18	0.005*
Hospital census division (Reference: New England)			
East North Central	0.47	0.42-0.53	<0.001**
West North Central	0.23	0.19-0.27	<0.001**
Middle Atlantic	0.87	0.81-0.92	<0.001**
South Atlantic	0.93	0.85-1.02	0.15
East South Central	0.62	0.54-0.71	<0.001**
West South Central	0.63	0.55-0.72	<0.001**
Mountain	0.35	0.29-0.43	<0.001**
Pacific	0.53	0.47-0.60	<0.001**

TABLE 2: Multivariable logistic regression analysis of factors associated with receipt of allogeneic stem cell transplantation among adults with relapsed acute myeloid leukemia.

Adjusted for age category, sex, race/ethnicity, comorbidity severity, primary expected payer, median household income quartile, and hospital census division. Analyses incorporated National Inpatient Sample discharge weights to generate nationally representative estimates. Two-sided *P* values < 0.05 were considered statistically significant (*, **).

OR, odds ratio

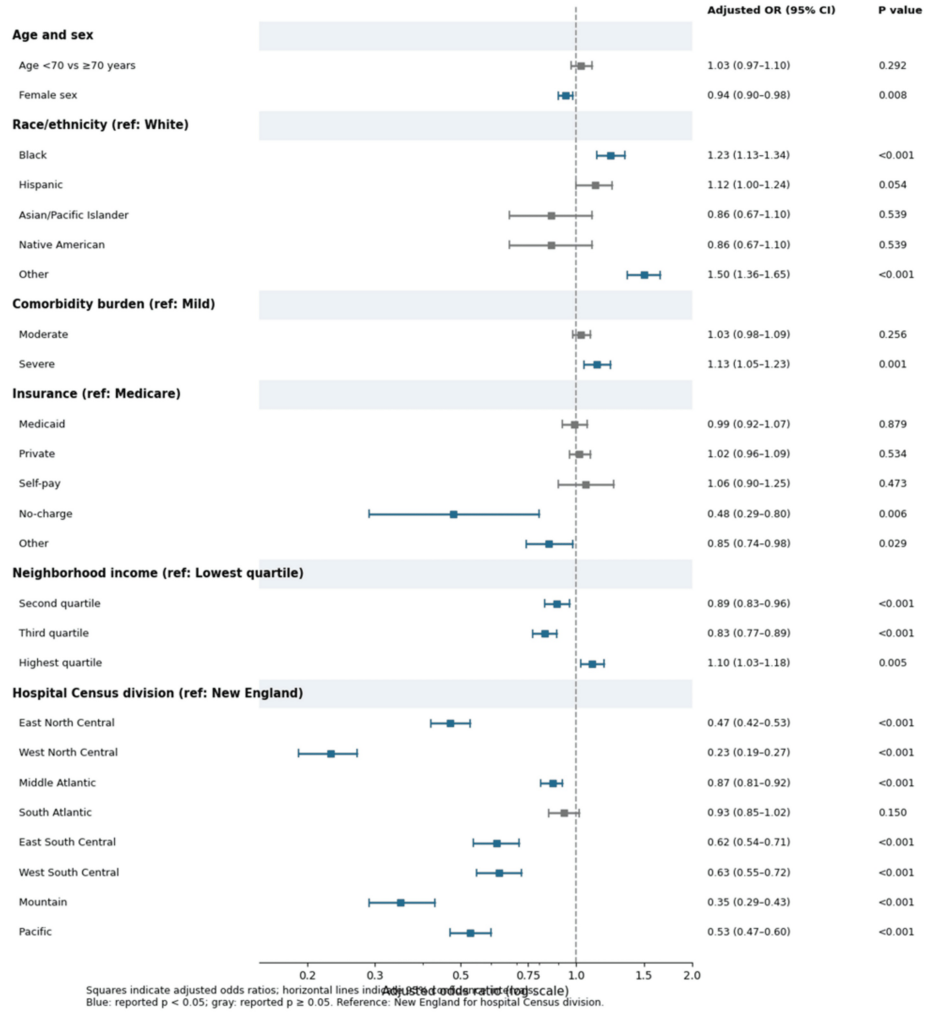


FIGURE 2: Forest plot of sociodemographic and socioeconomic factors associated with receipt of allogeneic stem cell transplantation (allo-SCT) among patients with relapsed acute myeloid leukemia (AML).

Hospitalizations involving female patients were associated with significantly lower odds of allo-SCT compared with those involving male patients (aOR, 0.94; 95% CI, 0.90-0.98; *P* = 0.008). Interestingly, compared with hospitalizations involving White patients, those involving Black patients had significantly higher adjusted odds of allo-SCT (aOR, 1.23; 95% CI, 1.13-1.34; *P* < 0.001). Similarly, hospitalizations involving patients categorized as Other race had higher odds of allo-SCT (aOR, 1.50; 95% CI, 1.36-1.65; *P* < 0.001). Although hospitalizations involving Hispanic patients had numerically higher odds of allo-SCT, this association did not reach statistical significance (aOR, 1.12; 95% CI, 1.00-1.24; *P* = 0.054). No statistically significant associations were observed for Asian/Pacific Islander or Native American patients.

Regarding comorbidity burden, hospitalizations classified as having severe comorbidity burden were associated with higher adjusted odds of allo-SCT compared with those classified as mild (aOR, 1.13; 95% CI, 1.05-1.23; *P* = 0.001). However, moderate comorbidity burden was not significantly associated with allo-SCT (aOR, 1.03; 95% CI, 0.98-1.09; *P* = 0.256).

Compared with Medicare, hospitalizations categorized under "no-charge" (aOR, 0.48; 95% CI, 0.29-0.80; *P* = 0.006) and "Other insurance" (aOR, 0.85; 95% CI, 0.74-0.98; *P* = 0.029) were associated with significantly lower adjusted odds of allo-SCT. No statistically significant associations were observed for Medicaid, private insurance, or self-pay.

Neighborhood median household income demonstrated a non-monotonic association with allo-SCT. Compared with the lowest-income quartile, hospitalizations involving patients from the low (aOR, 0.89; 95% CI, 0.83-0.96; *P* < 0.001) and high (aOR, 0.83; 95% CI, 0.77-0.89; *P* < 0.001) income quartiles had significantly lower odds of allo-SCT, whereas those from the highest-income quartile had higher odds (aOR, 1.10; 95% CI, 1.03-1.18; *P* = 0.005).

Geographic differences were also observed. Using New England as the reference category, hospitalizations in the East North Central (aOR, 0.47; 95% CI, 0.42-0.53), West North Central (aOR, 0.23; 95% CI, 0.19-0.27), Middle Atlantic (aOR, 0.87; 95% CI, 0.81-0.92), East South Central (aOR, 0.62; 95% CI, 0.54-0.71), West South Central (aOR, 0.63; 95% CI, 0.55-0.72), Mountain (aOR, 0.35; 95% CI, 0.29-0.43), and Pacific (aOR, 0.53; 95% CI, 0.47-0.60) divisions were associated with significantly lower adjusted odds of allo-SCT (all $P < 0.001$). No statistically significant association was observed for the South Atlantic division (aOR, 0.93; 95% CI, 0.85-1.02; $P = 0.150$).

Discussion

In this large, nationally representative study of relapsed AML hospitalizations, we examined sociodemographic, socioeconomic, and clinical factors associated with the receipt of allo-SCT. During the study period (2016-2022), AML-related hospitalizations declined. Adjusted analyses revealed significant variation in allo-SCT receipt by sex, race/ethnicity, insurance status, median household income, comorbidity burden, and hospital geographic region. These findings highlight the influence of sociodemographic and patient-related factors in determining access to potentially curative therapies for patients with relapsed AML.

The incidence of relapsed AML admissions declined over the study period. We believe this trend stems from our expanded molecular understanding of AML pathobiology, which has led to improved frontline therapies [16-18]. In addition, minimal residual disease monitoring using advanced diagnostic techniques has led to early identification of relapse and proactive initiation of therapy, thus preventing overt relapse [19-21]. Among those who underwent allo-SCT, significant declines in disease relapse rates over time could be explained by improved donor availability, better conditioning techniques, and improved prevention of graft-versus-host disease [22]. We also observed a significant decrease in relapsed AML hospitalizations in 2020 during the COVID-19 pandemic. Our findings align with other studies on hematologic malignancies and other cancers that reported declines in outpatient visits and hospital admissions among this vulnerable group [23,24]. This is likely due to the increased risk of viral exposure and adverse outcomes linked to hospitalization in this immunocompromised population. It is plausible that oncologists adopted strategies such as delaying chemotherapy or managing conditions remotely to reduce infection risk and lower hospital admissions and in-person visits.

We found no association between age and receipt of allo-SCT among hospitalized patients with relapsed AML. Overall survival (OS) has improved among patients older than 70 years over the past decade, attributable to reductions in non-relapse mortality and improvements in supportive care [25,26]. While this finding is encouraging, it should be interpreted with caution, as chronological age alone may not accurately reflect transplant eligibility or outcomes. Clinical factors such as functional status, comorbidity burden, and conditioning regimen intensity are more reliable predictors of outcomes than chronological age. For instance, Aoki et al. found that although advanced age was not an absolute contraindication to receiving allogeneic hematopoietic stem cell transplantation (allo-HSCT), individuals with a high Hematopoietic Cell Transplantation-specific Comorbidity Index (HCT-CI), reflecting a greater comorbidity burden, had worse OS and higher non-relapse mortality following transplantation [27,28]. These findings underscore the importance of individualized patient selection based on physiologic fitness and comorbidity burden rather than chronological age alone.

Hospitalizations involving female patients were associated with significantly lower adjusted odds of allo-SCT compared with those involving male patients (aOR 0.94, 95% CI 0.90-0.98; $P = 0.008$). This finding is consistent with previous research using national inpatient data that reported lower transplantation utilization among females with AML [29]. Other studies have documented sex-related differences in AML outcomes, including OS and non-relapse mortality [30]. Differences in disease incidence, relapse patterns, cytogenetic and molecular characteristics, and clinical presentation may contribute to sex-related variation in transplantation utilization [31,32]. However, we did not directly evaluate these factors, and their contribution to the observed association remains uncertain. Further studies incorporating detailed clinical and disease-specific characteristics are needed to determine the mechanisms underlying sex-related differences in allo-SCT utilization.

Race and ethnicity are important social determinants of healthcare utilization and outcomes in the United States. Previous studies have documented racial and ethnic disparities in cancer care, including differences in timely diagnosis, receipt of guideline-directed therapies, and survival outcomes [33-35]. Similar disparities have been reported in AML, where structural and systemic barriers may influence access to specialized treatments, including allo-SCT [36]. Contrary to expectations based on some previous studies, we observed significantly higher adjusted odds of inpatient allo-SCT among hospitalizations involving Black patients than among those involving White patients (aOR 1.23, 95% CI 1.13-1.34; $P < 0.001$). Hospitalizations involving Hispanic patients also demonstrated numerically higher odds, although this association did not reach statistical significance (aOR 1.12, 95% CI 1.00-1.24; $P = 0.054$).

These findings warrant cautious interpretation and should not be considered evidence of greater transplantation access among Black or Hispanic patients. The NIS captures hospitalizations rather than unique individuals, and our analysis was restricted to hospitalizations involving relapsed AML.

Consequently, the study population may not represent the broader population of patients with AML, including those who were never hospitalized or evaluated for transplantation. Differences in hospitalization patterns and the characteristics of patients admitted to transplant-capable institutions may influence the observed associations. Previous studies have documented differences in comorbidity burden across racial and ethnic populations [37,38], raising the possibility that differences in hospitalization frequency or inpatient case mix could contribute to these findings. However, this explanation remains hypothesis-generating. Other potential explanations include selection into hospitalization, differences in referral patterns, hospital characteristics, diagnostic and procedure coding practices, and residual confounding. Furthermore, the NIS does not provide information on cytogenetic or molecular risk, remission status, donor availability, or transplant eligibility. These unmeasured factors may contribute to the observed associations. Therefore, our findings should not be generalized to all patients with AML or interpreted as contradicting established evidence regarding racial disparities in donor availability and transplantation access.

Our study found that hospitalizations involving patients with relapsed AML and severe comorbidity burden had higher adjusted odds of allo-SCT compared with those involving patients with mild comorbidity burden. This finding appears to contrast with established clinical practice and previous literature, as greater pretransplant comorbidity burden is generally associated with increased transplant-related morbidity and mortality and may influence transplant eligibility. However, because the NIS is a hospitalization-level database, we could not establish the temporal relationship between recorded comorbidities and allo-SCT. It is possible that some conditions contributing to the recorded comorbidity burden developed during hospitalization, including complications following transplantation, which may partly explain the observed association. Furthermore, the Elixhauser-derived comorbidity count used in our study differs from the HCT-CI, which is specifically designed to assess pretransplant comorbidity-related risk. Further patient-level studies incorporating longitudinal clinical data are needed to clarify the temporal relationship between comorbidity burden and allo-SCT.

Socioeconomic characteristics were also associated with inpatient allo-SCT utilization, although the observed relationships were not uniform. Compared with hospitalizations involving patients from the lowest neighborhood median household income quartile, those involving patients from the low and high quartiles had significantly lower adjusted odds of allo-SCT (aOR 0.89 and 0.83, respectively), whereas those involving patients from the highest quartile had higher adjusted odds (aOR 1.10). This non-monotonic pattern does not support a consistent increase in transplantation utilization across progressively higher income quartiles. Additionally, compared with Medicare, hospitalizations classified under the no-charge payer category had significantly lower adjusted odds of allo-SCT (aOR 0.48, 95% CI 0.29-0.80; $P = 0.006$). However, the no-charge category should not be considered synonymous with being uninsured, as it represents a distinct administrative payer classification. In the adjusted analysis, Medicaid, private insurance, and self-pay were not significantly associated with allo-SCT relative to Medicare.

Previous studies have demonstrated associations between socioeconomic characteristics and HSCT utilization [39-41]. For example, Kang et al. reported differences in transplantation utilization associated with race, insurance status, and neighborhood socioeconomic characteristics [41]. Although these studies provide important context, differences in study populations, outcomes, and analytical approaches should be considered when comparing their findings with ours. Socioeconomic factors may influence healthcare utilization through multiple pathways, including insurance coverage, financial resources, geographic proximity to specialized centers, and referral opportunities. Furthermore, the substantial financial burden associated with contemporary hematologic malignancy treatment, including immunotherapy and stem cell transplantation, may contribute to financial toxicity, particularly among socially disadvantaged populations [42,43]. Nevertheless, our study cannot determine whether the observed associations reflect financial barriers, differences in transplant eligibility, referral practices, or other unmeasured factors.

We also observed geographic variation in inpatient allo-SCT utilization across hospital census divisions. Compared with the reference division, hospitalizations in several other divisions had significantly lower adjusted odds of allo-SCT, while the association for the South Atlantic division was not statistically significant. Previous studies have documented regional variation in HSCT utilization in the United States [44]. Differences in the geographic distribution of transplant centers, referral networks, institutional capabilities, and patient case mix may contribute to these patterns. However, our analysis did not directly evaluate these factors. Furthermore, hospital census division reflects the hospital's location rather than the patient's place of residence. Consequently, these findings should be interpreted as geographic variation in hospitalization-level transplantation utilization rather than direct evidence of regional differences in transplantation access.

An important strength of our study is its focus on hospitalizations involving adults with relapsed AML, a population for whom allo-SCT may represent a potentially curative treatment option depending on disease status, clinical fitness, and other eligibility considerations. Second, a large, nationally representative inpatient database spanning seven years enabled us to examine sociodemographic, socioeconomic, clinical, and geographic associations with transplantation utilization across a broad range of hospital settings. The multi-year study period also allowed us to evaluate hospitalization patterns over time. However, these findings reflect inpatient healthcare utilization and, again, may not represent the broader population of

individuals with relapsed AML.

However, several limitations need to be acknowledged. Although the NIS database provides sociodemographic and socioeconomic data on hospitalizations, it lacks other essential factors that influence receipt of transplantation, such as performance status indices like ECOG and, importantly, molecular and cytogenetic characteristics that influence AML and help classify risk. In addition, the NIS captures hospitalization-level data rather than individual patients, preventing longitudinal follow-up and potentially resulting in multiple admissions for the same patient. It also does not capture outpatient management or donor availability, both of which influence access to allo-SCT. Using ICD codes introduces potential coding inaccuracies, including misclassification of diagnostic and procedure codes, missing-data handling, residual confounding, and an inability to identify unique patients or assess the full transplantation pathway. Notably, the NIS database cannot determine whether patients who underwent transplantation were eligible, referred, or offered the procedure. Because the NIS records hospitalizations rather than individual patients, repeated admissions may affect estimates. Lastly, given the retrospective nature of the database, the associations do not imply causation. Despite these limitations, the nationally representative nature of the NIS provides a valuable opportunity to examine real-world disparities in access to transplantation among patients with relapsed AML.

Conclusions

In this nationally representative study, we identified associations between sociodemographic, socioeconomic, and geographic characteristics and allo-SCT recorded during hospitalizations involving adults with relapsed acute myeloid leukemia. Although these findings highlight variations in inpatient transplantation utilization, they do not establish causal relationships or necessarily indicate inequities in access to transplantation. Given the observational nature of the study and the potential for residual confounding, further patient-level research incorporating transplant eligibility, disease status, donor availability, referral pathways, clinical decision-making, and longitudinal outcomes is needed to better understand these associations and inform strategies to promote equitable access to transplantation.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Lemchukwu Amaeshi, Michael Imeh, Jude Ossai

Acquisition, analysis, or interpretation of data: Lemchukwu Amaeshi

Drafting of the manuscript: Lemchukwu Amaeshi

Critical review of the manuscript for important intellectual content: Lemchukwu Amaeshi, Michael Imeh, Jude Ossai

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. None issued approval none. This study utilized the Healthcare Cost and Utilization Project National Inpatient Sample (NIS), a publicly available, de-identified database. As no identifiable patient information was included, this study was exempt from Institutional Review Board approval and the requirement for informed consent. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Acknowledgements

ChatGPT (OpenAI, San Francisco, CA) was used as a supplementary tool to assist with statistical syntax guidance and support for the data analysis workflow. All statistical analyses and outputs were independently reviewed and validated by the authors.

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