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Racial disparities in hematopoietic cell transplantation in the United States

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Abstract

Hematopoietic cell transplantation (HCT) is a highly specialized, expensive and resource-intense medical procedure that can be associated with racial disparities. We review the prevailing literature on racial disparities in HCT in the United States and describe areas for future research and interventions. We discuss the complexity of interpreting race as a biological and social determinant of disease in biomedical research, especially as it relates to HCT. In the United States, race is often a surrogate for socioeconomic, education and health insurance status. We also discuss some of the nuances to consider while reviewing the literature on racial disparities. Disparities by race exist in three areas related to HCT: donor availability, access to HCT and outcomes of HCT. African-Americans/Blacks have a lower likelihood of finding an unrelated donor. Race and ethnicity definitions are country-specific and reconciling race data can represent significant challenges to unrelated donor registries worldwide. African-Americans/Blacks do not have the same access to autologous and allogeneic HCT as Whites. Racial disparities in outcomes of HCT are more prevalent among allogeneic HCT than autologous HCT recipients. More research is required to understand the biological, social, cultural, medical and financial aspects of race that may influence access to HCT and survival after transplantation. Better understanding of racial disparities will minimize inequities, inform health policy, guide development of interventions targeted to eliminate disparities and ensure equitable access to HCT for all populations.

Keywords

race/ethnicity; hematopoietic cell transplantation; allogeneic transplant; autologous transplant; access; health-care disparities

INTRODUCTION

The utilization of hematopoietic cell transplantation (HCT) continues to increase over time.[1] However, HCT is a highly specialized, technologically sophisticated, resource-intense and expensive procedure that is available at select centers in the country. Given its restricted availability, it can be associated with disparities in access and outcomes for minority populations.[2] In this paper, we review the concept of race and ethnicity in biomedical research in the United States, including the challenges of associating race with biology of disease and the role of race as a social construct in medicine. We describe some issues that

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CONFLICT OF INTEREST

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have to be considered when interpreting the research on racial disparities, especially as it relates to HCT. We also review the available literature on racial disparities in HCT and describe areas for future research and interventions.

RACE AND ETHNICITY IN MEDICINE

Race is considered to be a sociopolitical construct that is based on the geographic region of origin of an individual's ancestry.[3] The 2010 US census categorized race into five broad categories, based on guidance provided by the US Office of Management and Budget: White, Black or African-American (henceforth, referred to as Black), American-Indian or Alaska Native, Asian and Native Hawaiian or Other Pacific Islander.[4] A related concept is ethnicity, which is considered to be a broader construct that takes into account cultural tradition, common history, religion and often a shared genetic heritage.[3] The 2010 US census enquired about ethnic background and asked respondents to identify whether they were of Hispanic, Latino or Spanish origin.[4]

The use of race and ethnicity as a determinant of disease risk and outcome is very prevalent in biomedical research. However, there is considerable debate about the biological relevance of race. Some researchers have argued that because there is no basis in the genetic code for race, it serves as a flawed surrogate for multiple environmental and genetic factors in disease causation, and some have gone as far as suggesting that racial classifications be excluded from biomedical research.[5,6] At the other end of the spectrum, researchers argue that despite the genetic homogeneity of the human race, there exists considerable genetic variation among populations that is geographically structured, and as race is correlated with geography, there is some value to investigating the association of race and disease.[7,8] At the same time, because humans have been only partially isolated by geography, substantial overlap occurs between populations, and even proponents of studying race in medicine suggest careful and thoughtful interpretation of studies on the biological implications of race.

Race is an important social determinant of health. In the United States, race and ethnic background are strongly correlated with socioeconomic status and health insurance coverage, and hence, are robust predictors of access to and quality of healthcare.[3,9,10] However, even when other health-care access-related factors are the same (for example, ability to pay for care), racial and ethnic minorities still receive lower quality of health care than Whites.[10,11] Disparities in healthcare, which are defined as racial or ethnic differences in the quality of health care that are not due to access-related factors or clinical needs, preferences and appropriateness of intervention, result in poor overall health status among minority populations (for example, Blacks and Hispanics) compared with nonminority populations (for example, Whites).[9]

Racial disparities have been well documented among cancer patients in the United States.[12 – 17] Blacks have the highest death rate and shortest survival of any racial and ethnic group in the United States for most cancers.[18] The causes of these inequalities are thought to be complex and multifactorial, and likely reflect social and economic disparities more than biologic differences. Racial minorities with cancer are more likely to belong to lower socioeconomic strata, be under- or un-insured, and have lower levels of health literacy and education.[12,18,19] Also, physicians and providers may have race-based biases and beliefs about cancer treatments.[12] Health-care system, organizational and structural factors, reimbursement and financial forces can also contribute to racial disparities in cancer care.[12]

Issues to consider while interpreting the literature on racial disparities

When reviewing studies of race and ethnicity in biomedical research, several issues have to be considered.[20] These include:

1. *Race is more of a social than biological construct.* As noted above, there is more genetic variation within races than between races, and race does not reliably demarcate populations with discrete genetic characteristics. Studies that investigate association of race with a health condition should be hypothesis-driven and should consider relevant social, economic, environmental, biological or genetic factors in the analysis. If data on these variables are not readily available, there should be a discussion of alternative mechanisms to explain the findings observed.

2. *Has the validity and reliability of race assignment been considered?.* In research studies, data on race may be collected by self-report, direct observation, proxy report or extraction from records. In general, self-reported race is the most reliable and should be the preferred method for obtaining race information in research studies.

3. *Have other social indicators of health status been considered?* Very frequently in the United States, race is a surrogate for socioeconomic, education and health insurance status. Research in racial disparities should ideally account for as many such variables as possible. However, research shows that even after adjustment of socioeconomic status, racial disparities persist in some disease conditions.[21]

4. *Race does not always account for social determinants of health.* Culture is an example of a social determinant that has an impact on health behavior and outcomes independent of race. Culture has been defined as 'integrated patterns of human behavior that include the language, thoughts, communications, actions, customs, beliefs, values and institutions of racial, ethnic, religious or social groups.'[22] For instance, African-Americans who live in California may have different cultural values compared with those who live in the Southeast, who in turn may have distinct beliefs compared with Blacks who are first-generation immigrants from the African subcontinent. The current race classifications do not account for differences in beliefs, values and practices.

5. *Race categorizations are dynamic.* Because of their socio-political origin, race categories have reflected prevailing societal norms and have been modified over time with the changing demographics of the US population. Compared with contemporary race and ethnicity categories, a rather extreme example is the 1890 US census that instructed respondents to classify race as 'White', 'Black', 'Mulatto', 'Quadroon', 'Octoroon', 'Chinese', 'Japanese' or 'Indian'. Another example is individuals who consider themselves to be of 'mixed race'; they were able to assign themselves to more than one race only after the 1997 guidance from the Office of Management and Budget. The US demographics are also changing, with an increasing number of immigrants, and the 2010 US census reported significant differences in how foreign-born residents reported race and ethnicity compared with US-born residents.

6. *Race categorizations are country-specific.* Race and ethnicity categories are specific to the United States and do not apply to other countries and vice versa. Hence, studies investigating association of race with HCT outcomes are not generalizable to all countries. This can be an issue for donor registries as well and can lead to challenges in reconciling the race of an international donor with a recipient in the United States.

RACE AND ETHNICITY IN HCT

Certain aspects of HCT make it particularly susceptible to racial and ethnic disparities in access and outcomes.[2] Racial inequalities in healthcare are closely associated with socioeconomic and educational status, and health insurance coverage. Because HCT is an expensive and sophisticated procedure, socioeconomic and health literacy factors may be relevant in contributing to racial disparities. These factors may contribute to other social barriers, such as availability of caregivers and transportation as well as patient adherence (for example, related to high out-of-pocket deductibles for outpatient medications). For recipients of allogeneic HCT, the need for a diverse donor pool adds to race-related disparities.

Race and donor availability

A unique aspect of allogeneic HCT is the need for appropriately HLA-matched donors. About 70% of patients who need allogeneic HCT do not have a matched sibling and must rely on unrelated donors or umbilical cord blood (UCB). The distribution of HLA types in the human population is extremely diffuse and differs by ancestry. Although there is substantial overlap between these distributions, the likelihood of matching between two randomly selected individuals is higher if they are of the same race, which can on sometimes be a very crude surrogate for genetic ancestry.[23,24]

The National Marrow Donor Program's (NMDP) Be The Match Registry has about 9 million potential donors. Whites constitute nearly 6.5 million (74%) donors in the registry, whereas the representation of Hispanics (10%), Blacks (7%) and Asians (7%) is less frequent.[25] The probability of finding a match within the registry is estimated to be 0.93 for Whites, 0.82 for Hispanics, 0.77 for Asian Americans and 0.58 for Blacks. HCT recipients are more likely to match to a donor of the same race and ethnicity.[23] The NMDP has a number of ongoing initiatives to increase the diversity of its donor pool and to increase the representation of racial and ethnic minorities in its registry. These programs have resulted in a greater proportion of patients from the racial groups receiving unrelated donor allogeneic HCT over time.[25] However, availability of suitably HLA-matched unrelated donors continues to be a barrier to HCT among these populations.

As UCB transplantation can be successfully performed with partially HLA-matched units, it has the potential to increase the odds of finding an appropriate donor for patients from racial and ethnic minority populations. Recognizing this need, the NMDP has been actively working on increasing the repertoire of racially diverse UCB units available through its network of UCB banks. In 2010, over 40% of its pool of more than 145 000 UCB units was from racial and ethnic minorities.[25] In a recent study, Barker *et al.*[26] have demonstrated that UCB does increase access to allogeneic HCT for patients of all races and ethnicities. They prospectively evaluated the availability of unrelated donors and UCB based on patient ancestry by performing combined searches in 553 patients without sibling donors. A 10/10 HLA-matched unrelated donor was identified for 53% of patients of European ancestry, but only for 21% of patients of non-European origin; the majority of both groups had 5–6/6 HLA-matched UCB units available for allografting. Continued efforts directed towards increasing the pool of high quality UCB units from racial and ethnic minorities are still needed. In an analysis using data submitted to the Center for International Blood and Marrow Transplant Research (CIBMTR), Ballen *et al.*[27] found that among recipients of single UCB transplantation, more Whites (40%) and Hispanics (42%) than Blacks (21%) received UCB units that were well-matched (5–6/6 HLA-matched) and had an adequate cell dose ($\geq 2.5 \times 10^7$ nucleated cells/kg recipient body weight).

Race and access to HCT

HCT is most commonly performed for malignant hematologic disorders and the barriers that prevent access to cancer care for racial minorities are also relevant for HCT. Given that HCT is a complex and high-cost procedure, additional barriers may also have a role. The available literature on racial disparities in access to HCT is very limited (Table 1). Two relatively large database studies have addressed this issue.[28,29] The first study used hospital discharge data from four states (California, Massachusetts, Mary-land and New York) for two years (1988 and 1991) and used ICD-9 codes to identify 38 240 patients hospitalized with leukemia and lymphoma.[29] The authors found that after controlling for other factors, Black patients with leukemia were 51–53% as likely and Black patients with lymphoma were 34–45% as likely as Whites to undergo HCT ($P<0.05$). Medicaid patients were also significantly less likely to receive HCT compared with patients with private insurance. This was the first large study to address racial disparities in access to HCT; however, some shortcomings included the inclusion of hospitalized patients only and the use of medical codes for identifying patients, which can lack precision and have very limited details about disease-related prognostic factors. The second more contemporaneous study was conducted by the CIBMTR and used data from the Surveillance, Epidemiology, and End Results program and the CIBMTR.[28] This analysis included data on an estimated 273 853 incident cases and an estimated 45 750 transplant recipients with ALL, AML, CML, non-Hodgkin's lymphoma and multiple myeloma treated during 1997–2002. Compared with Blacks, the age-adjusted odds of receiving any type of HCT for all diseases considered was significantly higher for Whites (odds ratio = 1.40, $P<0.0001$). For each transplant type (autologous, HLA-identical sibling and unrelated donor HCT), Whites had a significantly higher odds of receiving HCT than Blacks. These differences also held true for the majority of diseases studied. In addition to the limitations associated with registry studies, this study could not account for patient socioeconomic status. Possible limitations in study design notwithstanding, these studies highlight racial disparities in access to transplantation in the United States and show that Black patients in general have lesser access to HCT compared with White patients.

Race and outcomes of HCT

Studies investigating the association of race and ethnicity with outcomes of HCT are summarized in Table 2.[27,30 – 36]

For autologous HCT, studies have mainly focused on patients with multiple myeloma. Although limited by a small number of minority patients included in each study, the literature generally shows that Black patients who receive an autologous HCT for myeloma have OS comparable to that of White patients.[32 – 34,36] In one of the largest studies to date, Hari *et al*.[32] used CIBMTR data to compare outcomes of 1892 White and 303 Black recipients of autologous HCT for myeloma. White and Black patients had similar probabilities of 5-year OS (47% vs 52%, $P = 0.19$) and progression-free survival (21% vs 19%, $P = 0.64$) as well as cumulative incidences of disease progression (72% vs 72%, $P = 0.97$) and non-relapse mortality (8% vs 9%, $P = 0.52$). In multivariate analyses, race was not associated with any of these outcomes.

In contrast, racial disparities have been noted in outcomes of allogeneic HCT.[27,30,31,35,37] This may partly reflect the more complex nature and expense of allogeneic HCT compared with autologous HCT. In addition, biological factors may vary with ancestry and may at least partly contribute to differences in outcomes by race. For instance, differences in HLA and minor transplantation Ag diversity and frequencies of cytokine gene polymorphisms may explain some of the differences in risks of GVHD observed between patients of different ancestries.[38 – 40] The largest analysis investigating association of race with

outcomes of allogeneic HCT has been conducted by Baker *et al.*[30] using data from the CIBMTR. Their study included 5253 White, 368 Black, 445 Hispanic and 141 Asian/Pacific Islander patients who had received a myeloablative HLA-matched unrelated donor HCT for AML, ALL, CML or myelodysplastic syndrome between 1995 and 2004. In multivariate analyses, Blacks had significantly worse OS (relative risk (RR) for mortality 1.47, $P<0.01$) and disease-free survival (RR 1.48, $P<0.01$) and higher risks of TRM (RR 1.56, $P<0.01$) compared with Whites. Survival of Hispanics and Asians/Pacific Islanders was comparable to that of Whites. Race had no influence on relapse risks. The association of Black race with outcomes was independent of socioeconomic status (median household income imputed by ZIP Code of residence), indicating that other biological, social or epidemiological factors could potentially be mediating overall mortality and treatment-related mortality.

Race and outcomes of UCB transplantation are of particular interest as UCB has the potential to increase access to HLA-matched unrelated donors for patients from specific racial and ethnic groups. Only one study has looked at this issue and was conducted by Ballen *et al.*[27] using CIBMTR data. Outcomes were analyzed for 612 Whites, 145 Blacks and 128 Hispanics who underwent single UCB HCT between 1995 and 2006 for ALL, AML, myelodysplastic syndrome and CML. After adjusting for important patient and disease-related factors, Blacks had higher risks of overall mortality (RR 1.30, $P = 0.02$), whereas survival of Hispanics was comparable to that of Whites. A significantly higher proportion of Blacks received units that were not well matched and had a low cell dose. On multivariate pair-wise comparisons, OS was similar among Blacks and Whites who received UCB units with adequate cell dose ($\geq 2.5 \times 10^7$ nucleated cells/kg). Similarly, survival was comparable among Black and White patients who received 5–6/6 HLA-matched UCB units. These findings indicate that differences in survival after UCB HCT can at least partly be overcome by using units with higher cell dose and a closer HCT match in racial minorities and provides impetus for continued efforts to improve the quality of banked UCB units for these populations.

Is race a surrogate for other sociodemographic factors?

In the field of biomedical research, race has been observed to be closely correlated with other social factors and these associations may modulate disease incidence and treatment outcomes.[3,9,11,18] For example, Blacks have lower socioeconomic status, poorer health literacy and lower education status compared with Whites, and these social factors have been implicated for the poor quality of health and cancer care among the former. In this context, a question arises whether the observed racial differences in outcomes of HCT are a consequence of these same socio-demographic factors. Few studies have rigorously addressed this issue to date. Baker *et al.*[30] used ZIP Codes to estimate median household income for patients included in their study. The median household income was lower for Blacks compared with Whites. Probability of overall mortality and treatment-related mortality was inversely related to household income. By multivariate analysis, the effect of household income on overall mortality and treatment-related mortality was found to be independent of race. Similarly, the negative impact of Black race on outcomes was independent of household income. In a smaller study, Mielcarek *et al.*[35] performed a subset analysis to evaluate the association of race, education, household income, employment status and medicaid/social security eligibility with outcomes of allogeneic HCT. Blacks had higher risks of overall mortality compared with Whites and adjustment for various combinations of socioeconomic indicators did not change these risks noticeably. These studies indicate that socioeconomic status can explain only some of the differences in survival by race after allogeneic HCT and that more research is needed to identify other biological, social and cultural factors that may explain the reason for these disparities.

Areas for future research

Three broad areas specific to HCT require more research on racial disparities: race and donor issues, race and access to HCT and race and outcomes of HCT (Table 3).

Among medical treatments, HCT is unique because of the requirement of a suitable HLA-matched donor for transplantation. Several initiatives within the NMDP have increased the representation of donors from racial and ethnic minorities in the United States. However, we need more information on whether race and other social factors have any association with availability of unrelated donors. Race, donor availability and their impact on HCT outcomes also needs to be investigated. The number of US residents who identify themselves with more than one race represents another challenge to registry models that are built on 'one race–one person' concept; more research to better understand the changing demographics of the US population and its implications for donor recruitment and availability is needed.

Research is needed to further characterize causes for racial and ethnic disparities in access to HCT. Studies performed to date have used a variety of databases to address access issues. A more comprehensive assessment of geographic, social and cultural barriers to access to transplantation for patients belonging to minority racial groups is needed. Such studies will have to be performed at a patient and center level and will have to address inherent racial inequities due to biological and medical factors. For example, ethnic and racial minorities have a lower probability of finding a suitable donor and have a higher prevalence of comorbidities that may make them ineligible for transplantation.[41 – 43] There are systemic issues with data collection and reporting practices with respect to race and ethnicity that need to be evaluated and addressed. Given that the expense of HCT procedure itself and the associated patient-related costs of undergoing transplantation (for example, transportation, time away from work, travel and lodging near center, deductibles and co-pays for outpatient medications) can be large, financial barriers may further accentuate racial disparities and need to be better understood. A related issue is family structure and support (for example, single parent households), which can be highly correlated with race and low socioeconomic status, and its association with access to and outcomes of HCT. Because of the complexity of HCT, health literacy also has the potential to influence access to and outcomes of transplantation and has not been well studied. Once etiologies of disparate access have been better characterized, studies evaluating targeted interventions to address these barriers are also needed. Better understanding of race-related factors that have an impact on outcomes of HCT are needed. Studies also need to investigate interventions to mitigate racial inequalities in post-transplant outcomes.

To eliminate racial disparities in the field of HCT, it is important that healthcare providers and transplant centers be aware of their existence. As we learn more about their causes and ways to eliminate them, the medical community including payors, policy makers, transplant centers and healthcare providers must use the current awareness of these inequalities to examine their own practices and work to eliminate inappropriate disparities in HCT.

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Table 1

Summary of relatively large contemporaneous studies that have addressed race and access to HCT in the United States

Reference	Data sources	Study design	n	Population characteristics	Results	Conclusions
Mitchell *et al.*[29]	Inpatient hospital discharge data for California, Maryland, Massachusetts and New York; 1988 and 1991	ICD-9 codes used to identify inpatients with leukemia or lymphoma, and auto- and allo-HCT recipients	38 420 Patients with leukemia or lymphoma; 1655 HCT recipients	Acute and chronic leukemia ~50%, lymphoma ~50%; Whites 60–80%, Blacks 6–13%; Hispanics 10–23%[a]	Compared with Whites, Blacks 51–53% as likely to receive HCT for leukemia and 34–45% as likely to receive HCT for lymphoma ($P<0.05$ for all comparisons)	Blacks less likely than Whites to receive HCT
Hwang *et al.*[44]	Texas inpatient hospital discharge data; 1999	ICD-9 codes used to identify inpatients with acute or chronic leukemia, and auto- and allo-HCT recipients	6574 Patients with leukemia; 1604 HCT recipients	AML 27%, ALL 24%, CML 13%, CLL 31%; Whites 70%, Blacks 8%	Compared with Whites, OR for receiving HCT in Blacks was 0.98 in pediatric, 0.77 in adult and 1.21 in elderly patients (P = NS for all comparisons)	No association of race with HCT use
Joshua *et al.*[28]	CIBMTR, SEER, US Census Bureau; 1997–2002	SEER incidence estimates and transplant utilization data from CIBMTR used to estimate rates of auto- and allo-HCT for leukemia, lymphoma and myeloma	273 853 Patients with leukemia, lymphoma or myeloma; 45 750 HCT recipients	AML 21%, ALL 9%, CML 11%, NHL 21%, MM 40%; Whites 90%, Blacks 10%	Compared with Blacks, OR for receiving HCT in Whites was 1.40 for all HCT, 1.24 for auto-HCT, 1.59 for HLA-identical sibling HCT and 2.02 for unrelated donor HCT ($P<0.0001$ for all comparisons)	Blacks less likely than Whites to receive HCT

Abbreviations: CIBMTR = Center for International Blood and Marrow Transplant Research; HCT = hematopoietic cell transplantation; HMO = Health Maintenance Organization; ICD = International Classification of Diseases; MM = multiple myeloma; NHL = non-Hodgkin's lymphoma; OR = odds ratio; SEER = Surveillance Epidemiology and End Results.

[a] Population characteristics varied by state.

Table 2

Summary of relatively large contemporaneous studies that have addressed race and outcomes of HCT in the United States

Reference	Data sources	*n*	Population characteristics	Results	Conclusions
Serna *et al.*[37]	IBMTR;[a] 1985–1999	White = 5301, Black = 460, Hispanic = 423, Asian = 259	AML, ALL, CML, allo-HCT, MSD	Compared with Whites, RR for OS was 1.46 (P<0.01) for Hispanics transplanted in 1995–1999; Blacks and Asians had comparable outcomes	Hispanics had worse OS than Whites after allo-MSD in 1995 – 1999; did not account for SES
Baker *et al.*[31]	IBMTR;[a] 1990–2000	White = 2418, Black = 251, Hispanic = 237, Asian = 122	AML, ALL, CML, allo-HCT, MSD	Compared with Whites, RR for OS was 1.23 (P = 0.02) and treatment failure was 1.30 (P<0.01) for Hispanics; Blacks and Asians had comparable outcomes	Higher risks of overall mortality and treatment failure in Hispanics receiving allo-MSD HCT; did not account for SES
Mielcarek *et al.*[35]	Single institution; 1992–2000	White = 2925, Black = 92, Hispanic = 142, Asian = 68, native American = 45, Other = 93	Multiple diagnoses, auto- HCT (n = 1366), allo-HCT (N = 2221), MSD and MUD	No difference in OS by race in auto-HCT recipients; Among allo-HCT recipients, compared with Whites, HR for OS was 1.71 (P<0.05), TRM 1.74 (P<0.05) and relapse mortality 2.03 (P<0.05) for Blacks	No association of race and outcomes of auto-HCT; Black allo-HCT recipients had higher risks of mortality compared with Whites; effect of race was independent of SES
Saraf *et al.*[45]	Single institution; 1999 – 2004	Black = 38, not Black = 32	MM, auto-HCT	No difference in OS by race	No association of race and outcomes of auto-HCT; did not account for SES
Verma *et al.*[36]	Department of Defense; 1995 – 2006	White = 55, Black = 36	MM, auto-HCT	Compared with Whites, HR for OS was 1.4 (P = 0.41) and PFS 1.3 (P = 0.46) for Blacks	No association of race and outcomes of auto-HCT for MM in an equal access health-care system
Khaled *et al.*[33]	Three institutions from Michigan; 1996 – 2006	Black = 101, matched pair analysis with Whites (n = 37) within one center	MM, auto-HCT	Median OS 50.8 mos, median PFS 15.6 mos for all Blacks;on unadjusted matched pair analysis at one center, median OS for Whites and Blacks was 87.8 and 68.6 mos, respectively (P = 0.05) and median PFS was 38 and 16 mos, respectively (P = 0.02)	Blacks had shorter PFS compared with Whites after auto-HCT for MM; did not account for SES
Baker *et al.*[30]	CIBMTR; 1995 – 2004	White = 5253, Black = 368, Hispanic = 445, Asian/Pacific Islander = 141	AML, ALL, CML, MDS, allo-HCT and MUD	Compared with Whites, RR for OS was 1.47 (<0.01), DFS 1.48 (P<0.01) and TRM 1.56 (P<0.01) for Blacks; Hispanics had comparable OS and DFS, but RR for TRM was 1.30 (P<0.01); race had no impact on relapse risk	Black allo-MUD recipients had worse OS, DFS and higher TRM than whites; effect of race was independent of SES
Hari *et al.*[32]	CIBMTR; 1995 – 2005	White = 1892, Black = 303	MM, auto-HCT	Compared with Whites, RR for OS was 0.94 (P = 0.50), PFS 0.94 (P = 0.39), relapse 0.92 (P = 0.28) and TRM 1.16 (P = 0.51) for Blacks	No association of race and outcomes of auto-HCT for MM; did not account for SES
Ballen *et al.*[27]	CIBMTR; 1995 – 2006	White = 612, Black = 145, Hispanic = 128	AML, ALL, CML, MDS, allo-HCT, single UCB	Compared with Whites, RR for OS was 1.31 (P = 0.02) for Blacks; Hispanics had comparable survival	Blacks had worse OS compared with Whites after single UCB HCT; did not account for SES

Abbreviations: Allo = allogeneic; Auto = autologous; CIBMTR = Center for International Blood and Marrow Transplant Research; DFS = disease free survival; HCT = hematopoietic cell transplantation; HR = hazard ratio; IBMTR = International Bone Marrow Transplant Registry; MDS = myelodysplastic syndrome; MM = multiple myeloma; mos = months; MSD = matched sibling donor; MUD = matched unrelated donor; RR = relative risk; SES = socioeconomic status; UCB = umbilical cord blood.

[a] Now CIBMTR.

Table 3

Some areas for future research related to racial disparities in HCT in the United States

Donor availability
Enhance recruitment and representation of racial minorities in unrelated donor registries.
Race/ethnicity and unrelated donor availability.
Adapt unrelated donor registries to represent changing US population demographics.
Donor issues related to 'mixed race' recipients.
Race/ethnicity and quality of banked umbilical cord blood units.
Reconcile race/ethnicity data with international unrelated donor registries.
Access to HCT
Improve center data collection and reporting practices on recipient race/ethnicity.
Evaluate medical, geographic, social, cultural and financial barriers to access to HCT by race.
Develop and test interventions to address racial disparities in access to HCT.
HCT outcomes
Race/ethnicity and outcomes of umbilical cord blood transplantation.
Investigate causes of racial disparities in outcomes of HCT, including medical, geographic, social, cultural and financial issues.
Evaluate whether ancestry-related inherited biological factors (for example genetic polymorphisms) can partially explain racial disparities in HCT outcomes.
Develop and test interventions to address racial disparities in HCT outcomes.