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Real-world data showing trends and outcomes by race and ethnicity in allogeneic hematopoietic cell transplantation: a report from the Center for International Blood and Marrow Transplant Research

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Abstract

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Data Use Statement

CIBMTR supports accessibility of research in accord with the National Institutes of Health (NIH) Data Sharing Policy and the National Cancer Institute (NCI) Cancer Moonshot Public Access and Data Sharing Policy. The CIBMTR only releases de-identified datasets that comply with all relevant global regulations regarding privacy and confidentiality.

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Background.—Use of human leukocyte antigen (HLA)-mismatched donors could enable more patients with ethnically diverse backgrounds to receive allogeneic hematopoietic cell transplantation (HCT) in the United States. However, real-world trends and outcomes following mismatched donor HCT for diverse patients remain largely undefined.

Objective.—To determine whether mismatched donor platforms have increased access to allogeneic HCT for ethnically diverse patients, particularly through the application of novel graft-versus-host disease (GvHD) prophylaxis regimens, and if outcomes for diverse patients were comparable to those of non-Hispanic White patients.

Design.—Observational cross-sectional study using real-world data from the Center for International Blood and Marrow Transplant Research (CIBMTR) registry. All patients receiving their first allogeneic HCT in the U.S. from 2009–2020 with focus on transplants performed in 2020 were included. Data from patients receiving allogeneic HCT using bone marrow, peripheral blood or cord blood from HLA-matched or mismatched related and unrelated donors was analyzed. Specifically, relative proportions of allogeneic HCT were generated as percent of total for donor type and for patient age, disease indication, GvHD prophylaxis, and race and ethnicity. Causes of death were summarized using frequencies, and the Kaplan-Meier estimator was used for estimating overall survival.

Results.—Compared to matched related donor and matched unrelated donor HCT, more ethnically diverse patients received mismatched unrelated donor, haploidentical donor, and cord blood HCT. Matched unrelated donor remains the most common donor type, but use of haploidentical donors has increased significantly over the last 5 years. Paralleling the increase in haploidentical HCT is the increased use of post-transplant cyclophosphamide (PTCy) as GvHD prophylaxis. Relative to older transplant eras, the most contemporary transplant era associates with the highest survival rates following allogeneic HCT irrespective of patient race and ethnicity. However, disease relapse remains the primary cause of death for both adult and pediatric allogeneic HCT recipients by donor type and across all patient race and ethnicity groups.

Conclusions.—Ethnically diverse patients are undergoing allogeneic HCTs at higher rates largely through the use of alternative donor platforms incorporating PTCy. Maintaining access to potential life-saving allogeneic HCT using alternative donors and novel GvHD prophylaxis strategies and improving HCT outcomes, particularly disease relapse, are urgent clinical needs.

Keywords

Bone marrow transplantation; cord blood; death; ethnicity; graft versus host disease; haploidentical; hematopoietic cell transplantation; infection; related donor; unrelated donor; peripheral blood; race; relapse; survival

Introduction

Allogeneic hematopoietic cell transplantation (HCT) is the definitive cure for many malignant and non-malignant hematologic diseases. Yet the patient journey to allogeneic HCT can be difficult, particularly for ethnically diverse (ED) patients, who can experience several patient-, physician- and healthcare system-related barriers to HCT¹. A human leukocyte antigen (HLA)-matched sibling donor (MSD) currently remains the preferred

donor type and yields the best allogeneic HCT outcomes among all donor types², but is available only for approximately 13–51% of patients³. Therefore, the majority of patients requiring allogeneic HCT receive a graft from an alternative donor source, most commonly from a matched unrelated donor (MUD)^{4,5}. However, unrelated donor (URD) availability is not universal especially for diverse patients, as the likelihood of finding a MUD is largely determined by racial and ethnic representation in donor registries⁶. Furthermore, as the United States (U.S.) is becoming more racially and ethnically diverse⁷, finding a MUD for a patient in need will likely become more challenging.

To expand the options for all patients who could benefit from allogeneic HCT, alternative donor types have been used, including cord blood (CB), haploidentical donor, and mismatched unrelated donor (MMUD). Success of these alternative donor platforms requires crossing the HLA barrier, as donor-recipient HLA disparity underlies graft-versus-host disease (GvHD) and graft failure, significant causes of transplant-related morbidity and mortality⁸. Historically, combination methotrexate and calcineurin inhibitors have been used as GvHD prophylaxis for MUD bone marrow (BM) and peripheral blood (PB) HCT. Post-transplant cyclophosphamide (PTCy) has been used successfully as GvHD prophylaxis in the haploidentical transplant setting⁹ and has recently been applied for other allogeneic donor HCT platforms, including MSD, MUD and MMUD¹⁰.

The Center for International Blood and Marrow Transplant Research (CIBMTR) has been collecting detailed demographic and transplant-specific clinical and outcome data for HCT and other cellular therapies for 50 years. Since 2005, the CIBMTR has held a federal contract to deliver an annual transplant center-specific one-year survival report. Thus, reporting all allogeneic HCT in the US to CIBMTR is mandated by Human Research and Services Administration (HRSA) as part of the C.W. Bill Young Cell Transplantation Program. As a result, the CIBMTR is uniquely positioned to study trends in allogeneic HCT activity, including use of alternative donors, types of GvHD prophylaxis, and patient outcomes. The CIBMTR produces a comprehensive set of summary slides each year showing allogeneic HCT trends and outcomes⁵. In this publication, our focus is restricted to allogeneic HCT recipients in the U.S. to determine if the use of alternative donor platforms increased access to allogeneic HCT for ethnically diverse patients, particularly through the application of novel GvHD prophylaxis regimens, and if outcomes among diverse patients were comparable to those of non-Hispanic White (NHW) patients.

Methods

Center for International Blood and Marrow Transplant Research Cellular Therapy Outcomes Registry

The CIBMTR is a research collaboration between the National Marrow Donor Program and the Medical College of Wisconsin. The CIBMTR has information for more than 625,000 recipients from more than 330 participating centers.

Transplant centers submit data to the CIBMTR using a web-based data collection system, FormsNet. HCT patients have core or “essential” data completed using Transplant Essential Data (TED) forms or detailed disease- and treatment-related data using Comprehensive

Report Forms. Patient assignment to specific data tracks is done upon submission of the initial pre-HCT TED form using a weighted randomization algorithm. The algorithm is designed to produce a representative cohort of current practice with adequate numbers of patients with rare conditions undergoing HCT or receiving emerging HCT strategies.

Data are collected at pre-HCT and 100 days, 6 months, 1 year, annually for the subsequent 6 years post-HCT, and then biannually. Details including data collection forms, forms instruction manual, data quality and audit guide, and data management guide as well as the CIBMTR Manual of Operations are available online at <https://www.cibmtr.org>.

The current publication is based on the 2020 transplant activity representing all first allogeneic HCTs registered with the CIBMTR in the U.S.⁵ Prior years are included to analyze trends.

Statistics

Patient-, disease-, and transplant-related factors describe all patients with counts and percent of total for categorical variables. The Kaplan-Meier estimator was used for estimating the overall survival with 95% confidence intervals, and estimations of survival and comparisons across survival curves were not adjusted for potentially important contributing factors. Cause of death was summarized using frequencies.

Results

Trends in allogeneic hematopoietic cell transplantation

Annual numbers of transplant recipients in the U.S. were compiled according to the number of first transplants registered with the CIBMTR (Table 1). In 2020, 8,326 allogeneic hematopoietic cell transplants (HCT) were reported, down from 8,740 in 2019 (4.7% decrease) (Supplemental Figure 1). Over the last decade, relative proportions of patients by race and ethnicity receiving allogeneic HCT have remained fairly constant with the exception being decreases in the proportions of Non-Hispanic White (NHW) patients, while absolute numbers of ethnically diverse patients receiving allogeneic HCT have increased (Figure 1, panel A). In 2010, 75% (n=4914) NHW, 13% (n=852) Hispanic, and 8% (n=524) non-Hispanic Black or African American patients received allogeneic HCT. In 2020, 69% (n=5432) NHW, 15% (n=1169) Hispanic, and 9% (n=740) non-Hispanic Black or African American patients received allogeneic HCT.

In 2020, the most frequent disease indications for allogeneic HCT were acute myeloid leukemia (AML, n=3,216), ALL (n=1,299), and myelodysplastic syndrome (MDS, n=1,170) (Table 1). Relative proportions of diverse patients across these disease indications were similar with the exception of ALL, which had the largest proportion of Hispanic recipients (31%). Notably, aplastic anemia (13%) and non-malignant disease (30%) had higher proportions of non-Hispanic Black or African Americans (B/AA) relative to AML (7%), ALL (7%), and MDS (5%) (Figure 1, panel B).

Donor types and graft-versus-host disease prophylaxis

Since 2000, use of MUD has steadily increased, while use of MRD has decreased (Figure 1, panel C). In 2020, MUD and MRD represented 43% and 22% of donor types, respectively. Use of haploidentical donors has increased, representing 6% of donor types in 2013 to 24% of donor types in 2020. MMUD has remained nearly constant for the last decade. In contrast, CB has decreased during this time frame.

MUD remains the most common donor type irrespective of recipient age and has increased in relative proportion with advancing recipient age (Supplemental Figure 2). Notably, recipients aged ≥ 65 y are second only to recipients aged 40–64y as the most frequent age group receiving allogeneic HCT (10,281 and 22,939 transplants, respectively). Pediatric recipients represent 18% (7,623) of total allogeneic HCT (50,123) in the last 6 years. CB donors are most commonly used in pediatrics (age $<$ 18y), and haploidentical donors are similarly represented across age groups.

Use of alternative donor types (haploidentical, MMUD, CB) may provide greater opportunity for ethnically diverse patients to receive allogeneic HCT. Therefore, we determined how donor types used in allogeneic HCT differed by race and ethnicity (R&E) and how donor type trends changed across two transplant periods, 2009–2014 and 2015–2020 (Figure 2). Overall, NHW patients received the most allogeneic HCT irrespective of donor type and across both transplant periods. For HLA-matched donors, more diverse groups received allogeneic HCT using a MRD than a MUD, which was consistent across both transplant periods (Figure 2). Alternative donor types associated with the highest relative proportions of diverse patients receiving allogeneic HCT. Specifically, both haploidentical donor and MMUD HCT had greater proportions of diverse patients than MUD HCT (Figure 2). CB also had a high proportion of diverse groups (Figure 2). While relative proportions of NHW and ethnically diverse patients receiving CB remained nearly constant between transplant periods, proportions of NHW patients receiving haploidentical and MMUD transplants decreased (57% to 52% and 67% to 69%, respectively). In contrast to NHW patients, relative proportions of Hispanic patients receiving haploidentical and MMUD transplants increased (13% to 19% and 15% to 18%, respectively) between transplant periods.

Given the use of alternative donor platforms, we sought to define trends in GvHD prophylaxis (Figure 3). Overall, CNI-based GvHD prophylaxis was used primarily in the HLA-matched donor setting (Figure 3, panel A), whereas post-transplant cyclophosphamide (PTCy) was used primarily in the HLA-mismatched donor setting (Figure 3, panel B). As graft source differs by recipient age (BM in pediatrics and PB in adults) (Supplemental Figure 3, panels A and B, respectively), we also wanted to determine if recipient age influenced the choice of GvHD prophylaxes. Despite age-related differences in allograft types, calcineurin inhibitor (CNI)-based GvHD prophylaxis predominated in the HLA-matched setting for both pediatric and adult allogeneic HCT (Supplemental Figure 4, panels A-D). For pediatric patients, *ex vivo* graft manipulation was used more in the MUD than MRD settings, but overall much less than CNI-based GvHD prophylaxis in either setting (Supplemental Figure 4, panels A and C). For adult recipients, use of PTCy increased in the HLA-matched donor settings (Supplemental Figure 4, panel E). While CNI-based GvHD

prophylaxis in haploidentical HCT dramatically decreased, use of PTCy increased nearly to exclusivity by 2020 (Supplemental Figure 4, panel E). Use of PTCy also increased for MMUD HCT from 8% in 2015 to 55% of MMUD transplants in 2020 (Supplemental Figure 4, panel F).

Lastly, with a notable decline in the number of allogeneic HCT performed in 2020, we wanted to determine if frequencies of graft types and GvHD prophylaxis also differed from those in previous years (2009–2019) (Table 1). Specifically, less BM (17% vs. 22%) and more PB (78% vs. 69%) were used as allografts in 2020 than in the previous decade, respectively. Also, less CN1-based (56% vs. 79%) and more PTCy-based (39% vs. 14%) GvHD prophylaxes were used in 2020 than in the previous decade, respectively.

Trends in survival and causes of death after allogeneic HCT

We next examined trends in survival probability by transplant era, race and ethnicity, and age. For the most frequent disease indications for allogeneic HCT (ALL, AML, and MDS), trends in survival were highest during the most recent contemporary transplant era (2016–2019) (Figure 4). Favorable survival rates for patients with hematologic malignancies associating with the most contemporary transplant era was noted for all race and ethnic patient groups (Supplemental Figures 5, 6 and 7) and in both pediatric and adult patients (data not shown).

Having observed similar survival probability among R&E groups, we also wanted to compare trends in reported causes of death (COD) by age and donor type across patient R&E groups (Supplemental Table 1). Primary disease was the most common COD following allogeneic HCT for adults and pediatrics across all patient groups. In pediatrics, organ failure was the second most frequent reported COD after allogeneic HCT. In contrast to adults, pediatric allogeneic HCT recipients had lower trends in GvHD as a reported COD. Comparing trends in COD by donor types, primary disease was again the most frequent reported COD across all patient R&E groups and donor types (Supplemental Table 1). Among patient R&E groups, GvHD was generally reported more frequently as COD following MUD and MMUD HCT versus MRD and haploidentical donor HCT. General trends for reported COD were similar across R&E groups with one notable exception being a higher reported frequency of GvHD as a COD for Black/African American patients following MUD HCT.

Discussion

Analyzing real-world data in allogeneic HCT in the CIBMTR registry provides an accurate assessment of practice trends in allogeneic HCT in the U.S. Five key findings resulted from our analyses. First, in 2020, total numbers of allogeneic HCTs decreased for the first time since 2000⁵. Specifically, ~5% less allogeneic HCTs were performed in 2020 relative to 2019, likely reflecting the first full year of Coronavirus Disease 2019 (COVID-19), which was declared a pandemic by the World Health Organization (WHO) on March 11, 2020¹¹. COVID-19 caused many transplant centers to defer all but the most urgent procedures and impeded unrelated donor confirmatory typing and clearance as well as product acquisition and transport¹². Secondary impacts of the pandemic including staff and supply shortages

still remain¹³. Immunotherapy, including cellular therapy like chimeric antigen receptor (CAR) T-cells, may also have contributed to the decrease in allogeneic HCT for malignant diseases like diffuse large B-cell lymphoma¹⁴ and precursor B-cell acute lymphoblastic leukemia (ALL)¹⁵. The decrease in allogeneic HCT in 2020 was also associated with increased frequencies of PB allografts and PTCy-based GvHD prophylaxis relative to the previous decade (2009–2019), likely reflecting mandates for using cryopreservation early in the pandemic¹⁶. Compared to 2020, numbers of allogeneic HCT have risen by 2% in 2021 (8498) but remain lower than in 2019 (8740) and 2018 (8678). Second, use of haploidentical donors and post-transplant cyclophosphamide (PTCy) as GvHD prophylaxis have increased in frequency over the last decade. While the use of PTCy has increased with all donor types, its use is most marked in the HLA-mismatched setting. Third, although allogeneic HCT has been performed in more NHW patients, relative proportions of ethnically diverse patients receiving haploidentical and MMUD have increased over the last decade. Fourth, CB also associates with diverse patient backgrounds similar to haploidentical and MMUD, but its use as a graft source relative to bone marrow and peripheral blood has decreased over the last decade. Fifth, patients in all R&E groups experienced increases in survival in the more contemporary transplant eras, and primary disease was the main cause of death by age and donor type. Together, these data suggest that more ethnically diverse patients are able to receive allogeneic HCT largely due to the use of alternative donor platforms and PTCy as GvHD prophylaxis. While not shown in this manuscript, the annual center-specific analysis shows race and ethnicity are not significant factors associated with survival when survival is adjusted for all appropriate variables, including donor type and GvHD prophylaxis^{17–19}.

Allogeneic transplant indications including ALL, aplastic anemia and non-malignant disorders like hemoglobinopathies differentially affect patients based upon their R&E, suggesting a persistent unmet need in that allogeneic HCT should be offered more to patients with diverse backgrounds²⁰. Haploidentical, MMUD and UCB have been used for similar relative proportions of diverse patients, which are higher in and all associated with greater R&E diversity than MUD. Novel GvHD prophylaxis strategies like PTCy and abatacept have successfully been used in the HLA-mismatched setting, enabling more diverse patients to receive allogeneic HCT. In the NMDP-sponsored 15-MMUD phase II study (NCT02793544) incorporating PTCy in combination with sirolimus and mycophenolate mofetil (MMF) as GvHD prophylaxis and MMUD BM, 48% of total enrolled patients were ED¹⁰. In the City of Hope experience using MMUD PBSC and combination PTCy, MMF and tacrolimus as GvHD as GvHD prophylaxis (NCT03128359), 61% of total enrolled patients were ethnically diverse²¹. Lastly, in a post-hoc analysis of the phase II trial Abatacept 2 (ABA2, NCT01743131) incorporating abatacept in combination with calcineurin inhibitor and MMF²², 30.2% patients receiving this combination as GvHD prophylaxis were diverse patients²³. Together, these studies suggest that more ethnically diverse patients with hematologic malignancies can receive transplants if HLA mismatch donors are used.

Historical data shows that patients receiving HLA-mismatch donor types have inferior survival to those using HLA-matched donors⁸. However, whether patients receiving HLA-mismatched HCT using novel GvHD prophylaxis achieve similar post-transplant outcomes as patients receiving HLA-matched HCT remains to be determined. As no randomized

control trials have been performed in this setting. Furthermore, study results suggest that access barriers beyond securing an available donor continue to impede ethnically diverse patients from receiving allogeneic HCT within the U.S.²⁴ and internationally²⁵. Therefore, a holistic approach is needed not only incorporating patient support services including education, counseling and financial assistance, but also addressing fundamental issues like poverty and racial inequity by key stakeholders across the HCT ecosystem such as transplant centers, payors, industry and federal institutions²⁶.

Access barriers based upon R&E may result in outcome disparities by not enabling such patients to achieve best outcomes by receiving standard-of-care therapy for high-risk malignant disease. In addition, R&E could impact outcomes by influencing care received post-HCT. In a previous CIBMTR study, Baker et al. found that Blacks receiving myeloablative MUD HCT for ALL, AML, MDS and chronic myeloid leukemia had worse OS, disease free survival (DFS), and higher transplant-related mortality (TRM) than Whites²⁷. In the MUD HCT setting, worse survival associating with race may reflect not only underlying HLA biology²⁸, but also social determinants of health that may have biologic ramifications²⁹. Likewise, biology of underlying malignant disease also contributes to post-transplant survival. AML in Black/African American (B/AA) adult and pediatric patients is associated with high-risk cytogenetic profiles and subsequent poor survival^{30,31}. Therefore, B/AA patients with newly diagnosed AML may require faster donor identification and referral to transplant centers in order to improve and achieve best survival outcomes³².

The study has several limitations, largely reflecting its data being from a retrospective, observational registry. First, CIBMTR only collects data on those patients who receive HCT so the denominator of patients requiring but not receiving HCT cannot be addressed. In addition, R&E and minimal other social determinants of health were reported by transplant centers and may not accurately reflect persons of mixed race, given mixed races were grouped as “other” rather than defined by patient self-reporting. Second, the data are presented as trends. Notwithstanding, findings from this real-world evidence, observational database provide the foundation to investigate further the influence of R&E on post-transplant outcomes and use of alternative donor platforms to provide allogeneic transplant to more ethnically diverse patients in need.

In summary, these results show that ethnically diverse patients are receiving higher numbers of allogeneic HCT largely through the use of alternative donor platforms incorporating PTCy. Improving HCT outcomes using alternative donors and novel GvHD prophylaxis strategies is an urgent need for the field.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Conflicts of Interest

Dr. Jeffery Auletta reports Employee, National Marrow Donor Program and Advisory Committee for AscellaHealth.

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Relationships: Non-profit leadership: Board of Directors, National Marrow Donor Program. Spouse - Non-profit leadership: Secretary/Treasurer, Society for Investigative Dermatology Proprietary Interests: Spouse - Patents: Immunotherapy for Merkel Cell Carcinoma.

Dr. Marcelo Pasquini reports compensation from Bristol Myers Squibb for consulting.

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Dr. Marcie Riches reports: Compensation: IQVIA Biotech, employee (as of 1/10/22).

Dr. Douglas Rizzo reports: Compensation: I participate in Optum Stem Cell Expert Panel to provide input / information about the center specific survival analysis based on my expertise. Compensation for this effort (~\$1000) is directed to MCW rather than to me personally.

Dr. Bronwen Shaw reports consulting to Orcabio and Mallinckrodt.

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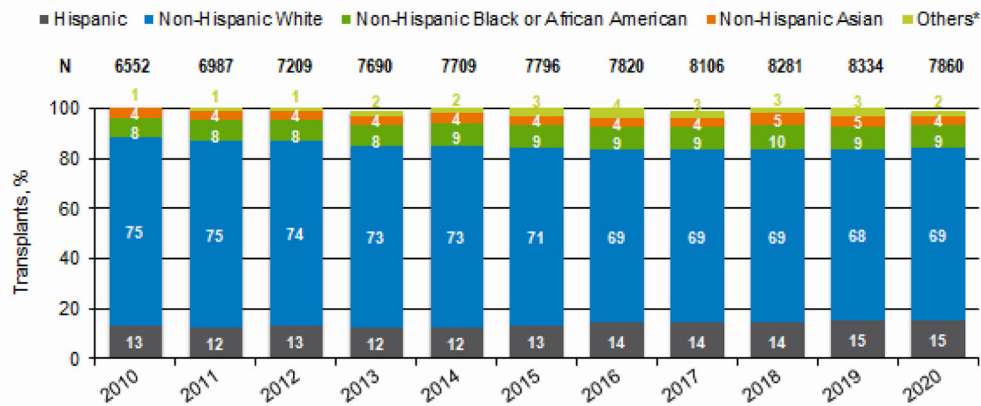
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A

Relative Proportion of Allogeneic HCTs in the US by Race and Ethnicity

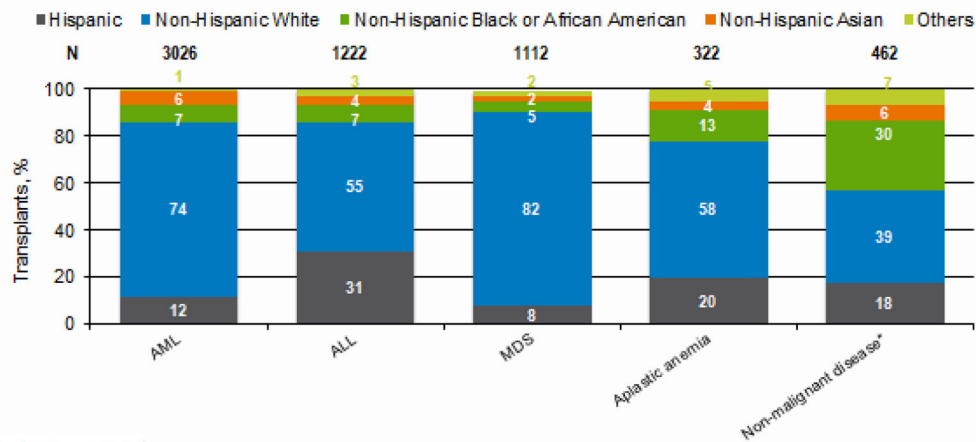


*Includes non-Hispanic Native Hawaiian or other Pacific Islander (n=19), American Indian or Alaska Native (n=32), More than one race (n=51), and Non-resident of the US (n=75) in 2020

2

B

Relative Proportion of Allogeneic HCTs by Indications in the US by Race and Ethnicity, 2020



Abbreviations – AML: Acute myelogenous leukemia; ALL: Acute lymphoblastic leukemia; MDS: Myelodysplastic syndromes
*excludes Aplastic anemia

3

C

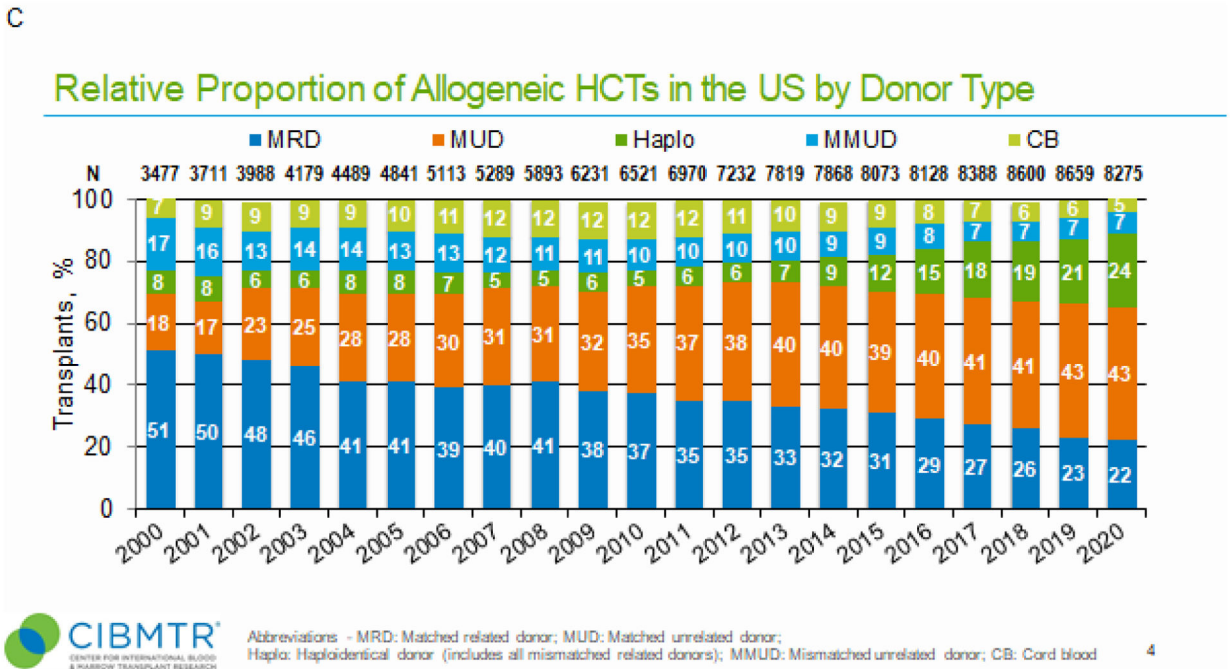


Figure 1. Relative proportion of allogeneic hematopoietic cell transplants (HCTs) in the United States by recipient race and ethnicity, disease indications, and donor types.

Panel A, Relative proportion of allogeneic HCTs in the U.S. by recipient race and ethnicity (2010–2020). For each year, proportions of transplants by indicated race and ethnicity group is shown as percentage of absolute number of transplants performed (N) for that year.

“Other” race and ethnicity group includes non-Hispanic Native Hawaiian or other Pacific Islander, American Indian or Alaska Native, more than one race, and non-resident of the U.S.

Panel B, Relative proportion of allogeneic HCTs by disease indications in the U.S. by race and ethnicity in 2020. For each year, proportions of transplants by indicated disease indication is shown as percentage of absolute number of transplants performed (N) for that year. Non-malignant diseases category excludes aplastic anemia. ALL, acute lymphoblastic leukemia; AML, acute myeloid leukemia; MDS, myelodysplastic syndromes.

Panel C, Relative proportion of allogeneic HCT in the U.S. by donor type (2010–2020). For each year, proportions of transplants by indicated donor type is shown as percentage of absolute number of transplants performed (N) for that year. CB, cord blood; Haplo, haploidentical donor; MMUD, mismatched unrelated donor; MRD, matched related donor; MUD, matched unrelated donor.

Relative Proportion of HCTs in the US by Race and Ethnicity

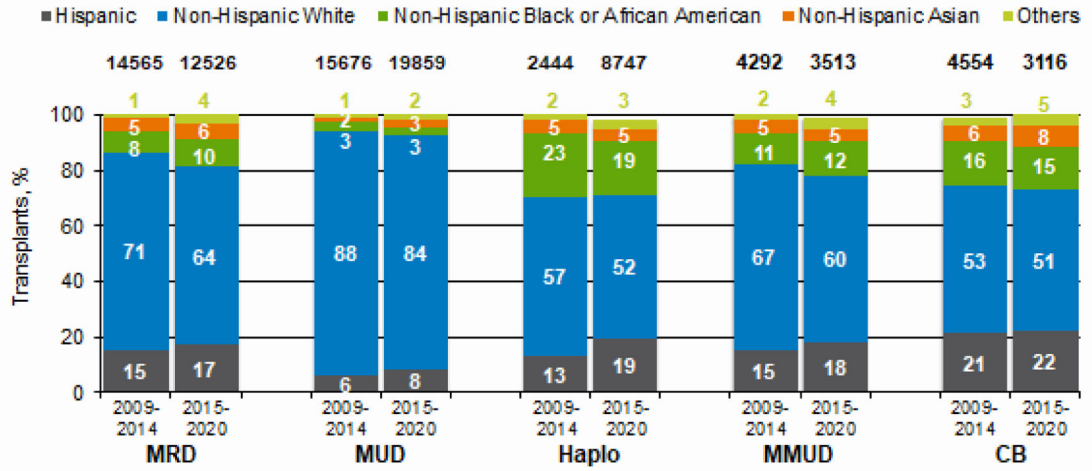


Figure 2. Relative proportion of allogeneic HCTs in the United States by recipient race and ethnicity for two transplant eras, 2009–2014 and 2015–2020.

For each transplant era, proportions of transplants by indicated donor type is shown as percentage of absolute number of transplants performed (N) for that year. “Other” patient race and ethnicity group includes non-Hispanic Native Hawaiian or other Pacific Islander, American Indian or Alaska Native, more than one race, and non-resident of the U.S.

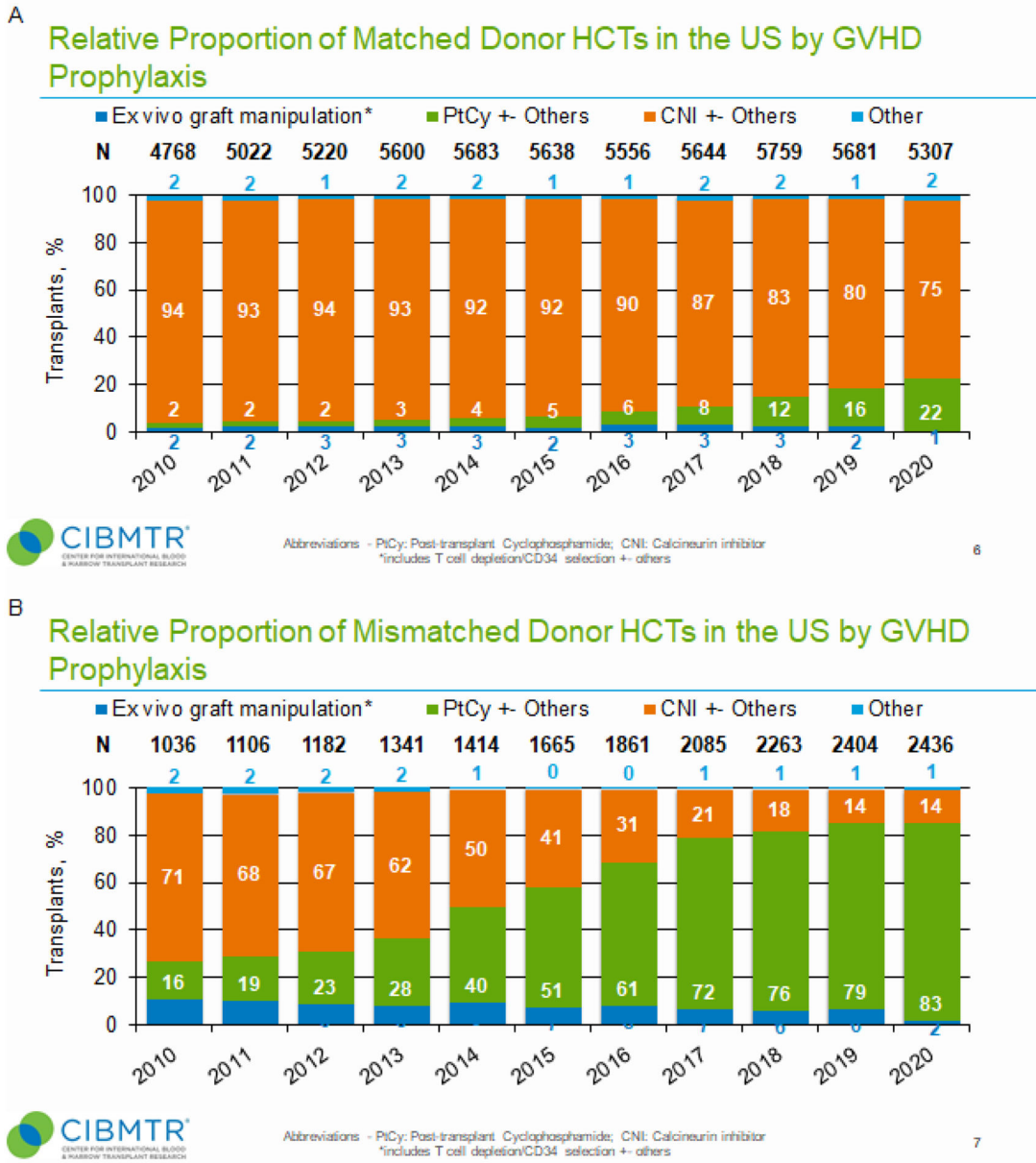
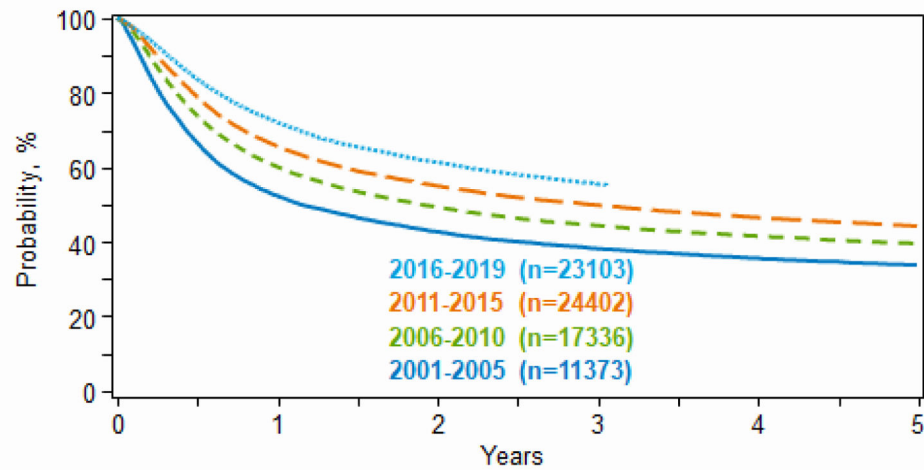


Figure 3. Relative proportion of matched and mismatched donor HCT in the U.S. by graft-versus-host disease (GvHD) prophylaxis (2010–2020).

Panel A, Relative proportion of matched donor HCTs in the U.S. by GvHD prophylaxis. For each year, proportions of transplants by indicated GvHD prophylaxis is shown as percentage of absolute number of transplants performed (N) for that year. **Panel B**, Relative proportion of mismatched donor HCTs in the U.S. by GvHD prophylaxis. *Ex vivo* graft manipulation includes T-cell depletion/CD34 selection as well as other techniques. CNI, calcineurin inhibitor; PTCy, post-transplant cyclophosphamide.

Trends in Survival after Allogeneic HCTs for Acute Myelogenous Leukemia, Myelodysplastic Syndromes and Acute Lymphoblastic Leukemia, in the US, 2001-2019



8

Figure 4. Trends in recipient overall survival after allogeneic HCT for hematologic malignancies by transplant era.

Kaplan-Meier curves combining survival data for AML, ALL and MDS is shown for each indicated transplant era.

Table 1.**Characteristics of Domestic First Allogeneic Transplant Recipients (2009–2020)**

Characteristic	2009–2019	2020
No. of patients	85464	8326
Age in years at HCT - no. (%)		
Median (min-max)	51 (0–100)	54 (0–82)
<10	8273 (10)	657 (8)
10–17	5425 (6)	533 (6)
18–29	8796 (10)	761 (9)
30–39	7578 (9)	750 (9)
40–49	11106 (13)	931 (11)
50–59	19241 (23)	1538 (18)
60–69	20913 (24)	2306 (28)
70+	4132 (5)	850 (10)
Race - no. (%)		
White	69185 (81)	6472 (78)
Black or African-American	7608 (9)	790 (9)
Asian	3668 (4)	356 (4)
Native Hawaiian or other Pacific Islander	266 (0)	23 (0)
American Indian or Alaska Native	430 (1)	43 (1)
More than one race	635 (1)	76 (1)
Not reported	3672 (4)	566 (7)
Ethnicity - no. (%)		
Hispanic or Latino	10814 (13)	1169 (14)
Not Hispanic or Latino	71994 (84)	6749 (81)
Non-resident of the U.S.	843 (1)	75 (1)
Not reported	1813 (2)	333 (4)
Race and Ethnicity - no. (%)		
Hispanic	10814 (13)	1169 (14)
Non-Hispanic White	59408 (70)	5432 (65)
Non-Hispanic Black or African American	7158 (8)	740 (9)
Non-Hispanic Asian	3538 (4)	342 (4)
Non-Hispanic Others	1899 (2)	177 (2)
Not reported	2647 (3)	466 (6)
Donor type - no. (%)		
Matched related donor	26190 (31)	1808 (22)
Matched unrelated donor	33073 (39)	3566 (43)
Haploidentical donor	10122 (12)	1970 (24)
Mismatched unrelated donor	7492 (9)	550 (7)
Cord Blood	7612 (9)	381 (5)
Multiple donor	200 (0)	22 (0)
Twins	343 (0)	14 (0)

Characteristic	2009–2019	2020
Unknown Match Unrelated donor	429 (1)	2 (0)
Not reported	3 (0)	13 (0)
Graft type - no. (%)		
BM	19030 (22)	1454 (17)
PB	58822 (69)	6491 (78)
CB	7612 (9)	381 (5)
Disease group - no. (%)		
AML	31671 (37)	3216 (39)
ALL	12652 (15)	1299 (16)
MDS	10999 (13)	1170 (14)
MPN	3789 (4)	623 (7)
NHL/HL	9974 (12)	709 (9)
Aplastic Anemia	2947 (3)	340 (4)
CML	2569 (3)	250 (3)
Myeloma/PCD	2039 (2)	87 (1)
Other Leukemia	2292 (3)	107 (1)
Other malignancy	125 (0)	4 (0)
Other Non-Malignant Disease	6306 (7)	496 (6)
Not reported	101 (0)	25 (0)
Disease status at time of HCT (AML/ALL) - no. (%)		
CR1	26511 (60)	3105 (69)
CR2+	9630 (22)	928 (21)
Relapse/Never in CR	7161 (16)	369 (8)
Not reported	1021 (2)	113 (2)
N/A, other disease	41141	3811
MDS disease status - no. (%)		
Early disease	2441 (22)	239 (21)
Advanced disease	6351 (58)	784 (67)
Not reported	2207 (20)	147 (12)
N/A, other diseases	74472	7159
GVHD Prophylaxis - no. (%)		
Ex vivo graft manipulation	3414 (4)	111 (1)
PTCy ± others	12326 (14)	3214 (39)
CNI ± others	67453 (79)	4686 (56)
Other	1294 (2)	149 (2)
Not reported	473 (1)	156 (2)
Conditioning regimen for AML/ALL/MDS/MPN - no. (%)		
MAC Bu/Cy ± others	7884 (13)	563 (9)
MAC Bu/Flu ± others	11753 (20)	1276 (20)
MAC TBI ± others	13751 (23)	1154 (18)
MAC others	2690 (5)	227 (4)
RIC/NMA Bu/Flu ± others	5991 (10)	512 (8)

Characteristic	2009–2019	2020
RIC/NMA Flu/Mel ± others	7947 (13)	1119 (18)
RIC/NMA TBI ± others	7918 (13)	1371 (22)
RIC/NMA other	1125 (1)	67 (1)
Not reported	53 (0)	23 (0)
N/A, other diseases	26352	2014

ALL, acute lymphoblastic leukemia; AML, acute myeloid leukemia; BM, bone marrow; Bu, busulfan; CB, cord blood; CLL, chronic lymphocytic leukemia; CML, chronic myeloid leukemia; CNI, calcineurin inhibitor; CR, complete response; Cy, cyclophosphamide; Flu, fludarabine; GVHD, graft-versus-host disease; HCT, hematopoietic cell transplantation; HL, Hodgkin lymphoma; Mel, melphalan; MDS/MPN, myelodysplastic syndrome/myeloproliferative neoplasms; MAC, myeloablative conditioning; N/A, not available; NHL, non-Hodgkin lymphoma; No., number; NMA, non-myeloablative; PB, peripheral blood; PCD, plasma cell disorder; PTCy, post-transplant cyclophosphamide; RIC, reduced intensity conditioning; TBI, total body irradiation.

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