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Costs and Cost-Effectiveness of Hematopoietic Cell Transplantation

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Abstract

Interest is growing in economic and comparative effectiveness analyses, with increasing emphasis on optimizing healthcare resources and costs. Limited information is available on the economic aspects of hematopoietic cell transplantation (HCT). We review contemporary literature on the costs and cost-effectiveness of HCT in the United States and worldwide. Published studies confirm the high costs associated with HCT, although the reported costs are highly variable, related to the differing methodologies used across studies. We examine the challenges in reviewing costs and cost-effectiveness across studies specific to HCTand highlight factors identified as associated with higher costs of HCT. We also discuss opportunities for future research in this area.

Keywords

Autologous; Allogeneic; Economic analysis; Cost-identification analysis; Cost-utility analysis

INTRODUCTION

Hematopoietic cell transplantation (HCT) is the preferred therapy for many patients with high-risk hematopoietic disease. Annually, approximately 55,000 HCTs are performed worldwide, including 20,000 in the United States [1]. This number is expected to increase

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SUPPLEMENTARY DATA

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with continuing improvements in transplantation technology and supportive care practices and the emergence of new indications and alternative graft sources [2,3].

HCT is a highly specialized, resource-intense, and costly medical procedure, A 2009 Agency for Healthcare Research and Quality report using data from the Healthcare Cost and Utilization Project noted that despite being a relatively uncommon procedure, HCT was among the top 10 procedures with the greatest increase in hospital costs. Between 2004 and 2007, HCT-associated hospital costs increased by 85%, from $694 million to $1.3 billion, related to increases in both costs and the number of hospitalizations [4]. HCT-associated costs will become an increasingly important consideration with more widespread application of this treatment. In this article, we review the available literature on the costs and cost-effectiveness of HCT to summarize what is known about these costs, identify the drivers of these costs, highlight limitations of the literature, and describe opportunities for further research in this area.

ECONOMIC ANALYSIS IN HEALTHCARE: A PRIMER FOR TRANSPLANTATION PROVIDERS

In a society with finite health care resources, it is important to understand the costs and benefits of medical interventions to evaluate whether they provide good value [5,6]. There are various ways to analyze costs, including cost identification, cost-effectiveness, cost-utility, and cost-benefit analyses (Table 1). The method used depends on the purpose of the research and the data available [7–16].

Various issues must be considered when reviewing economic studies of HCT. Waters et al. [13] reviewed and provided a structure for reviewing cost and cost-effectiveness studies related to HCT.

Types of Direct Medical Costs Evaluated

Direct costs consist of the value of goods, services, and resources consumed in the delivery of a medical treatment and can include costs of drugs, supplies, radiologic investigations, laboratory services, and health care personnel [17]. Studies of HCT costs differ in the types of direct costs they include. Examples of direct cost categories that have been variably included are costs of pretransplantation patient testing, costs related to donor search and graft procurement, costs of outpatient prescription drugs and home care services, and costs of physician services.

Inclusion of Direct Nonmedical and Indirect Costs

These costs generally include patient-related direct nonmedical costs (eg, out-of-pocket costs, expenses related to transportation and lodging) and indirect costs related to the loss of patient and caregiver productivity (ie, current and future wages) [17,18]. These costs can be difficult to capture and are defined inconsistently across studies [17].

Perspective of Economic Analysis

The specific question addressed by an economic analysis can determine which costs are included. For example, inclusion of indirect costs is relevant for analyses performed from a societal or patient perspective, but might not be as important when studying the economic impact of an intervention from a payor’s or hospital’s perspective.

Time Frame

There can be substantial variation in the time horizons considered both before and after transplantation. This can lead to differences in the costs reported for the same procedure. For instance, unlike studies that follow patients through only day-100 posttransplantation, studies that follow patients for a longer period can include costs related to chronic graft-versus-host disease (GVHD).

Patient Mix and Practice Patterns

The availability of local resources, characteristics of patients undergoing HCT, and the practice styles of individual transplantation centers and medical providers can have an impact on transplantation costs. The majority of economic analyses in HCT are single-center studies, and the reported costs reflect that center's patient mix, practice patterns, and transplantation protocols.

Methods of Estimating and Metrics Used to Describe Costs

Studies vary in the methods used to obtain cost information, and a variety of metrics may be used to describe costs of HCT. Examples of methods of obtaining costs include using information from databases, the hospital accounting system, and review of patient medical records.

International Differences

Reimbursement mechanisms vary by country. Some countries have a single governmental payor, whereas others, including the United States, have multiple payors, which can include a mix of governmental and private payors.

METHODS

We searched the literature for English language articles on HCT costs and cost-effectiveness using the MEDLINE (PubMed) database. We limited our search to articles published between January 2000 and July 2011 to obtain a more contemporary perspective of costs for this procedure. The search terms for costs included "comparative effective," "economic analysis," "economic evaluation," "cost-minimization," "cost-effective," "cost," "cost-benefit," and "cost-utility." The search terms for HCT included "allogeneic bone marrow transplant," "autologous bone marrow transplant," "unrelated bone marrow transplant," "hematopoietic stem cell transplant," "hematopoietic cell transplant," "peripheral blood stem cell transplant," "stem cell transplant," "PBSCT," "HSCT," "HCT," and "cord blood transplant." Bibliographies of source articles were hand-searched for additional relevant references. Studies that described economic evaluation of HCT and included patients diagnosed with cancer or other diseases commonly treatable by HCT (excluding breast cancer) were included in our review. A total of 205 abstracts were identified. Screening of titles and abstracts identified 30 articles that provided information on costs and cost-effectiveness. On further review, 10 of these articles were excluded because they were narrative reviews, did not describe costs, consisted of more than one publication using the same data, or described rare indications for HCT (ie, multiple sclerosis and thalassemia). The 20 original articles that provided information on HCT costs and cost-effectiveness are described. Detailed descriptions of these 20 articles are available in an online supplement.

HCT COST IDENTIFICATION STUDIES

Costs of HCT

Cost identification studies from the United States (US) and from international centers are summarized in Tables 2 and 3. Almost all of the US studies are single-institution studies (Table 2). The majority underestimate the total costs of HCT, because they do not include data on costs outside of the transplant center (eg, outpatient medications, home infusions), donor search and graft procurement, and physician charges. Furthermore, because of the differences in types of costs included and time horizons considered, the costs of HCT in the US vary considerably, and a generalizable nationally representative estimate of the costs of allogeneic or autologous HCT cannot be derived.

Among recipients of allogeneic HCT, costs vary by donor source and conditioning regimen intensity, ranging from $80,499 to $137,564 in more contemporary studies. Majhail et al. [19] reported median costs of $83,583 for related donor HCT and $137,564 for umbilical cord blood (UCB) HCT through 100 days posttransplantation. They also reported a median cost of $137,112 for myeloablative conditioning HCT and $84,824 for reduced-intensity conditioning (RIC) HCT [19]. Saito et al. [20] found a similar pattern when examining costs over 1 year posttransplantation, reporting median 1-year costs of $128,253 for myeloablative HCT and $80,499 for RIC HCT. In a later study evaluating allogeneic HCT with related and unrelated donors, Saito et al. [21] found higher costs associated with unrelated donor HCT compared with related donor HCT.

Autologous HCT is generally less costly than allogeneic HCT. Lee et al. [22] reported a mean cost of autologous transplantation from admission until discharge of $55,500, just slightly more than half that of allogeneic HCT ($105,300). Using data from the Nationwide Inpatient Sample, Jones et al. [23] found a mean cost of $51,312 for hospitalization for autologous HCT.

International cost studies are described in Table 3. More of the international studies included multiple institutions compared with the US studies, although the international studies generally included a smaller number of patients. Some studies had findings similar to those reported in the US studies; for example, in a single-institution study from Sweden, Svahn et al. [24] found lower costs for HCT with related donor transplantations compared with HCT with unrelated donor transplantations (€129,133 versus €160,658). Some international studies reported contrasting findings to the US studies. Examining costs over a 12-month period in France, Cordonnier et al. [25] found that myeloablative transplantations cost less than RIC transplants (€74,900 versus €78,700), although the difference was not statistically significant. In a single-institution study in Thailand, Ngamkiatphaisan et al. [26] found lower costs for allogeneic HCT compared with autologous HCT over 1-year posttransplantation. Economic evaluations of HCT are difficult to compare between countries because of differences in health care systems, transplantation cover-age, and payment policies.

Factors Associated with High Costs

Even given the differences in US and international studies, similar factors were found to be associated with increased costs across studies. The most common drivers of total costs were costs related to hospitalization, treatment of complications, and transplantation for more advanced disease.

Costs related to hospitalization generally were the major cost contributors across the studies, and costs associated with the initial hospitalization for HCT were identified as the main driver of total costs in the first 100 days posttransplantation [21,22]. In general, costs of

HCT within the first 100 days were closely associated with the length of hospital stay. Although many types of costs are incurred during hospitalization, medical staff costs, room and board, pharmacy, laboratory services, radiology, blood bank, and blood products were identified as the major cost contributors [19,21,22,27,28].

Posttransplantation complications are a major contributor to HCT costs and tend to be associated with the duration of hospitalization as well. Saito et al. [21] found that costs rise by an average of $20,228 per complication. Jones et al. [23] reported that hospitalizations without complications were the least expensive and cost less than the average HCT regardless of the patient's diagnosis. Studies have suggested that decreasing the risk of severe complications could reduce overall costs.

Disease status also plays a role in driving up the cost of HCT. Saito et al. [21] reported higher costs in patients with advanced disease compared with those with less advanced disease. Most of the articles also noted that costs were a reflection of the patient mix in the individual transplantation centers.

The majority of cost-identification studies to date have focused on early costs of HCT. The economic impacts of long-term care and chronic GVHD are not clear.

COST-EFFECTIVENESS OF HCT

Few studies reported to date have examined the cost-effectiveness of HCT (Table 4). Findings in the available studies are not consistent, given the variations in comparison of treatment methods across studies. For example, researchers have compared transplantation and no transplantation [27], RIC and conventional myeloablative conditioning [12], and conventional chemotherapy and autologous chemotherapy with peripheral blood stem cell (PBSC) support [29]. In a systematic review and decision model analysis, Costa et al. [30] compared unrelated bone marrow (BM) or PBSC HCT, UCB HCT, and no transplantation in adult patients with acute leukemia who were not expected to be cured with chemotherapy. Compared with no transplantation, the estimated incremental cost-effectiveness ratio (ICER) was $16,346 for BM/PBSC HCT and $34,360 for UCB HCT. The authors concluded that although initial transplantation costs and treatment-related mortality rates were high, there were long-term health benefits compared with not undergoing transplantation. The ICER rates were acceptable (<$50,000). These results suggest that if an unrelated donor is needed, BM/PBSC should be the first option, but UCB is an acceptable cost-effective alternative if a BM/PBSC donor is not available. They also suggest that because UCB transplantation is relatively new, future improvements and progression on the learning curve might improve its cost-effectiveness [30].

Comparing PBSC and BM HCT in pediatric patients with acute myelogenous leukemia or acute lymphoblastic leukemia, Lin et al. [6] found that the cost-effectiveness of treatment differed based on the patient's disease status. For example, in standard-risk disease, BM transplantation was associated with greater effectiveness and lower costs compared with PBSC transplantation. Further uncertainty analysis suggested that BM transplantation was more cost-effective in this group of patients. However, in the high-risk group, BM transplantation was more expensive and more effective than PBSC transplantation. On further uncertainty analysis, the authors were unable to demonstrate a clear advantage of one donor source over another.

Similar to the cost identification studies, drivers of costs in cost-effectiveness studies included hospital costs, disease risk, and complications.

AREAS FOR FUTURE RESEARCH

Many economic aspects of autologous and allogeneic HCT need further evaluation. The costs of transplantation need to be better described. The current perspective costs relies on single-institution studies. Multicenter studies or studies using databases that capture costs from multiple institutions will provide a better understanding of the costs of HCT. Such studies can help identify and address specific questions related to these costs, for example, geographic variation in costs and center practices and characteristics (eg, pediatric versus adult centers) that may affect costs. Research following this foundational work could focus on investigating and identifying practices at specific centers that are cost-effective and then translating these practices to other centers to decrease the costs of HCT without compromising patient outcomes.

As HCT outcomes improve and transplantation center capacity increases, there is a greater need for long-term follow-up of survivors and a better understanding of the costs associated with the long-term care of HCT survivors. A long-term perspective is important for some newer transplantation modalities as well. For example, UCB HCT may be associated with higher up front costs secondary to the costs of graft acquisition and graft failure, but the incidence of chronic GVHD is lower in UCB HCT compared with matched unrelated donor HCT, and thus the overall costs of UCB HCT may be lower in the long run. In addition, research examining the costs of up front HCT versus treatment for relapsed disease is required (eg, multiple myeloma).

More research is needed to better understand the costs of HCT to caregivers and patients. Including patient-related nonmedical and indirect costs (eg, temporary housing costs, transportation costs, lost productivity) prospectively in studies may increase the understanding of the true cost of HCT from patient and societal perspectives. This is particularly relevant as centers look at outpatient HCT as a way to decrease the costs of HCT. In this setting, there is the potential for the transfer of some costs to patients and their caregivers (eg, transportation, outpatient visit, prescription co-pays).

More cost-effectiveness studies that take into account transplantation risks and mortality are needed. Cost-utility analyses that consider patients' quality of life will aid in evaluating the comparative effectiveness of various transplantation modalities (eg, myeloablative versus RIC, UCB versus PBSCs/BM) and transplantation versus no transplantation (eg, allogeneic HCT versus chemotherapy only). Depending on the economic question addressed in these studies, investigators would ideally consider a long-term perspective that takes into account risks and quality-of-life impairments related to chronic GVHD. More emphasis also should be placed in including economic endpoints in future multicenter phase III studies related to HCT.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Methods of Analyzing Healthcare Costs

Method	Characteristics
Cost identification or cost-minimization analysis	• Compares costs of 2 or more interventions with the assumption that their outcomes are similar
Cost-effectiveness analysis	• Compares net costs of 2 or more interventions in monetary units with their effectiveness (e.g., survival) • ICER is calculated (ratio of difference in costs versus difference in effectiveness) • Less costly and more effective intervention preferred over more costly and less or equally effective therapy
Cost-utility analysis	• A type of cost-effectiveness analysis that incorporates quality-of-life considerations in the outcomes • Results are expressed as cost per quality-adjusted life-year gained • Survival time is adjusted using “patient utilities” (ranging from 0 for death to 1 for full health)
Cost-benefit analysis	• Assigns a dollar value to clinical benefit and estimates net financial impact of an intervention • Not commonly performed in medicine, given the challenges in assigning monetary value to health or a disease state

Table 2

Summary of Cost-Identification Studies of HCT in the United States Published after 2000

Reference	Data Source	Population Characteristics	Costs	Conclusions/Remarks
Lee et al. [22]	Single institution, 1994-1997 Time horizon: hospital admission for conditioning until discharge	n = 236 (auto, allo: MRD, URD) Inpatient only; adult patients	Median costs: Auto: $55,500 Allo: $105,300	Overall costs were significantly higher for allo-HCT than for auto-HCT. Higher costs were driven by occurrence of major complications. Use of mismatched donors among allo-HCT recipients was a significant pre-HCT predictor of costs.
Saito et al. [20]	Single institution, 2000-2003 Time horizon: graft infusion through 1 year post-HCT	n = 275 (allo: MA, RIC) Inpatient and outpatient; adult patients	Median costs: Allo-MA: $128,253 Allo-RIC: $80,499	For 1 year after allo-HCT, RIC HCT was less expensive than MA HCT with comparable clinical outcomes. Costs were significantly higher for unrelated donor HCT than for related donor HCT. HCT was more costly for patients with advanced disease than for those with less advanced disease.
Saito et al. [21]	Single institution, 2000-2004 Time horizon: admission to 1 year post-HCT	n = 315 (allo: MRD, MUD) Inpatient only; adult patients	Median total cost over first year: $128,800	Room, pharmacy, and blood bank costs were the largest contributors to total costs in first 100 days post-HCT. Pretransplantation predictors of higher costs included the use of unrelated donors and advanced disease status. Both before and after HCT, complications were associated with higher costs.
Majhail et al. [19]	Single institution, 2004-2006 Time horizon: from 30 days before until 100 days after HCT	n = 294 (MA: MRD, UCB; RIC: MRD, UCB) Inpatient and outpatient; adult patients	Median costs: MA: $137,112 RIC: $84,824 UCB: $137,564 MRD: $83,583	Room and board and pharmacy services were the major contributors to total costs. UCB HCT was more expensive than MRD HCT, and MA HCT was more expensive than RIC HCT. Costs for both UCB HCT and MRD HCT were driven primarily by severe posttransplantation complications and prolonged inpatient stay.
Majhail et al. [28]	Single institution, 2004-2006 Time horizon: from 30 days before until 100 days after HCT	n = 146 (allo: MRD, MUD, UCB) Inpatient and outpatient; pediatric patients	Mean cost per day survived: MRD: $3,446 MUD: $4,050 UCB: $4,522	Costs of MUD HCT and UCB HCT were similar; MRD HCT was less costly. Room and board and pharmacy services were major contributors to total costs. Costs were driven primarily by post-HCT complications.
Jones et al. [23]	Secondary database analysis (HCUP NIS), 2000-2001 Time horizon: admission to discharge for single HCT hospitalization	n = 8,891 (auto) Inpatient only; adult patients	Mean costs: $51,312	Complications were associated with increased hospital costs. Use of total body irradiation was associated with longer hospital stay and higher hospital costs.

Allo indicates allogeneic; auto, autologous; HCUP NIS, Healthcare Cost and Utilization Project Nationwide Inpatient Sample; MA, myeloablative; MRD, matched related donor; MUD, matched unrelated donor.

Table 3

Summary of Cost Identification Studies of HCT from Countries Other Than the United States Published after 2000

Reference	Data Source	Population Characteristics	Costs	Conclusions/Remarks
Ngamkiatphaisan et al. [26]	Thailand; single institution; 1994-2005 Time horizon: 1 year post-HCT	n = 67 (allo: PBSC, BM; auto: PBSC) Inpatient and outpatient; pediatric and adult patients	Total costs of HCT: Auto: €24,171 Allo: €22,593	Drug costs were the major cost driver for allo-HCT. Routine service costs (labor, material, capital costs, and indirect costs) were cost drivers of auto-HCT.
Svahn et al. [24]	Sweden; single institution; 1998-1999 Time horizon: day of admission through 5 years after HCT	n = 93 (allo: MRD, MUD, mismatched UD) Inpatient and outpatient; pediatric and adult patients	Median total costs: MRD: $129,133 MUD: €160,658	Total costs were higher in patients with acute leukemia than in those with all other diagnoses. Costs were highest during the first year post-HCT. Total costs were similar for MUD HCT and MRD HCT over the 5-year period; cost drivers included hospitalization and complications.
Mishra et al. [31]	Norway; single institution; 1999-2000 Time horizon: pre-HCT phase through 1 year post-HCT	n = 17 (allo: MRD, MUC, PBSC, BM) Inpatient only; adult patients	Median total costs: $69,270	In the transplantation phase, mean personnel costs represented 54% of the total costs. A correlation was found between length of stay and hospital cost.
Espérou et al. [32]	France; 19 centers; 1998-2000 Time horizon: through 24 months post-HCT	n = 85 (allo: MRD PBSC, BM) Inpatient and outpatient; pediatric and adult patients	Mean total costs: €76,237	The major cost driver was total hospital days. Among complications, predictors of costs were GVHD and more than 2 documented infections (added costs of $20,000-$30,000).
Cordonnier et al. [25]	France; 2 centers; 1998-2003 Time horizon: first day of hospitalization before conditioning regimen, through 12 months post-HCT or death	n = 23 (allo-MRD: MA, RIC) Inpatient and outpatient; adult patients	Mean total costs: MRD-MA: €74,900 MRD-RIC: $78,700	The major cost driver was length of stay. Mean 1-year total costs did not differ significantly between the 2 groups. Total costs not different during the first 6 months but were significantly higher in the RIC group during the last 6 months.
Faucher et al. [33]	France; 3 centers; 2001-2005 Randomized trial of early discharge versus standard hospital-based follow-up Time horizon: day of PBSC harvest until day-60 post-HCT	n = 131 (auto-PBSC HCT: early discharge; standard inpatient) Inpatient and outpatient; adult patients	Mean total cost: Early discharge: $9,777 Standard inpatient: €10,436	Majore cost drivers for both arms were hospitalization and medications. Early discharge led to 20% decrease in post-auto-HCT hospitalization costs.
van Agthoven et al. [34]	The Netherlands; 6-center randomized phase III trial; 1994-1998 Time horizon: start of first chemotherapy course to 3 months after hospital discharge	n = 91 (auto: BM, PBSC) Inpatient and outpatient; adult patients	Mean total cost of transplantation phase: Auto-BM: $19,000 Auto-PBSC: €15,008	Auto-PBSC HCT was less costly than auto BM HCT. Hospital days were the main component of total HCT costs. The major costs during follow-up were blood components and hospital stay.
van Agthoven et al. [35]	The Netherlands; 4 centers; 1994-1999 Time horizon: from patient screening up to 2 years after HCT	n =97 (allo: MRD-BM, MRD-PBSC, MUD-BM, or PBSC) Inpatient and outpatient; pediatric and adult patients	Average costs: MRD BM: $98,334 MRD PBSC: €98,977 MUD: $151,754	The major cost components were hospitalization and personnel. For MUD HCT, nearly one-third of total costs were related to donor search.

Allo indicates allogeneic; auto, autologous; MA, myeloablative; MRD, matched related donor; MUD, matched unrelated donor; URD, unrelated donor.

Table 4

Summary of Cost-Effectiveness Analyses of HCT Published after 2000

Reference	Data Source	Population Characteristics	ICER	Conclusions
Lin et al. [6]	United States; single institution; 2001-2006 Time horizon: initial hospitalization to 1-year	n = 140 (costs for 76) (allo-MUD: PBSC, BM) Pediatric patients	ICER for standard-risk subgroup: $687,108 (favoring BM) ICER for high-risk subgroup: $1.69 million (no clear benefit for either graft source)	For patients with standard-risk disease, BM was associated with lower costs and greater effectiveness compared with PBSC. For patients with high-risk disease, no clear benefit was seen for either donor source.
Kouroukis et al. [36]	Canada; single institution; 1998-2000 Time horizon: initial therapy to not specified	n = 52 (auto: melphalan and prednisone) Adult patients	ICER for base case: $18,974 ICER for drug acquisition and clinic costs of additional treatment with pamidronate: $25,710 (favoring HCT)	Cost per life-year gained with HCT compares positively with other interventions. The highest HCT costs were related to hospitalization, chemotherapy, intensive care unit admission, and use of granulocyte-colony stimulating factor.
Yu et al. [11]	Taiwan; single institution; 1994-2002 Time horizon: admission through “whole treatment period” (cure or mortality)	n = 106 (HiDAC-based therapy, allo, auto; intensive therapy) Adult patients	Mean cost per life-year saved: HiDAC: $11,224 Allo: $21,564	HiDAC is more cost-effective than allo-HCT in patients with acute myelogenous leukemia with either intermediate or unknown cytogenetic risk. Allo-HCT was associated with higher costs than HiDAC or auto-HCT. Age, cytogenetic risk, and intensive therapy were associated with higher overall survival
Costa et al. [30]	International; multiple centers; articles published between 2000 and 2005 Time horizon: transplantation, first-year, and total 10-year cumulative costs	n = 4,056 (allo: UCB, BM/PBSC) Adult patients	ICER (compared with no HCT): BM/PBSC: $16,346 UCB: $34,360	Most costs were incurred early in the course of HCT. BM/PBSC sources should be the first option for unrelated donors if clinically indicated, but UCB is a reasonable, cost-effective substitute.
Imataki et al. [12]	Japan; single institution; 2000-2002 Time horizon: admission until discharge, up to 2 years after HCT	n = 50 (allo-RIC, allo-MA) Adult patients	ICER (MA compared with RIC): $469/year	Hospitalization represented the largest proportion of costs. Total hospitalization was longer in MA compared with RIC. MA and RIC were comparable in terms of cost and mean survival.
Fagnoni et al. [29]	Phase III multicenter GOELAMS 072 study; 1994-1999 Time horizon: costs followed from first course of chemotherapy until last CHOP course or PBSC hospitalization discharge	n = 197 (conventional chemotherapy [CHOP]; auto-PBSC) Pediatric and adult patients	ICER: €79,111 with auto-PBSC. ICER for patients with high-intermediate risk according to age-adjusted IPI: €34,315 with auto-PBSC	Auto-PBSC might be considered cost-effective in patients with NHL classified as high-to-intermediate risk according to age-adjusted IPI. Long-term effectiveness data were not included. No indirect costs were included. No quality-of-life information was included.

Allo indicates allogeneic HCT; auto, autologous HCT; HiDAC, High-dose arabinoside; IPI, International Prognostic Index; MA, myeloablative; MRD, matched related donor; MUD, matched unrelated donor; Non-medical costs include patient time and productivity costs.