VALUE IN HEALTH ▮ (2018) ▮▮▮–▮▮▮

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jval

On the Value of the Umbilical Cord Blood Supply

Aaron Strong, PhD[*], *Tadeja Gračner, PhD*, *Peggy Chen, MD*, *Kandice Kapinos, PhD*

RAND Corporation, Arlington, VA, USA

ABSTRACT

Background: Several public cord blood banks are struggling financially, and the question remains as to whether additional allocations of funds to them are justified. **Objectives:** To estimate the social benefits of public cord blood bank inventory net of cord blood banks' operational costs. **Methods:** We used publicly available data from the Health Resources and Service Administration on the number of annual cord blood transplants as well as the patient age distribution in 2010, and the survival estimates between 2008 and 2012 for the several diseases treated by cord blood transplantation. Data on aggregate annual costs to the cord blood industry for recruitment, processing, and storage were obtained from published work. We used estimated increases in life expectancy due to treatment using umbilical cord blood and value for life-years gained to estimate the social benefits of the public cord blood inventory annually. **Results:** We found that the annual social benefits of between $500 million and $1.5 billion outweigh the current operational annual costs of running cord blood banks of $60 to $70 million by a significant margin. **Conclusions:** We estimated that the annual social benefit of having a cord blood system far outweighs its costs, by more than an order of magnitude. Thus, the social benefits of maintaining the US public cord blood banking system at the present time far outweigh the costs of collecting, storing, and distributing cord blood. This suggests that there is a potential justification for government intervention to align social benefits and costs. Nevertheless, simple fixes may produce unintended consequences, and so a careful design for subsidies is needed.

Keywords: banking, umbilical cord blood, value.

Introduction

Cord blood is one source of hematopoietic stem cells (HSCs), which is used to treat several life-threatening illnesses, including leukemia or lymphoma, disorders of the blood and immune systems, severe aplastic anemia, sickle cell disease, and certain inherited metabolic diseases [1–3]. Cord blood offers advantages over the other HSC sources—bone marrow and peripheral blood—because it requires less stringent human leukocyte antigen matching, making it a source for many patients who cannot otherwise find a match. Evidence suggests that health outcomes from these less precisely matched cord blood cells are just as good as those from matched bone marrow grafts [4]. Cord blood is, therefore, particularly useful in cases in which an exact match cannot be obtained from other sources—a situation that tends to occur more frequently in the United States for certain minority populations [1]. The market for cord blood is unique in many ways that create challenges for public cord blood banks. In particular, cord blood is collected from unpaid donors, processed, and banked in advance of any specific patient actually needing it. This contrasts with bone marrow and peripheral blood, which are not banked but harvested from the donor for use by a specific recipient. Clinically, cord blood takes longer to engraft than other sources, resulting in longer inpatient hospital stays for patients, but the evidence suggests that longer term health outcomes may be better for cord blood transplant patients relative to other sources [5–7].

The federal government has supported the public cord blood banking system dating back to at least the passage of the Stem Cell Therapeutic and Research Act of 2005, which provided the initial funding for the "collection and maintenance of 150,000 new units of high-quality cord blood to be made available for transplantation through the C.W. Bill Young Cell Transplantation Program."[1] The act was re-authorized in 2010 and 2015. The main goal of the act was to increase the availability of stem cells for any individual in case of need. In conjunction with this goal, government funds have also been allocated to increase the genetic diversity of the National Cord Blood Inventory (NCBI) or, in other words, to increase the probability that anyone who needs a unit will find a high-quality, useable match [8]. The probability of finding a high-quality match is significantly lower for certain racial and ethnic minorities. As noted earlier, a "less precise" match is required for cord blood relative to other HSC sources, but this relationship between human leukocyte antigen matching and patient outcomes is nonlinear and affected by the total nucleated cell (TNC) count—a usual proxy for cell quality—of the cord blood unit. Although an exact match is ideal, patient

An earlier version of this research was conducted under contract number HHSP233201500038I.

[*]*Address correspondence to:* Aaron Strong, RAND Corporation, 1200 South Hayes Street, Arlington, VA 20222.

E-mail: astrong@rand.org

[1]H.R. 2520 (109th): Stem Cell Therapeutic and Research Act of 2005, Sec. 2, Paragraph 1.

1098-3015$36.00 – see front matter

https://doi.org/10.1016/j.jval.2018.03.003

outcomes are statistically similar with one or two mismatched antigens *if* the cord blood unit has a sufficiently large TNC count [9]. Although the original estimated target for the national inventory to contain at least 150,000 units was based on "provid[ing] appropriate matches to 80 to 90 percent of patients seeking cord blood stem cell transplants,"[2] it is assumed that 93% of adults needing a transplant could find a match with no more than two antigen mismatches [10]. A more recent study finds that 81% to 96% of adults (older than 20 years) can find an adequately sized cord blood unit from the national inventory, but this falls to 23% to 66% if only one antigen mismatch is allowed [11]. Minority patients are significantly less likely to find cord blood units with one or zero mismatches and fall at the lower ends of these ranges. Pediatric patients have a 95% chance (or more depending on race or ethnicity) of finding a match with no more than two antigen mismatches [11]. Currently, the United States has more than 200,000 cord blood units available for transplant, but a recent study of the public cord blood industry suggests that the useable inventory—those units that are large enough in TNC count to be used successfully—is much smaller [12]. Thus, continued increases in the public inventory, particularly of higher TNC count units, are still needed.

About 90% of worldwide public cord blood banks have stated that they are struggling financially [13]. A US Government Accountability Office report found that financial sustainability is a problem for US-based cord blood banks as well [1]. Thus, in light of the current size of the useable national inventory in the United States and the financial challenges facing public cord blood banks, continued federal support of the industry may be necessary. We know little about the societal benefits of the system, which can be compared with the operational costs of the system and the extent to which the system improves access to HSC treatment for those who have no other options. As dicussions of restructuring the current reimbursement process through the NCBI and the National Marrow Donor Program (NMDP) administered by the Health Resources and Service Administration (HRSA) have been raised in light of these trends [12], we aim to provide some context on the public financial support of cord blood banking by estimating the annual use value of the US cord blood supply comparing this with annual estimates of industry costs for collection, processing, and storage. This study is not a cost-benefit analysis, because costs could be from the vantage point of the public banks or from the federal government; instead, we calculate the current net present value of annual benefits derived from patients who receive cord blood transplants. We used publicly available data from HRSA for our calculations and assumptions on benefits from earlier studies as delineated herein.

Methods

Data

We relied on publicly available data from HRSA to obtain the number of annual cord blood transplants[3] as well as the patient age distribution in 2010.[4] According to these data, there were 855 cord blood transplants in 2010.[5] Although this number of transplants has declined slightly over time [13], we used 2010 data to match with our survival estimates, which spanned from 2008 to 2012.[6] The publicly available survival estimates used are from 2008 to 2012 for the following diseases treated by cord blood transplantation: acute lymphoblastic leukemia, acute myelogenous leukemia, chronic myelogenous leukemia, myelodysplastic disorders, and severe aplastic anemia. Estimates of survival rates by other diseases treated by cord blood transplantation were unavailable because of small sample sizes.

Approach

First, we estimated the number of cord blood transplants for each disease category for pediatric and adult patients using 2010 data. For example, there were approximately 61 cord blood transplants for patients with acute lymphoblastic leukemia (ALL) in their first remission in 2010. Among all allogeneic cord blood transplant patients in 2010, 50% were 20 years or younger, and so we estimated that there were 30.5 pediatric patients with ALL in their first remission who received a cord blood transplant.

Next, building on earlier studies [10,12], we estimated the additional life-years gained from cord blood transplantation using HRSA survival data. To do this, we first transformed the disease-specific survival rates to expected additional life-years gained from cord blood transplant for pediatric and adult recipients separately. Using 100-day, 1-year, and 3-year disease-specific survival rates paired to the estimated number of cord blood transplants per year, we calculated the number of adult and pediatric patients in four mutually exclusive survival categories: those surviving 1) less than 100 days, 2) between 100 days and 1 year, 3) between 1 and 3 years, and 4) 3 or more years. For example, the 100-day, 1-year, and 3-year survival rates for patients with ALL in their first remission were 86.3%, 64.9%, and 55.6%, respectively. Of the estimated 30.5 pediatric patients with ALL in their first remission, we estimated that about 4 would survive less than 100 days ($30.5 \times [1 - 0.863]$), less than 6.5 would survive between 100 days and 1 year ($30.5 \times [0.863 - 0.649]$), 3 would survive from 1 to 3 years ($30.5 \times [0.649 - 0.556]$), and almost 17 would survive 3 or more years (30.5×0.556). For diseases without 3-year survival rates, we used the average 3-year survival rate.

For the first year after transplant, we assumed that patients in category 1 (surviving <100 days) gained 0 additional life-years; those in category 2 gained 0.5 a year, on average. We assumed that those in category 3 gained 2 life-years on average. For those surviving 3 or more years (category 4), we allowed for a range of additional total life-years gained from 50 to 90 additional life-years for pediatric patients and 25 to 50 additional life-years for adult patients. Howard et al. [10] assumed that pediatric and adult patients who survived 5 years would live an additional 68 and 25 years, respectively. We therefore highlight those values herein.

For each life-year gained, we assigned the value of a statistical life-year at $100,000, which is a common assumption used across many health care studies in the United States [14–16]. We then assumed a discount rate of 3% to calculate the net present value of the future life-years gained.

Results

In Table 1, we present the number of cord blood transplants and survival rates by disease categories. The average 100-day, 1-year, and 3-year survival rates weighted by the number of patients in each disease category were 80.3%, 54.9%, and 42.4%, respectively. About 58% of cord blood transplant patients had leukemia and

[2]H.R. 596 (109th) Cord Blood Stem Cell Act of 2005, Sec. 2, Paragraph 4.

[3]https://bloodcell.transplant.hrsa.gov/research/transplant_data/transplant_activity_report/bydiseasecategorycellsource.pdf.

[4]https://bloodcell.transplant.hrsa.gov/research/transplant_data/transplant_activity_report/byagecellsource.pdf.

[5]Although HRSA registry data report 1153 cord blood transplants in 2010 (https://bloodcell.transplant.hrsa.gov/research/transplant_data/registry_tx_data/longdesc/index.html), we use the lower value of 855 as reported in the survival data for consistency. We also note that the registry data report 853 cord blood transplants in 2016.

[6]https://bloodcell.transplant.hrsa.gov/research/transplant_data/us_tx_data/survival_data/survival.aspx.