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A costing study of blood and marrow transplantation services in NSW: final report

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Executive Summary

This is the final report of a study undertaken by the Centre for Health Service Development (CHSD), University of Wollongong. The study was commissioned by the NSW Department of Health to provide a costing of blood and marrow transplantation services in NSW. Blood and Marrow Transplantation (BMT) is a high cost and relatively low volume specialty service. The scope of this study encompassed both inpatient and related outpatient BMT services. The aim was to develop an understanding of cost structures associated with BMT services.

Blood and marrow transplantation is used to treat a range of diseases including haematological (blood) diseases such as leukaemia, lymphoma and multiple myeloma, as well as some immune disorders and, occasionally solid tumours. There are two main types of stem cell transplants autologous (where the patient is their own cell donor) and allogeneic (where stem cells are donated by another person). Allogeneic transplants are considered to be more complex, higher risk and consume most resources.

Currently, fifteen hospitals deliver BMT services across NSW and there are eight specialty BMT laboratories. Data collection was restricted to hospitals that operate 'clinical costing' systems and could therefore produce 'episode level' cost data for BMT patients. This resulted in the inclusion of data from eight hospitals: Sydney Children's Hospital, Children's Hospital Westmead, St Vincent's Hospital, Royal North Shore Hospital, Westmead Hospital, Nepean Hospital, Prince of Wales Hospital and St George Hospital. Data from these eight hospitals formed what is referred to during the remainder of this report as the 'study dataset'.

We have compared the volume of activity in the study dataset with activity data reported by the NSW Department of Health in its annual hospital cost data collection. This shows that for adults, the study dataset represents approximately 90.1% of allogeneic and 58.1% of autologous BMT transplant episodes undertaken annually in NSW. For paediatric services, it represents 96% of allogeneic transplants and 97% of autologous transplants undertaken annually in NSW. On this basis, we are confident that the study is representative of BMT services across the State.

The primary questions addressed in this study, as identified in the project brief are as follows:

- What is the average per patient cost of autologous and allogeneic BMT?
- What is the breakdown of costs for each of these, in terms of the inpatient and ambulatory phase of treatment?
- Are there available costings from other States in Australia with which to compare, and if significantly different, why?
- What proportion of BMT costs do pharmaceuticals represent?
- What, if any, difference is there between costs for adult patients and paediatric BMT?
- What are the financial implications of the projected increase in BMT activity in NSW by 2011?

This study has developed a set of cost results in relation to each of the above questions. A range of associated cost results are included to provide a more detailed breakdown of various BMT cost structures. The results are presented in the context of the NSW health system and the current funding arrangements that operate within that context.

This report is structured to reflect the activities undertaken during the study.

Section 1 provides an overview of the project deliverables and context for the development of this costing study.

Section 2 provides a summary of the consultation process that has informed the study. Over fifty consultation sessions occurred with predominantly clinical and costing personnel. There were several purposes to this consultation process, including to: understand the clinical process of BMT; inform the decisions about start and end points of the patient journey and identify costing issues of concern to clinicians.

Section 3 provides the results of a targeted literature review undertaken to identify any relevant previous costing studies of BMT services. As was expected, one of the major difficulties in identifying relevant work is the widely varying objectives and methodologies used in previous studies. In particular, many studies examined the cost of particular components of BMT, such as certain types of pharmaceuticals or a particular method of stem cell harvesting. Whilst these results provided useful background information, they often were of limited value in seeking to develop an understanding of the overall cost of BMT services.

Section 4 flowcharts and discusses the 'patient journey' for all types of BMT services; adult and paediatric and autologous and allogeneic. The patient journey follows similar key steps with all autologous transplant patients requiring workup; mobilisation, stem cell harvest and cell processing, transplant (including conditioning) and post transplant management. In addition, allogeneic transplant patients require tissue typing and they are not subject to stem cell harvest – a donor supplies the cells which must be collected and processed. The majority of the BMT patient journey is consumed by the inpatient admission for transplant. Several aspects of clinical practice were identified during the clinical consultation that could not be costed and this is discussed further in the body of the report.

Sections 5 and 6 describe the process for developing the study data collection protocol, corresponding dataset and costing methodology. Data from the eight hospitals previously identified formed the 'study dataset'. Cost estimates were developed for the various care processes involved in the delivery of BMT services including BMT episodes, related inpatient episodes and a range of outpatient BMT services. Several issues emerged during data collections which are discussed in detail in Section 5. A range of preparatory data analysis tasks were undertaken and business rules were developed to govern the inclusion of data in the final study dataset. After the adjustments described in Section 6 were completed the final study dataset consisted of:

- 508 BMT episodes
- 2,258 Related inpatient episodes
- 7,485 Outpatient medical, nursing and allied health clinic occasions of service
- 6,272 Outpatient dispensed drugs
- 435 Other outpatient treatments.

Section 7 presents the study results comprising a set of cost estimates for a range of BMT related services undertaken in NSW. The total cost of BMT services by transplant type and adult and paediatric hospital is shown in the table below. The total annual cost of BMT services (allogeneic and autologous; adult and paediatric; inpatient and outpatient) for the study dataset is $30,882,930. The average cost per BMT in paediatric hospitals is approximately double the average cost per BMT in adult hospitals. The cost per allogeneic BMT is approximately twice as much as the cost per autologous BMT in both adult and paediatric facilities.

Ward costs account for approximately 40% of the inpatient component of transplant episodes for both adult and paediatric transplants. Pharmacy costs are the second highest cost bucket representing approximately 30% in adult hospitals and 25% in paediatric hospitals. Across the adult hospitals in the study dataset, ICU costs contributed 7% of total costs for allogeneic transplant episodes and 11% in paediatric hospitals.

Table 1 below shows the total annual cost of both allogeneic and autologous transplant services for each hospital that participated in the study. Total cost is $30.88 m annually for 134 allogeneic and 153 autologous transplants undertaken across the eight hospitals. Total costs range from $610,020 at St George Hospital which undertakes 11 autologous transplants, to $7.95m at

Westmead Hospital which undertakes an average of 57 allogeneic and 26 autologous transplants annually.

Table 1 Total annual costs of allogeneic and autologous BMT – study dataset

Hospital	Cost Per Allogeneic Transplant	Number of Allogeneic Transplants	Cost Per Autologous Transplant	Number of Autologous Transplants	Total Number of Transplants Per Year	Total Annual Cost
St Vincent's Hospital	$120,510	27	$71,905	23	50	$4,907,576
Westmead Hospital	$117,569	57	$48,263	26	83	$7,956,278
Royal North Shore Hospital	$93,571	17	$67,581	39	56	$4,226,365
Prince of Wales Hospital	$0	0	$69,440	9	9	$624,956
St George Hospital	$0	0	$55,456	11	11	$610,020
Nepean Hospital	$0	0	$63,183	12	12	$758,191
Adult Hospitals	**$114,316**	**101**	**$62,812**	**120**	**221**	**$19,083,386**
Sydney Children's Hospital	$237,407	15	$104,346	16	31	$5,230,632
Children's Hospital Westmead	$218,851	18	$154,681	17	35	$6,568,895
Paediatric Hospitals	**$227,286**	**33**	**$119,367**	**33**	**66**	**$11,799,536**
Total	**$142,137**	**134**	**$75,010**	**153**	**287**	**$30,882,930**

The financial implications of the projected increase in BMT activity in NSW are an increased in Statewide expenditure to $46.49m by 2011 and $53.58m by 2016.

A set of key messages arising from the study follows.

Key Messages

- There are few published costing studies on BMT and those that are available usually include insufficient detail to facilitate comparison between studies.

- It is inherently difficult to cost BMT services because of the issue of determining the point at which BMT treatment commences and treatment of the underlying disease ends. For this study, it was decided to cost a window of services commencing 60 days prior to transplant and ending 365 days post transplant.

- The average (mean) cost of a BMT episode including inpatient and outpatient services in NSW was found to be:
    - adult allogeneic transplant: $114,316
    - adult autologous transplant: $62,812
    - paediatric allogeneic transplant: $227,286
    - paediatric autologous transplant: $119,367

- Costing studies inevitably require a trade-off between what is desirable and what is feasible. This study sought to capture cost data on the major elements of BMT recognising that it was not possible to identify all costs.

- The projected cost of BMT services (all inpatient and outpatient) in NSW will increase from its current level to $46.49m in 2011 and $53.58m in 2016.

- In this study, there were 508 transplant episodes, which we consider to be an appropriate sample size. Of these 60% were autologous and 40% allogeneic. The ratio is consistent with levels of activity reported elsewhere.

- The cost of paediatric BMT services is significantly higher than the cost of adult BMT services. The difference in cost is less for the transplant episode component of the BMT, but is still large enough to support an argument for the AR-DRG classification system to separate adult and paediatric BMT transplant episodes.

- Overall, the higher cost of paediatric services aligns with the views expressed by clinicians during the clinical consultations. In part, this may be a reflection of the higher proportion of unrelated donor transplants and the growing number of cord blood transplants undertaken at these facilities.

- There is considerable variation in the cost of individual episodes within both allogeneic and autologous patients. This is a function of the variation in clinical condition between patients and is reflected in the large difference between the mean and median costs across hospitals.

- For adult hospitals providing unrelated allogeneic transplants (St Vincent's and Westmead), the costs are consistent with a slightly lower cost for Royal North Shore Hospital which undertakes only sibling related allogeneic transplants.

- There is no evidence to suggest that autologous transplants are more or less expensive at hospitals that undertake only autologous transplants regardless of the number of transplants undertaken. This may have implications in a planning context.

- There may be growing demand for transplants due to the widening indications such as non malignant conditions in children; transplant genetics; availability of cord blood and capacity for reduced intensity conditioning to be used with older patients. Greater use of reduced-intensity conditioning regimens, increasing worldwide donor availability and the availability of alternative drug treatments were noted as significant trends likely to lead to increasing use of transplant for a range of indications.

1 Introduction

This is the final report of a study undertaken by the Centre for Health Service Development (CHSD), University of Wollongong. The study was commissioned by the NSW Department of Health to provide a costing of blood and marrow transplantation services in NSW. An interim report was issued in September 2008 and circulated to stakeholders for comment. The major principles set out in the interim report were acceptable to all parties. This report incorporates modifications based on stakeholder feedback and data received from hospitals and provides cost results for BMT services in NSW.

This study was commissioned in recognition of the importance of developing an understanding of current cost structures associated with blood and marrow transplantation (BMT) services. The outputs of this study will be used to inform the "NSW Blood & Marrow Transplantation Service Plan" currently under development by the NSW BMT Service Plan Development Working Group. It is hoped that this will in turn provide valuable information to feed into future policy and planning processes.

The scope of this study encompassed both inpatient and related outpatient BMT services. Currently, fifteen hospitals deliver BMT services across NSW as shown in Table 2 below. The work of these transplant centres is supported by specialty blood and marrow laboratories. There are eight BMT laboratories servicing NSW located at: Royal North Shore Hospital, Royal Prince Alfred Hospital, St Vincent's Hospital, Westmead Hospital, Liverpool Hospital, Newcastle Mater, Prince of Wales Hospital and St George Hospital.

Table 2: Number of BMT transplants in NSW 2007

Adult Allogeneic and Autologous Transplants	**Number of Transplants**
St. Vincent's Hospital (incl. Private)	60
Westmead Hospital	79
Royal North Shore Hospital	42
Royal Prince Alfred Hospital	37
Paediatric Allogeneic and Autologous Transplants	
Sydney Children's Hospital	29
Children's Hospital Westmead	27
Adult Autologous Transplant Services	
Concord Hospital	13
Gosford Hospital	7
Liverpool Hospital	18
Nepean Hospital	12
Newcastle Mater Hospital	12
Prince of Wales Hospital	8
St George Hospital	11
Wollongong Hospital	18
Paediatric Autologous Transplants	
John Hunter Children's*	3
Total	**376**

Source: Australasian BMT Recipient Registry, March 2008.
*John Hunter Children's Hospital manages autologous transplants in collaboration with Newcastle Mater and Sydney Children's Hospital.

1.1 Study objectives

The primary questions addressed in this study, as identified in the project brief are as follows:

- What is the average per patient cost of autologous and allogeneic BMT?
- What is the breakdown of costs for each of these, in terms of the inpatient and ambulatory phase of treatment?
- Are there available costings from other States in Australia with which to compare, and if significantly different, why?
- What proportion of BMT costs do pharmaceuticals represent?
- What, if any, difference is there between costs for adult patients and paediatric BMT?
- What are the financial implications of the projected increase in BMT activity in NSW by 2011?

This study has developed a set of cost results in relation to each of the above questions. A range of associated cost results are included to provide a more detailed breakdown of various BMT cost structures. The results are presented in the context of the NSW health system and the current funding arrangements that operate within that context. In doing so, the study aims to identify the major costs associated with BMT services in NSW.

1.2 Structure of this report

This report is structured to reflect the activities undertaken during the study.

- **Section 2** provides a summary of the consultation process undertaken at the commencement of the study;
- **Section 3** provides summary results of a targeted literature review undertaken to identify any relevant previous costing studies of BMT services. The full results are provided in Appendix 2
- **Section 4** presents an overview of the clinical processes associated with the BMT process developed from a series of consultations conducted with clinicians throughout the project;
- **Sections 5 and 6** describe the process for developing the study data collection protocol, corresponding dataset and costing methodology;
- **Section 7** presents the study results comprising a set of cost estimates for a range of BMT related services undertaken in NSW;
- **Section 8** provides a discussion of the results in the context of implications for the planning and delivery of BMT services in NSW in the future.

1.3 The study dataset

We raise this issue at the outset as it was identified in the early stages of the study and impacted on the subsequent data collection and costing methodology. This issue is outlined in detail in Section 5 and relates to the availability of activity and cost data from the fifteen BMT hospitals.

The models of care and treatment protocols vary to some extent between hospitals. Some key areas of difference include drug regimens, methods of harvesting stem cells and the mixture of services provided on an inpatient versus outpatient basis. As these differences potentially result in variations in cost, it would have been ideal to obtain data from all fifteen BMT hospitals.

However, the information systems required to extract relevant data do not routinely operate at each site. For this reason, it was necessary to restrict the data collection to hospitals that operate 'clinical costing' systems and could therefore produce 'episode level' cost data for BMT patients.

This comprised eight of the fifteen BMT hospitals. These hospitals provided cost data for all transplant and related inpatient episodes for a one, two or three year period between 2004/05 and 2006/07. In most cases, data were available for either two or three years during this time. Similarly, all but one of these hospitals could provide outpatient data for some or all of this period. The one hospital that did not provide outpatient data undertakes only a small number of autologous transplants each year.

Data from these eight hospitals formed what is referred to during the remainder of this report as the 'study dataset'. Details of the number of episodes and outpatient occasions of service are provided in Section 6.6. We have compared the volume of activity in the study dataset with activity data reported by the NSW Department of Health in its annual hospital cost data collection. This shows that the study dataset represents approximately 90.1% of allogeneic and 58.1% of all autologous BMT transplant episodes undertaken annually in NSW. For paediatric services, it represents of 96% of allogeneic transplants and 97% of autologous transplants undertaken annually in NSW. On this basis, we are confident that the study is representative of BMT services across the State.

1.3.1 The NSW and annual cost data collection

We note here that the NSW Department of Health undertakes an annual hospital costing process involving all NSW public hospitals including the fifteen BMT hospitals. The NSW cost study produces cost results at the AR-DRG level. The cost data provided for this BMT study is essentially the same data that was used in the NSW cost study. As such, the results for transplant episodes at the eight hospitals are likely to be similar across the two studies. The key element of our study that is additional to the NSW study is the inclusion of cost estimates for non-transplant related inpatient episodes and outpatient services. Non-transplant inpatient episodes related to BMT cannot be identified in the NSW study as they are assigned to potentially any AR-DRG and cannot be separated from other episodes in that AR-DRG. Outpatient episodes are not in scope for the NSW study.

We utilised the results of the NSW study to obtain costs for the three BMT AR-DRGs from the seven hospitals that do not operate clinical costing systems. We have also included the results of the NSW study for all hospitals in Appendix 5.

1.3.2 The National hospital cost data collection

We also note that the Commonwealth Department of Health and Ageing conducts a national hospital cost data collection (NHCDC). This study involves all States and Territories and produces cost results at the AR-DRG level. Again, for NSW services the AR-DRG level data obtained for this BMT study is essentially the same data submitted by NSW public hospitals to the NHCDC. As such, the results for transplant AR-DRGs at the eight hospitals are likely to be similar between this

study and the NHCDC. The NHCDC results do however allow a comparison of the cost of BMT AR-DRGs in NSW with other States. For this reason, at Appendix 6 we have included a breakdown of the BMT AR-DRGs reported in the NHCDC.

1.4 Costing versus funding – an important distinction

It is important to distinguish between studies that deal with costing issues on the one hand and studies that deal primarily with funding models. Whilst the two are closely related, the terms of reference for this project are explicit in that issues relating to funding are out of scope.

We would note our understanding that Statewide and Selected Specialty Services (such as BMT) receive enhancement funding from the NSW Department of Health. This funding is allocated to the host Area Health Service to be passed on to the Statewide service. There is also an allowance in the Resource Distribution Formula to ensure the host Area's target share of funding reflects the fact that it hosts a Statewide service.

The primary objective of this study was to identify and cost the core services associated with providing BMT services. During the clinical consultation process, a range of issues were raised in relation to costs that are incurred by hospitals providing BMT services. In some cases, it was suggested that current funding arrangements do not adequately reimburse hospitals for providing these services.

To ensure that we have accurately and thoroughly represented the views expressed during the consultations, we have included these issues in our summary of the clinical consultation process in 4 and in the discussion of costing issues in 7.4. We would suggest, however, that many of these issues are more appropriately dealt with in a consideration of the broader funding issues associated with BMT services.

2 Consultations with stakeholders

The starting point for this study is to understand the patient journey for autologous and allogeneic BMT as it applies in practice for both adults and children. This process assists in defining the 'episodes of care' that most accurately represent current clinical practice in blood & marrow transplantation. A series of consultations have occurred with clinicians to ensure CHSD has a comprehensive understanding of this process. These consultations have centred on four key stakeholder groups: clinicians, casemix and costing staff, executive leaders and other agencies with a major interest in BMT. A list of consultations completed to date is provided at Appendix 1.

2.1 Clinical

An important objective of the clinical consultations is to ensure that the costing process accurately reflects the range of clinical processes that are associated with BMT services. Consultations have been undertaken with twenty-eight clinicians including senior medical officers, clinical nurse consultants, hospital scientists and pharmacists. Consultations have also been undertaken with representatives from the three Children's Hospitals in NSW to identify any differences between paediatric and adult BMT. The CHSD team has consulted with personnel from twelve hospitals, (all four facilities delivering adult allogeneic transplants have been consulted).

2.2 Casemix and costing

Obtaining appropriate service utilisation and financial/costing data is a critical input for this project. Consultations with costing staff from nine hospitals have been undertaken. In some cases, these staff have been able to provide data for several hospitals within an Area Health Service. As expected, the consultation process has revealed considerable variation between facilities in terms of their capacity to contribute cost data to the study. This issue is discussed in more detail in Section 5.1 of this report. However, there has been a high degree of consistency across facilities in terms of the various costing processes that are routinely undertaken. This has improved the capacity to combine cost data across facilities to produce overall BMT cost estimates.

2.3 Executive

The proposed approach to the costing study has been outlined to the Director, Clinical Operations from South Eastern Sydney Illawarra, (this Area Health Service has five BMT sites, including adult, paediatric, autologous and allogeneic services) and to the Director, Clinical Services at Sydney Children's Hospital. This has been helpful in providing a broader strategic perspective in relation to BMT services and in advising Statewide Services Development Branch (SSDB) about a potential "validation" process for data obtained from Area Health Services.

2.4 Other agencies

Interviews have occurred with the Executive Officer and the Principal Scientist from the Australian Bone Marrow Donor Registry. This has provided useful insights into the costs associated with the procurement of stem cells both within Australia and internationally. Statewide Services Development Branch (SSDB) has informed the NSW Cancer Institute of the progress of this study. In addition, a preliminary presentation outlining the approach to this costing study was delivered to the NSW BMT Service Plan Development Working Group in late September 2008.

3 Literature review summary

A key question for this study was to determine the availability of cost data for BMT services from other studies which might be compared with the results of this study. To this end, a targeted literature review was undertaken at the outset of the study. The results are provided in Appendix 2. This section provides an overview of methodology and the key findings of the literature review. It identifies various cost drivers and a range of cost estimates found in the Australian and international literature.

As was expected, one of the major difficulties in identifying relevant work is the widely varying objectives and methodologies used in previous studies. In particular, many studies examined the cost of particular components of BMT, such as certain types of pharmaceuticals or a particular method of stem cell harvesting. Whilst these results provide useful background information, they often are of limited value in seeking to develop an understanding of the overall cost of BMT services.

3.1 Defining blood and marrow transplantation

Whilst the acronym BMT is commonly thought to stand for "bone marrow transplant" it actually refers to the term "blood and marrow transplant". Bradstock et al. (2006:7) note that:

> *"BMT is a general term used to cover all types of transplants using haematopoietic stem cells: cord blood transplant (CBT), peripheral blood stem cell transplant (PBSCT), haematopoietic stem cell transplant (HSCT) and bone marrow transplant."*

Blood and marrow transplantation is used to treat a range of diseases including haematological (blood) diseases such as leukaemia, lymphoma and multiple myeloma, as well as some immune disorders and, occasionally solid tumours. There are two main types of stem cell transplants autologous and allogeneic.

> *"In autologous stem cell transplants, the patient is their own stem cell donor. The patient's blood stem cells are collected in advance (while they are in remission) and then returned to them after they receive high-doses of chemotherapy…In allogeneic stem cell transplants the stem cells are donated by another person. Allogeneic transplants are more complex and carry more risks than autologous transplants."* (Daly 2006:15)

In allogeneic transplant, stem cells may be donated by a family member or unrelated donor, including cord blood.

3.2 Introduction

The NSW BMT Service Plan Development Working Group provided the starting point for the literature review. State government officials from the relevant departments in Victoria, Queensland, South Australia and Western Australia were contacted regarding the existence of any documented costing studies in those states. Only two studies were discovered – a very small scale study undertaken in Queensland in 2004, and a study undertaken by the Royal Melbourne Hospital. Permission to include details of the latter study was not granted.

3.3 Search strategy

Relevant papers were identified by searching the electronic databases Medline, EconLit, Science Direct, Cinahl and Cochrane databases using combinations of the search terms transplant$, blood, bone marrow, stem cell, cord, umbilical, cost$ and method, costing, costing method$, costing model$, cost accounting, and case-mix. Key journals such as *Bone Marrow Transplantation*, *Blood*, *Clinical and Laboratory Haematology* as well as *Cancer Treatment Reviews* and the *European Journal of Cancer* were also searched separately to ensure all references were found.

The resulting citations were culled to exclude those that did not focus on either costing or economic evaluation of blood and bone marrow transplantation. Only English language citations were retained. Additional citations were identified by internet searching, reviewing reference lists in recently published work and searching for recent publications by key researchers in the field. A second round of culling was undertaken based on reading the abstract or executive summary of each paper or report. Full text copies of the remaining 34 papers/reports were then reviewed.

3.4 Overview

The literature on costing blood and bone marrow transplants comprises only a small number of studies, with the main work undertaken in the USA and Europe, in particular Scandinavia and the Netherlands. The studies are limited in scope, most are targeted to particular indications and underlying disease, and few provide detailed costing of the stages of transplant.

While about a third of the papers were published in the last 5 years, many refer to research undertaken more than a decade ago. Each of two recent systematic reviews (of the health economics of managing multiple myeloma, and of the comparative costs of high-dose chemotherapy and autologous stem cell transplantation vs. conventional chemotherapy), reported on only five studies examining the cost of BMT services (Moeremans and Annemans 2006, Simnett et al. 2000).

Several economic evaluations of blood and marrow transplantation were found. Whilst economic evaluation was outside the scope of this project the studies were reviewed for details of the costing methodologies employed. In most such studies, the costing methodologies were not fully explained, nor were costing details reported, but they were useful for the purposes of shedding light on the overall magnitude of costs of different BMT service types.

Very little economic analyses of BMT services that take account of recent changes in clinical practice and/or advances in new technology and diagnostics in the past few years, in particular in relation to gene therapy and sources of donor stem cells are available. Thus, in terms of informing the development of costings for BMT service components, most of the literature was of marginal value.

The terminology used to refer to the economic aspects of BMT services differs throughout the literature, at times affecting interpretation. It was important to distinguish, for example, between charges and costs, in particular in regard to studies undertaken in the United States, since studies reporting the hospital charge for BMT services and products, may not necessarily report the actual costs of services.

A major difficulty in costing BMT services is that widely differing assumptions and a variety of different inputs may be used to derive costings. This is particularly the case because there are many different treatment methodologies covering both autologous and allogeneic transplants, a variety of donor stem cells, and an increasing range of indications and clinical practice modalities. Moreover, costs do not remain static and, because of the complexity of treatments and indications, even small changes in protocol can lead to a large difference in cost (Freeman et al 1996). Most studies refer to this matter, in keeping with the general principle that robust cost comparisons can only be made when cost measurement is in reasonable compliance with a standardised costing methodology (Smith and Mogyorosy 2005).

The pace of change in BMT is rapid so that conclusions regarding changes in clinical practice and emerging technologies that may impact on service provision, if based on retrospective studies, may already be out of date with practices and technologies well-established.

In a recent paper that aimed to identify trends in Europe in BMT patient numbers and to anticipate transplant rates for the next 5 years, estimates of activity and expected changes in practice were used to estimate likely costs (Tan et al. 2007). Greater use of reduced-intensity conditioning regimens followed by transplantation (RIC-HSCT) and increasing worldwide donor availability were noted as significant trends likely to lead to increasing use of transplant for a range of indications.

The availability of alternative drug treatments was another key factor expected to influence trends in transplantation. The study predicted an increase in autologous transplantation in Europe of 6% between 2005-2010, with particular reference to the treatment of acute leukaemia and auto-immune diseases. An even greater increase of about 20% in allogeneic transplantation was predicted, with rises in use for all indications except chronic myeloid leukaemia, due mainly to the expected increased use of RIC-HSCT in older patients and in patients with co-morbidities.

Changes in the characteristics of BMT service delivery and consequent changes in costs and shifts in cost distribution are the subject of discussion in a number of papers.

In terms of disaggregated costing data, the most comprehensive analyses found were:

- a 2002 Dutch study of a cost analysis for HLA-identical sibling and voluntary unrelated allogeneic bone marrow and peripheral blood stem cell transplantation in adults with acute myeloid leukaemia (AML) or acute lymphoblastic leukaemia (ALL) (van Agthoven et al. 2002); and
- a 2005 report prepared for the Technology Assessment Unit of the McGill University Health Centre (Canada) on allogeneic transplantation in adults of stem cells from unrelated donors.

A study by Prajogo (2004) reporting the results of a cost comparison of high-dose chemotherapy and autologous bone marrow transplantation vs. standard dose chemotherapy for patients with non-Hodgkin's lymphoma at the Calvary Mater Misericordiae Hospital in Newcastle (NMMH) provided the most relevant Australian analysis.

3.5 Cost drivers

Many of the studies identified factors that have an important impact on costs. The cost drivers depended partly on the type(s) of BMT services being studied, the aim of the study, the country in which the study was undertaken, data availability and the study methodology.

A number of studies noted the fundamental structural differences between the United States and Europe in terms of health service delivery, resulting in different cost drivers for BMT services depending on where studies are conducted.

For studies of autologous BMT, examples of cost drivers include:

- number of hospital days and blood products (for the period from hospital admission to discharge only)
- stem cell mobilisation costs (harvest phase), nursing costs and pharmacy
- room costs, laboratory, pharmacy, medical consultant fees; radiology and supportive care
- conditioning regimens, number of hospital days, blood products, antibiotic and supportive care
- induction chemotherapy (and within this, the number of cycles to achieve remission); post-induction: blood products, inpatient costs (medical staff and accommodation), laboratory/radiology and pharmacy
- number of hospital days, number of stem cells collected, phase and type of disease, whether patient is a child or adult.

For allogeneic transplants, examples of cost drivers include:

- tissue typing and donor stem cell collection costs, medical and nursing staff costs, pharmacy, blood products and laboratory costs
- pharmacy, number of hospital days
- total body irradiation (TBI)
- number of hospital days, medical and nursing staff costs
- GVHD prophylaxis

- number of hospital days, post-transplant complications including infections, veno-occlusive disease, GVHD, death..

3.6 Detailed cost analyses by stage of transplant

A Dutch cost analysis of HLA-identical sibling and voluntary unrelated allogeneic bone marrow and peripheral blood stem cell transplantation in adults with AML or ALL between 1994 and 1999 included costs for patients prepared for, but who did not undergo, transplantation, and covered all stages from pre-transplant tissue typing up to 24 months after transplantation. Costs were separately identified for three transplant types (bone marrow transplant (BMT), matched unrelated donor (MUD) and peripheral blood stem cell transplant (PBSCT)) and allocated either to the pre-transplant phase, transplantation phase, or to one of the three follow-up phases (that is, 1-6 months, 6-12 months and 12-24 months after transplantation). Total costs per living patient were estimated to be approximately $195,600[1] for BMT, $301,900[2] (MUD) and $196,900[3] (PBSCT).

A Canadian comparison of the costs of allogeneic transplantation in 17 adults in 2004, using either cord blood or PBSCT from unrelated donors, included costs for the transplantation procedure and estimates of costs for up to 10 years after transplantation. Based on possible relapses, infections and chronic GVHD, the total cost of an allogeneic stem cell transplantation including a 10-year follow-up (excluding the cost of procurement of stem cells) in an adult patient was estimated at approximately $A65,500[4] and $A69,500[5] for bone marrow and cord blood transplantation respectively**.**

3.7 Previous cost estimates

In 2004, a study at the Royal Brisbane and Women's Hospital estimated the approximate total cost of bone marrow transplants, by transplant type, at that hospital. It should be noted that only two patients were enrolled in each costing type. The study suggested benchmark mean costs of approximately $54,500 for autologous transplants and $130,500 for allogeneic transplants[6].

Prajogo (2004) investigated the costs of high-dose chemotherapy and autologous bone marrow transplantation vs. standard chemotherapy in patients with relapsed non-Hodgkin's lymphoma treated at Newcastle Mater Misericordiae Hospital from January 1995 to June 2002. The study covered the period from induction chemotherapy to conditioning and transplant only. Non-pharmaceuticals comprised the largest overall cost (61%), with the cost of inpatient stay the major factor within the non-pharmaceuticals component (40% of total). The estimated total mean cost per patient of $37,490 (in 2001) was compared with the cost of autologous transplantation in patients with either lymphoma or acute leukaemia ($A70,769), or non-Hodgkin's lymphoma ($A59,500) in the Netherlands. It was suggested that the differences related to factors including use of total body irradiation before transplantation, service utilisation rates and the costs of hospitalisation and blood products in the two countries, the proportion of total costs of pharmaceuticals, and whether the transplant was PBSCT or autologous bone marrow transplantation (ABMT).

1 $A2007 – costs converted from Euro 2002 to A$ and escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au
2 $A2007 – costs converted from Euro 2002 to A$ and escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au
3 $A2007 – costs converted from Euro 2002 to A$ and escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au
4 $A2007 – costs converted from CDN to A$ and escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au
5 $A2007 – costs converted from CDN to A$ and escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au
6 $A2007 – costs escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au

4 An overview of the BMT clinical process

An understanding of the clinical process of BMT was fundamental in undertaking this costing study. Clinicians assisted in flowcharting the patient journey to identify the key stages of the BMT process from the clinical care or service delivery perspective. This section provides an overview of the BMT process identified by clinicians.

An important element of the consultation process was to form a view regarding start and end points of the BMT process for the costing process. A consistent view was expressed that BMT physicians and other staff are involved in treating patient's at several stages before and after transplantation. At the same time, however, views on the detail of this involvement differed between clinicians as well as between adult and paediatric services.

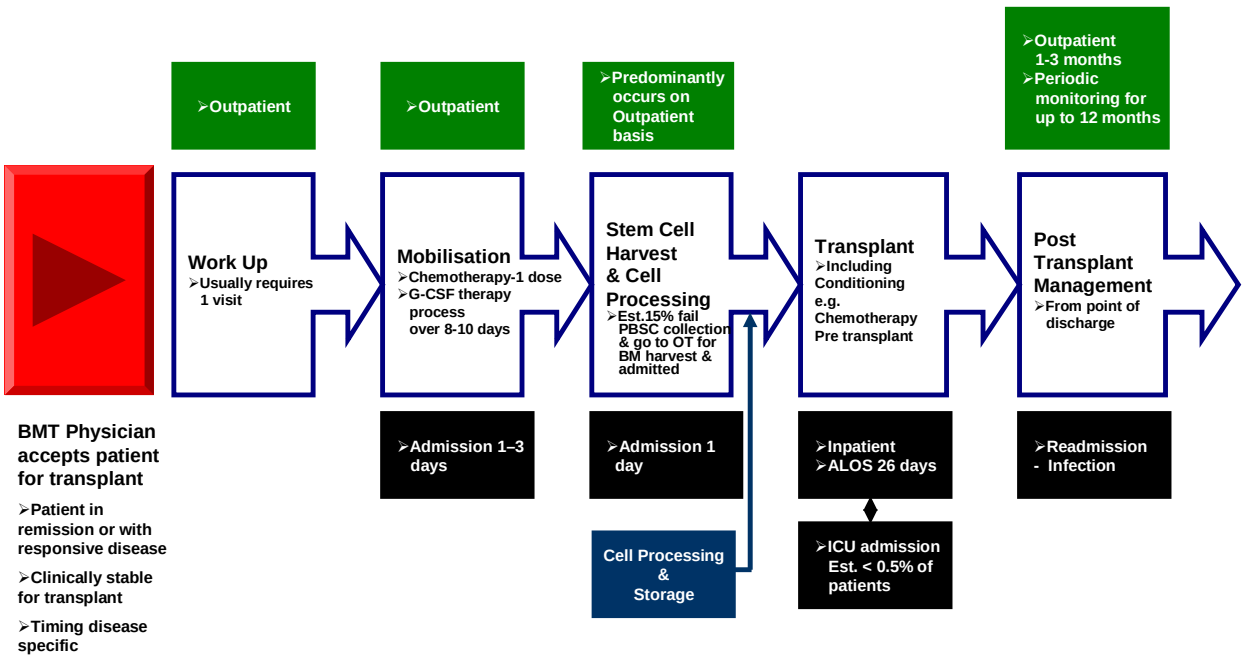
During the consultation, various hypotheses were generated that were tested with clinical activity data provided by hospitals to determine appropriate 'start' and 'end' points in this context. Based on this, business rules were developed and applied in the costing process. These are presented in Section 6.2 for inpatient episodes and Section 6.5 for outpatient activity.

The remainder of this section set outs 'patient journey' flowcharts, and a discussion of clinical and related issues that were raised during the consultation process. In the discussion, an emphasis has been placed on the issue of determining start and end points in the BMT process. Separate flowcharts are provided for allogeneic and autologous transplants as well as for adult and paediatric transplants.

4.1 Adult autologous blood and marrow transplant

The stages of the adult autologous BMT patient journey are depicted below in Figure 1.

Figure 1: The adult patient journey - autologous blood and marrow transplant



4.1.1 BMT Physician accepts patient for transplant

Autologous transplantation can be done if a patient is in remission or with responsive disease. The patient is ideally clinically stable and the timing of the transplant is disease specific. Peripheral blood stem cells are the most common source of stem cells for autologous BMT in adults (Eden et al. 2007).

Three views emerged on the "start" point or beginning of the patient journey:

- The BMT journey starts when a decision is made to transplant the patient; this is reflected in practice by the BMT Physician or BMT team accepting the patient.
- The BMT journey starts when there is an intention to transplant the patient.
- The BMT journey starts from when a patient is diagnosed with a condition in which BMT may be indicated.

The distinction between the "decision to transplant" and the "intention to transplant" has been made particularly by clinicians working with children. Using "intention to transplant" as the starting point will ensure that the activity related to patients who are intended for transplant and therefore placed on certain treatment regimes, counselled and potentially "worked up" but never actually proceed to transplant, are captured.

The course of the underlying disease may result in the period from intention to transplant to decision to transplant ranging from as short as two weeks through to several years. Using this definition as the "start" of BMT would make costing virtually impossible as the ability to distinguish between costs relating to the underlying disease and costs relating to a future transplant would become blurred. The same can be said for a start point coinciding with diagnosis of a condition that may be an indication for BMT.

An option presented in our interim report suggested that for costing purposes, the BMT process could be deemed to start at the point when the BMT Physician accepts a patient for transplant. This is usually reflected in practice by a series of outpatient visits as the patient is assessed and subsequently worked up for transplant. It is recognised that in practice, this process is not clear cut. Patients who have an underlying cancer that indicates BMT may have been managed by the hospital or treating haematologist/oncologist for some time prior to the transplant episode. However, in generating an accurate cost of BMT it is necessary to exclude episodes of care that can be attributed to the underlying disease as opposed to the transplant.

4.1.2 Work up

The consultation process confirmed the view expressed by key stakeholders, that there is a high level of consistency in the range of tests performed in the work up phase. Most routine medical tests occur on an outpatient basis before the patient is admitted to hospital for BMT. The range of tests performed depends on the type of underlying disease but the aim is to determine if the patient is fit enough to endure the physical stresses of BMT. Heart function may be tested by a gated heart pool scan and/or cardiac echo; kidney function is measured as well as lung function.

A chest or sinus x-ray may be indicated and some patients may require computerised tomography (CT or CAT) or Positron Emission Tomography (PET) scan. A number of blood tests are taken and these may screen for viral and bacterial infections, iron levels, blood glucose, clotting, thyroid and liver function. The patient will have a full blood count and blood group identified. Some patients may require a lumbar puncture and a bone marrow biopsy. Patients are also encouraged to have a dental check up and to maintain good nutrition prior to transplant (Eden et al. 2007 and Daly 2006).

4.1.3 Mobilisation

Eden et al. (2007:25) note that:

> *"Mobilisation occurs when the bone marrow increases production of stem cells, which then spill out into the circulating blood so they can be collected. Your BMT doctor will decide on the best regimen to mobilise your peripheral blood stem cells. The regimen will depend on your diagnosis, previous chemotherapy and radiotherapy, and your general health."*

Mobilisation usually includes chemotherapy (one dose) and G-CSF (Granulocyte colony stimulating factor) a synthetic version of a naturally occurring hormone, which is administered daily by injection for 8-10 days. G-CSF stimulates the growth of bone marrow stem cells and also

causes the mobilisation of peripheral stem cells. If the patient is well enough, many facilities provide this care on an outpatient basis. If the hospital has an appropriate outreach team, it is possible on occasion, for this process to occur in the patient's home. Some facilities prefer to admit the patient for anywhere from one to three days, depending on their level of wellness; status of their underlying disease and prescribed mobilisation regimen.

4.1.4 Stem cell harvest (cell processing and storage)

Stem cell harvest occurs when the circulating peripheral blood stem cells are deemed to have reached a certain level. Daily blood tests occur from mobilisation to the date of harvest to allow the BMT team to identify the optimal time for harvest. Stem cells are collected using an apheresis machine and this procedure usually occurs on an outpatient basis or in some cases as a day only admission.

The amount of blood processed during the harvest depends on the practice of the hospital. Two hospitals use large volume collection and process a minimum of 20 litres of blood during the stem cell harvest. This requires the patient to stay in hospital for an extended period of 6 – 8 hours. Most hospitals process a smaller volume of blood and if an inadequate number of stem cells are collected, ask the patient to return a couple of days later for a second collection. Should the source of stem cells be from bone marrow then a day only admission to hospital is required as bone marrow harvests are performed in the operating theatre under general anaesthesia.

After collection, the stem cells must be transported to an appropriate laboratory for processing. Major BMT sites have a laboratory on site. In NSW eight of the fifteen sites providing BMT have laboratory capacity. However smaller facilities transport the collected stem cells to an off-site for processing and storage until they are required. Transport costs are usually met by the hospital sending the stem cells, for example, if Wollongong Hospital sends stem cells to Westmead Hospital for processing and storage, Wollongong Hospital meets these costs. However when Westmead Hospital transports the cells back to Wollongong Hospital for the transplant procedure, Westmead Hospital pays the transport costs.

We note here that the scope of this study prevented a separate costing of the BMT laboratories from being undertaken. The issue is discussed further in Section 7.4.

4.1.5 Transplant (including conditioning)

The patient is admitted prior to transplant for the conditioning process. Usually a central venous catheter will be inserted and the patient will receive several days of chemotherapy and/or radiotherapy to destroy bone marrow and cancerous cells and make space in the bone marrow for the new stem cells. Whilst some facilities may provide this stage of the patient journey on an outpatient basis, our consultation process found that almost without exception this stage is provided on an inpatient basis as part of the "transplantation" admission.

> *"There are many different types of conditioning therapies used in autologous stem cell transplantation but as a general rule they involve between five and eight days of high-dose chemotherapy…Occasionally, chemotherapy is given with radiation therapy in the form of total body irradiation (TBI). The kind of conditioning therapy…will depend on several factors including the type of disease…age and general health and the type of transplant…"* (Daly 2006:32).

Eden et al. (2007:11) reports that the doses of chemotherapy and/or radiotherapy given to patients during conditioning are much stronger than doses given to patients with the same disease who are not having a BMT.

The transplant proceeds a couple of days after this conditioning treatment and consists of an infusion of the previously collected stem cells. This occurs in a hospital room rather than an operating theatre. The patient remains in hospital while engraftment occurs – in the period prior to

this the patient is at high risk of infection. A range of drug therapy will be required at this time and the patient typically spends 2 - 4 weeks in hospital (Eden et al. 2007).

The mean average length of stay (ALOS) for an adult autologous transplant is 26 days based on the data analysis undertaken in this study. A relatively small proportion of autologous transplant patients require admission to ICU during the transplant episode.

Some hospitals are implementing early discharge practices for adult autologous patients, particularly those with multiple myeloma. However, this requires an effective outreach or early discharge program to be in place and in practice, occurs only rarely. These patients are visited daily for 10 days. A major barrier to early discharge is the lack of available week-end outreach services.

4.1.6 Post transplant management

This stage commences from the end of the transplantation episode. Clinicians indicated that patients are normally seen once or twice per week immediately following transplantation and then with decreasing frequency. If the patient is progressing well he or she will return for review monthly for approximately six months, then revert to two-monthly visits for the remainder of the twelve month period post transplant. Practice of course varies in individual cases based on clinical judgement. If the patient has travelled from a rural area to a metropolitan centre for BMT he or she will return home, usually at the six week mark, with their referring haematologist or oncologist resuming care. There is a high requirement for prophylactic medication post transplant such as anti-viral and anti-biotic medications.

During the post transplant period, patients may be readmitted to hospital. The most common reasons for readmission cited during the consultations included: infection, fever and dehydration. In the case of autologous transplants readmissions are often due to the underlying disease. The inpatient data sourced from facilities has provided greater detail about the frequency and cause of readmissions and this is discussed in Section 7.2.

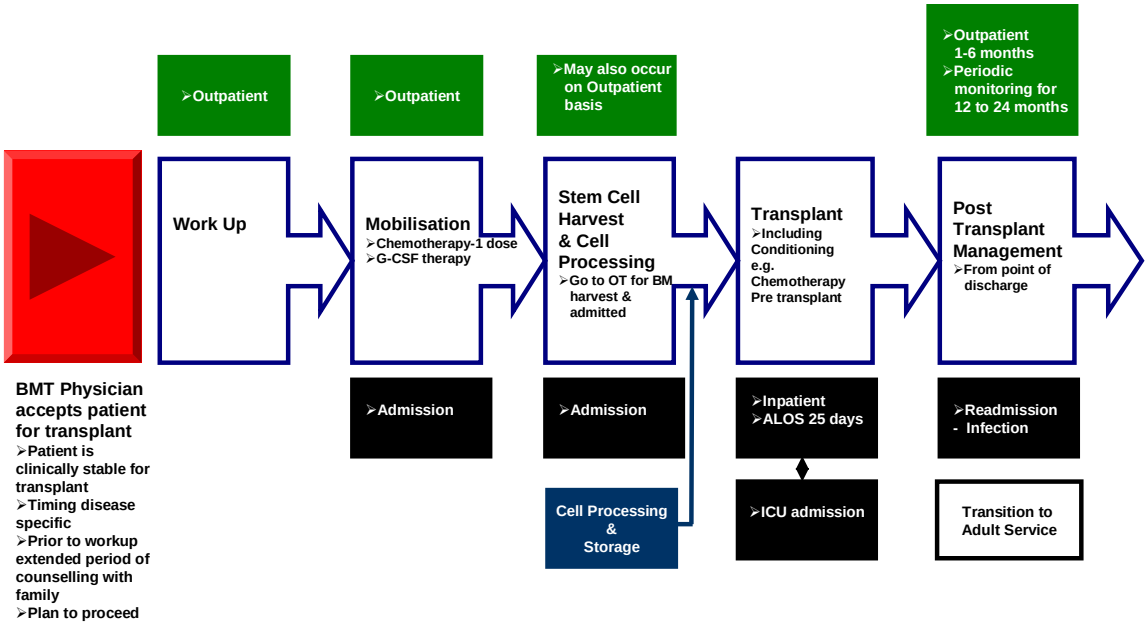
The views expressed regarding identifying an end point has been relatively consistent. Most clinicians agreed that the BMT process has usually ended by twelve months post transplant. Clinical management by the BMT team may finish earlier than this, with the patient referred back to their treating haematologist or oncologist. This discussion has been important in establishing the ‘end’ point of the transplant process for costing purposes.

Data provided by hospitals has been analysed in conjunction with the advice received during the consultation process to determine when the BMT process will be considered to have commenced and ended for costing purposes. The results of this process is outlined in Section 6.

4.2 Paediatric autologous blood and marrow transplant

The stages of the paediatric autologous BMT patient journey are depicted below in Figure 2.

Figure 2: The paediatric patient journey - autologous blood and marrow transplant



The paediatric patient journey in autologous BMT mirrors the stages of the adult patient journey. Whilst there are no major differences in the transplant process, several issues identified during the consultation process are discussed for each stage.

4.2.1 BMT Physician accepts patient for transplant

During the consultation process, paediatric clinicians pointed out that the patient may not be in remission prior to transplant. This may be related to the growing use of BMT in the management of non-malignant disease. It has also been emphasised that there is a significant amount of counselling and discussion that occurs with the patient's family - and often extended family - prior to the decision to transplant being made. In the case of children the transplant team have additional issues to manage. For example, if the family lives some distance from the treating hospital, they may all move to the metropolitan centre for the period of the patient's hospitalisation. This generates various support needs such as accommodation, financial assistance, counselling and schooling for siblings. This support is co-ordinated by the transplant team. The family often requires significant amounts of face to face time with the BMT Physician to understand the transplantation process. A proportion of families choose not to proceed with the transplant after this period of discussion and education.

Clinicians working in paediatric transplant centres recognise that time is invested in counselling the adult patient and family prior to the patient deciding to proceed to transplant. However, the dependent nature of the child does generate a greater degree of clinical and allied health input at this stage of the patient journey. This view is supported by the volume of outpatient activity reported by the paediatric facilities.

4.2.2 Work up

Where possible the patient work up occurs on an outpatient basis, however certain underlying diseases (e.g. acute leukaemia) may mean that the child is already hospitalised and the transplant work up occurs on an inpatient basis. Some patients require additional investigations

e.g. neuroblastoma patients, but as this need is driven by the diagnosis it does not materially impact the BMT costing process.

Clinicians identified that there is a cost associated with preparing paediatric patients for transplant who do not then proceed to transplant. We recognise that this a legitimate cost and that it has not been included in this study. The reason for its exclusion relates to data availability and the fact that the study dataset is based on patients who had received a transplant during the study period. As such, it was not possible to identify the range of costs incurred by patients that did not progress to transplantation.

4.2.3 Mobilisation

The major difference identified in this stage of paediatric autologous BMT is that stem cells are often mobilised 'off the back' of a course of chemotherapy that is being given to manage the underlying disease. The paediatric patient is more often an inpatient than an outpatient. The costs relating to mobilisation are captured through the inpatient episodes.

4.2.4 Stem cell harvest (cell processing and storage)

In the paediatric patient journey the primary source of stem cells is peripheral blood rather than bone marrow. This means that the child may require a visit to operating theatre and a general anaesthetic. The patient is always admitted in this situation. In children, stem cells may be stored for long periods as the course of the underlying disease can be unpredictable. In addition, it may be thought that a second transplant may be indicated at a future time.

4.2.5 Transplant (including conditioning)

The conditioning and transplant process is similar for adults - noting that conditioning regimens are clearly tailored for each paediatric patient. Chemotherapy is usually given for several days and the patient given two days break prior to the stem cell infusion. Patients who have myeloblative conditioning therapy will be very ill and highly immunosuppressed. Anecdotal advice suggests the average length of stay is longer for children than adults. An analysis of the data supplied resulted in an average length of stay (mean=25 days) that is similar to that for adult autologous transplant patients. (Refer to Section 7.1).

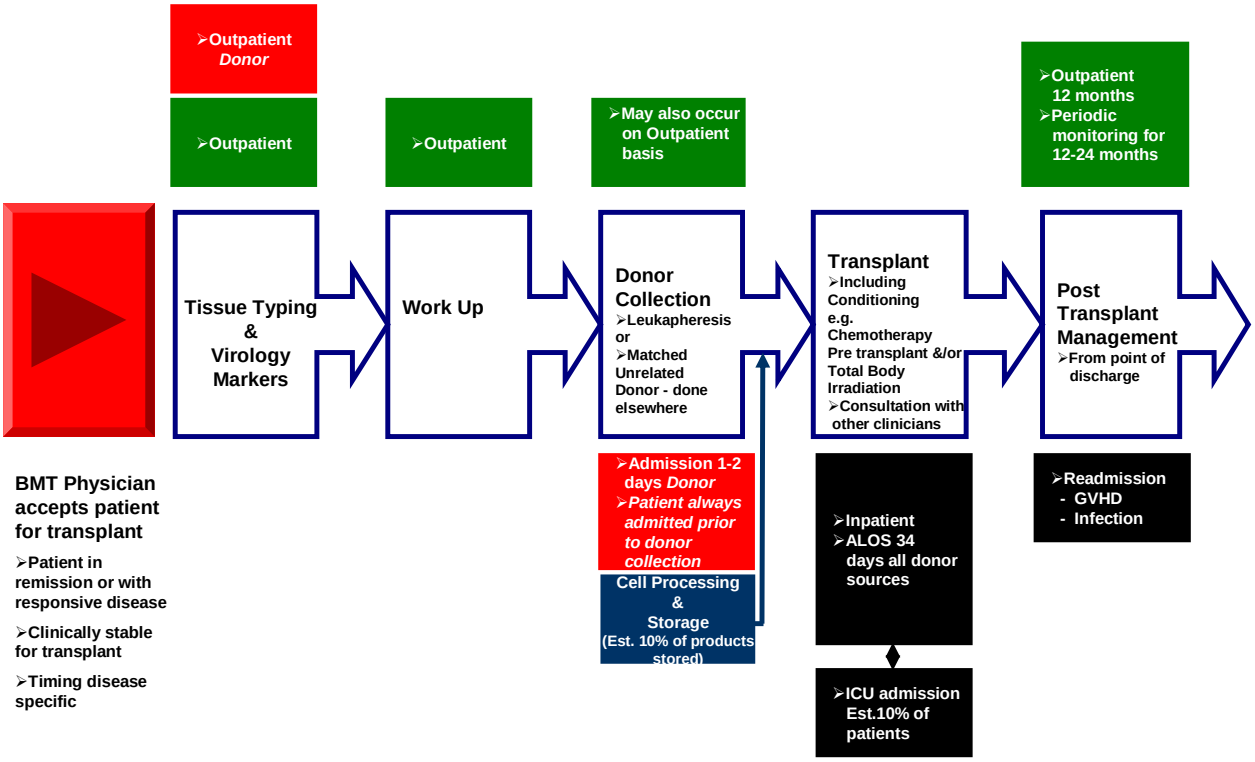
4.2.6 Post transplant management

Based on feedback provided during consultations, it appears that monitoring in the immediate post transplant phase is more frequent in paediatric patients. Initial discussions suggested that the period of post transplant management extends for 24 months. However, subsequent advice from paediatric BMT clinicians has confirmed that 12 months post transplant reflects actual practice. As children often do not have the comorbidities that may generate further readmissions post transplant, it is likely that most readmissions are due to the underlying disease as opposed to BMT.

4.3 Adult allogeneic blood and marrow transplant

The stages of the adult allogeneic BMT patient journey are depicted below in Figure 3.

Figure 3: The adult patient journey - allogeneic blood and marrow transplant



As many stages of care are similar to the autologous BMT patient journey, these are not restated in detail. Comment is provided on aspects unique to allogeneic BMT.

Clinicians emphasised the differences in the patient journey for autologous and allogeneic patients. The varying levels of complexity within the allogeneic transplant group have been consistently raised during interview and concerns expressed that the one AR DRG may not accurately capture the variations amongst allogeneic transplant patients.

The major determinants of complexity are three-fold:

- Donor status (related or unrelated; matched or unmatched);
- Source of stem cells (bone, peripheral blood or cord blood);
- Acuity of patient's underlying disease.

4.3.1 BMT Physician accepts patient for transplant

Allogeneic transplant uses stem cells donated by another person (a donor). Bradstock et al. (2006:8) describe two types of allogeneic transplants:

> *"**Myeloblative or full allo**: the aim is to destroy the patient's marrow and kill the cancer cells. **Non-myeloblative ("mini" allo)**: the aim is to suppress the patient's marrow and allow the donor cells to grow and attack the cancer cells. This is the graft-versus-tumour effect."*

With use of reduced intensity conditioning regimens in allogeneic transplantation, the age limit has increased, permitting the inclusion of older patients. This patient group may have a range of

comorbidities associated with advancing age and/or underlying disease. The patient is usually in remission and must be clinically stable for transplant. The timing of the transplant is always determined by each patient's underlying condition.

4.3.2 Tissue typing and virology markers

The BMT Physician accepts the patient for transplant recognising that tissue typing and virology markers are required. Unless a suitable donor can be found then it is not possible to proceed to transplant. The donor may be related or unrelated; matched or unmatched and the source of stem cells may be from peripheral blood, bone marrow or cord blood. In Australia in 2004, allogeneic related donor transplants comprised 56% of all allogeneic transplants and allogeneic unrelated donor transplants approximately 44%. (Nivison-Smith, Bradstock and Dodds et al. 2007)

Tissue typing is carried out by the Australian Red Cross. It is done to check how closely the patient's cells match the potential donor's cells. HLA (human leukocyte antigen) markers are found on almost all the cells in the body and they are one of the main ways the immune system can tell the difference between the patient's own cells and foreign cells. The closer the match in HLA types, the better the chance of a successful transplant. (Bradstock et al. 2006:25).

Both the donor and patient are tissue typed - this occurs on an outpatient basis. How the process proceeds depends on the nature (related or unrelated) of the donor and the location of the donor/and or stem cells. Whilst the most suitable donor for a stem cell transplant is a fully matched (tissue typed) family member, only about one person in three has such a donor. This means that several family members will need to be tissue typed and, if a donor is not found in the immediate family, a wider family search and/or unrelated donor search may be needed. (Bradstock et al. 2006). The search for a donor starts with the hospital who works in conjunction with the NSW Search Co-ordinator from the Australian Red Cross to try to find a related donor. The search may then be passed to the Australian Bone Marrow Donor Registry (ABMDR), should an unrelated donor be required.

Costs related to tissue typing have not been separately identified in this study. It should be recognised that costs relating to tissue typing have increased significantly in recent years due to the rapid advancements in tissue typing technology. Hospitals are only funded for Low Resolution Class 1 typing. High Resolution typing is now standard practice.

4.3.3 Work up

The work up process is similar to that described for autologous BMT and usually occurs on an outpatient basis.

4.3.4 Donor collection (cell processing and storage)

The donor collection stage is unique to allogeneic BMT, however the actual process of stem cell collection is similar to that described in Section 4.1.4. If the donor is unrelated, the collection process will occur in a separate facility to ensure patient confidentiality. Most transplants from unrelated donors use bone marrow cells. The donor may be managed as an outpatient or admitted. If for any reason the donor is admitted this is for a maximum of one to two days. The patient receiving the transplant is always admitted prior to donor collection to ensure their readiness for conditioning.

If the donor is related and resides within NSW they will normally travel to the hospital where the patient will have the transplant. This means that the donor or family of the transplant recipient will normally meet the costs related to the donor's travel, whilst the hospital stay would normally covered by Medicare. In these cases, it is possible that the NSW Isolated Patients Travel and Accommodation Assistance Scheme (IPTAAS) may offer some financial assistance. IPTAAS is a transport and accommodation subsidy scheme that assists people in isolated and rural communities to gain access to specialist medical treatment not available in their own area.

While donors outside NSW may choose to have their donor collection process in a transplant facility in their own state, any donor to a NSW resident who is an Australian resident is eligible to access the NSW IPTAAS. Usually collection of stem cells occurs from peripheral blood and this can be done via apheresis as an outpatient. The hospital treating the transplant recipient then arranges for collection and transport of the stem cells. The costs of this collection are met by the NSW based hospital that will provide the transplant.

If the donor is overseas then the Commonwealth funds the costs of stem cell collection and transport. International unrelated donor searches and cell procurement are managed by the ABMDR. If a NSW donor is a match for another international patient requiring a BMT than the assessment, work up and stem cell collection is done by a NSW hospital. The Commonwealth reimburses the NSW hospital for these costs up to a maximum of $2000 per patient, (this fee has apparently remained the same since 1992). If however a NSW donor is a match for another Australian patient requiring a BMT then the NSW hospital has to assess, work up the donor and collect the required stem cells at the cost of the hospital. According to the ABMDR, in NSW an estimated 25 patients per annum (international and national) are admitted for donor collection.

Cord blood donations require specific attention as obtaining these from overseas cord blood banks is very expensive, although the cost is usually mostly met by the Commonwealth. The ABMDR currently have a contract with the Commonwealth and a parallel contract with State Cord Blood Banks.

It has been suggested during consultation that there are higher costs of storage with allogeneic transplant patients – this is related to the use of donor cells that may require more complex processing and longer periods of storage.

4.3.5 Transplant (including conditioning)

The conditioning process is a critical part of the transplant process. For allogeneic transplant patients this will include chemotherapy and frequently Total Body Irradiation (TBI). In TBI, radiotherapy is given to the entire body to kill cancer cells and suppress the immune system to allow the transplanted cells to engraft. It is usually given in six treatment sessions over three days within the Radiation Oncology Department.

Often additional consultations are needed with other sub-specialists to manage any pre-existing co-morbidities or anticipated complications. The most complex type of allograft is that which uses a matched unrelated donor. These patients have a much higher incidence of admission to an Intensive Care Unit post transplant and a longer average length of stay. Figure 3 provides the mean ALOS for allogeneic transplants (all types) which is 34 days. Clinician advice suggests that the ALOS for matched unrelated donors is usually substantially longer than that for matched sibling donors.

4.3.6 Post transplant management

In the case of allogeneic transplants, whilst these patients are customarily followed up for longer than twelve months, most of the major costs “post transplant” are likely to occur in the first year post BMT. The post transplant stage follows a similar trajectory to that described for the autologous BMT patient recognising that periodic monitoring may extend for at least 24 months.

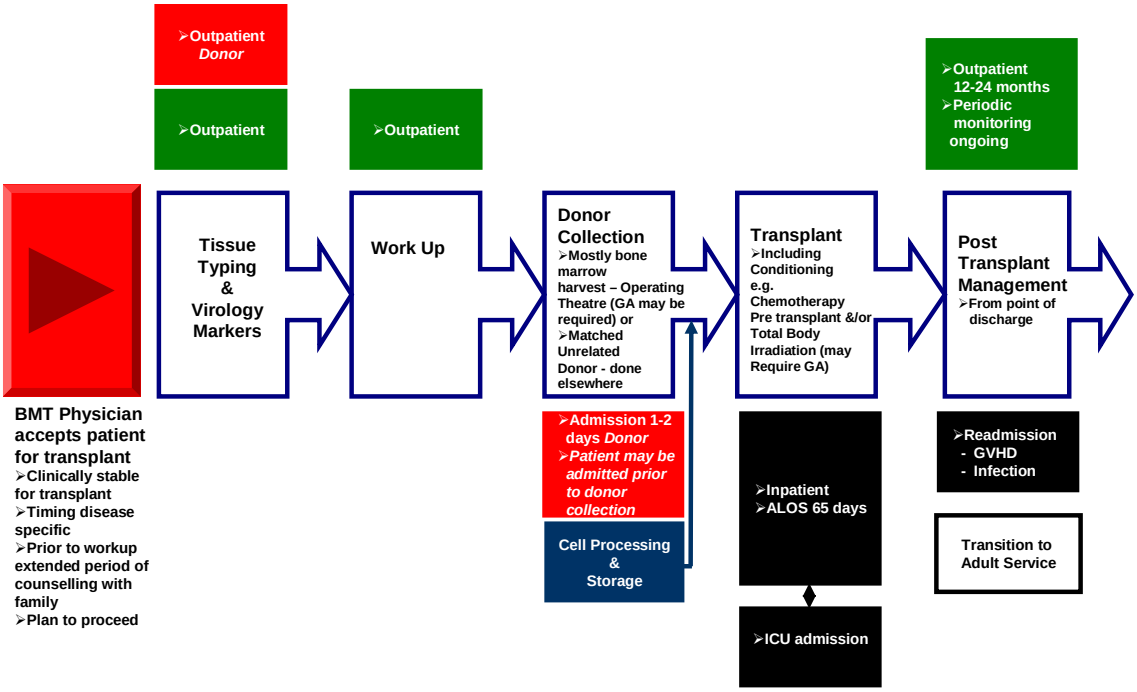
In the post transplant period, patients may be readmitted to hospital. The major difference with allografts is that the patient may develop Graft versus Host Disease (GVHD). This is a very serious complication of allogeneic BMT. It occurs when the donor marrow cells begin to engraft and multiply and the donor T lymphocytes see the patient’s own body as foreign and try to destroy tissues and organs. The conditioning therapy has suppressed or eliminated the patient’s immune system to stop their body rejecting the donor marrow. Acute GVHD occurs within 100 days after a BMT and may be mild through to life threatening. Chronic GVHD develops more than 100 days after BMT. Chronic GVHD is more common in people whose donor is unrelated or whose marrow is not perfectly matched (Bradstock et al. 2006:87-92).

The inpatient data sourced from facilities enumerates the major causes of readmission including those linked to GVHD. GVHD arose as a major concern during the consultation process due to the extraordinarily high costs of managing both acute and particularly chronic patients with this condition. It was suggested that the multi-drug therapy required by these patients post transplant for extended periods, has a significant cost impact, particularly anti-fungal therapy. Patients will also need to be re-immunised twelve months post transplant.

4.4 Paediatric allogeneic blood and marrow transplant

The stages of the paediatric allogeneic BMT patient journey are depicted below in Figure 4.

Figure 4: The paediatric patient journey - allogeneic blood and marrow transplant



Evidence gathered during consultations indicates that a higher proportion of unrelated donor transplants are done in paediatric BMT patients. In addition, the majority of cord blood transplants occur in paediatrics and these stem cells take longer to engraft therefore carrying higher risk and resulting in a longer length of stay. The mismatched cord blood transplant is deemed the most clinically difficult and costly.

4.4.1 BMT Physician accepts patient for transplant

This stage occurs in the same way that has been described for the paediatric autologous BMT patient. However paediatric clinicians have highlighted the diversity of underlying conditions for paediatric allograft patients and the fact that for complex non-malignant immunodeficiency or metabolic indications, there may be a much higher level of sub-specialty consultant input require both pre and post transplant.

4.4.2 Tissue typing and virology markers

The tissue typing stage is similar to that described for the adult allogeneic BMT patient journey. As with adults, several family members may be tissue typed to find an appropriate related donor.

4.4.3 Work up

Where possible the patient work up occurs on an outpatient basis. However as is the case in paediatric autologous BMT, certain underlying diseases (e.g. acute leukaemia) may mean that the child is already hospitalised and the transplant work up occurs on an inpatient basis. Anecdotal advice suggests that approximately 10% of paediatric patients may not survive or not go into remission and therefore do not proceed to transplant. Clinicians felt that if possible, these costs should be captured. However, as identified in Section 7.4, the study was limited to those patients who actually proceeded to transplant.

4.4.4 Donor collection (cell processing and storage)

There is no significant difference to the donor collection process except for the fact that the majority of donor cells used in paediatric BMT are sourced from bone marrow. The donor will be admitted for this bone marrow harvest. The transplant recipient is usually an inpatient at the time of donor collection.

With children, some stem cells may be stored for future transplants, particularly if their underlying disease makes them prone to relapse. As there are a higher proportion of unrelated transplants in children, this can increase demand for additional cell processing measures. These measures are high cost and are met by the treating hospital e.g. CD34 selection which filters out T cells from the stem cell graft reducing the risk of GVHD.

A proportion of donor collections will incur additional costs for the transplanting hospital, associated with stem cell procurement and transport.

4.4.5 Transplant (including conditioning)

The conditioning and transplant occur in the same episode. As conditioning is usually aggressive it is provided on an inpatient basis. In paediatric allogeneic BMT, children with malignant disease usually receive TBI unless they are younger than two years and/or have an existing developmental problem.

As the indications for non-myeloblative conditioning are increasing, the potential for a second transplant is becoming more common. Higher risk may be associated with paediatric patients having a second transplant. Data analysis reveals that the mean average length of stay for allogeneic paediatric patients is approximately 65 days. This longer length of stay is due in part to the acuity of children who have had intensive chemotherapy prior to transplant (for example whilst there has been some improvement in upfront treatment for leukaemia patients, these regimens are more intensive so if the child does have to progress to transplant they are often sicker). The higher proportion of unrelated donor transplants and the growing proportion of cord blood transplants (the latter taking longer to engraft) also impact on average length of stay.

4.4.6 Post transplant management

The paediatric allograft patient is seen up to two to three times per week for the first three months post transplant. Outpatient visits then reduce to weekly after three months post transplant and by the six month mark, the child is usually seen once per month. A variety of allied health professionals may be involved during the post transplant period, most often social work, dietetics, physiotherapy and occupational therapy. Whilst the GP is kept informed throughout the course of treatment, at the six month mark the BMT Physician actively tries to involve the child's GP in ongoing patient management.

Whilst the immediate transplant related complications occur in the first twelve months post BMT, the use of myeloblative conditioning protocols and associated risk of GVHD can lead to complications up to 24 months post transplant. The management of chronic GVHD can be particularly resource intensive, even though it occurs less often than in adults. With children there is the added complication of the potential impact of toxicity (from the high dose chemotherapy) on

future growth and development e.g. children may require a cardiac echo every two years to monitor risk of cardiac failure post high dose chemotherapy. This leads to a longer period of follow up and periodic monitoring for children, with six monthly monitoring often occurring for up to five years post transplant, with the patient then reverting to annual review.

Whilst it is recognised that paediatric patients do require follow up for longer periods than adults, data analysis demonstrates that the vast majority of related inpatient episodes occur in the 12 months immediately post transplant (as discussed in Section 7.2).

Another major challenge for paediatric BMT services is transitioning adolescents to adult haematology/oncology services. This is difficult as families often have a long association with their respective Children's Hospital and many are reluctant to transfer their child's care to an adult facility. Whilst adult patients can often be directed by the BMT Physician back to the referring haematologist/oncologist, this is more difficult with children who may have been referred by a generalist paediatrician. This means that paediatric haematologists/oncologists often manage the general follow up of children on an ongoing basis until the patient transitions to an adult service.

There continues to be high drug use during the post transplant stage with immunosuppressants, antifungals and antibiotics required. Patients will also need to re re-immunised twelve months post transplant. Most readmissions (if not related to the child's underlying disease) are due to BMT as these patients rarely have comorbidities.

4.5 Differing clinical practices

In developing the costing methodology it is necessary to distil other clinical issues from the consultations that may impact on BMT. These issues were "reality tested" with the Cost Study Reference Group.

Generally there is a high level of consistency in the management of BMT patients. The Greater Metropolitan Clinical Taskforce (GMCT) Bone Marrow Transplant Network has been highly effective in ensuring there are agreed indications for BMT and a standardised approach to the investigations required during the "work-up" stage pre transplant. If a patient has had extensive treatment of their underlying disease prior to transplant, more tests may be indicated. There are also common treatment protocols.

During the course of consultation very few differences in clinical practice have emerged. None of these differences were seen to have a material impact on this study.

- **Extended Family Donor Search:** When a related donor is being sought tissue typing usually occurs of immediate family members. One facility pursues extended family searches with as many as 20 – 30 persons tissue typed instead of the more common 3 – 4 persons. Tissue typing is recognised as an expensive process.

- **Mobilisation:** Whilst varying stages of the patient journey occur in the outpatient setting only one facility provides outreach services for BMT patients. This hospital has two Clinical Nurse Consultants who manage a cohort of haematology patients, including those who are to have, or have had BMT. These nurses assist suitable patients to manage the mobilisation process at home and assist with injections if necessary and collection of blood samples to monitor the CD34 cell count and predict the day of stem cell harvest. They will also administer blood and platelet transfusions in the home, should they be indicated.

- **Stem Cell Harvest:** A couple of hospitals use large volume collection and process a minimum of 20 litres of blood during the stem cell harvest. This requires the patient to stay in hospital (usually an outpatient setting) for an extended period of 6 – 8 hours. Best practice of stem cell collections needs to be validated, that is, large volume versus small

volume blood processing. For hospitals that perform small volume harvests, if inadequate stem cells are collected, the patient returns the very next day for another collection.

- **Interval from Harvest to Transplant:** This period can vary significantly from weeks to months and is driven by the patient's underlying disease. In children there may be a much longer period as stem cells may be required years later, this impacts on cell storage capacity and costs.

- **Rainy Day Harvest:** Most BMT teams treating adult patients try not to do rainy day harvests because of the additional costs and ongoing cell storage issues. However paediatric patients that are expected to have an allogeneic transplant have their own peripheral blood stem cells collected and these are routinely processed and stored as backup if the allogeneic transplant fails.

- **Use of PET scan:** Some clinicians advise that a PET (Positron Emission Tomography) scan is completed pre and post transplant for most lymphoma patients. (Patients are sent to either Royal Prince Alfred or Liverpool Hospital).

- **Post Transplant Care:** A few hospitals are trying to implement early discharge practices for adult autologous patients, particularly those with multiple myeloma, (there are strict criteria for eligibility for early discharge). In practice this occurs rarely and is only possible where there is an effective outreach or early discharge program. These patients are visited daily for 10 days; a major barrier to early discharge is the lack of week-end outreach services.

- **Extracorporeal Phosphoresis:** ECP may be a treatment of choice in patients with GVHD. Treatment occurs on consecutive days every two weeks for up to three months. Each treatment is costly. ECP in Australia is currently only accessible in Victoria.

4.6 Clinical issues that impact on BMT costs

Most clinical issues relevant in autologous and allogeneic BMT have been covered during the description of the respective adult and paediatric patient journeys. Some clinical issues were identified that may have an impact on the cost of providing BMT services and are therefore outlined here.

Firstly, it was noted that the growth in technology for tissue typing has increased the accessibility and utility of extended tissue typing (high resolution or molecular tissue typing). The indication for high resolution typing (HR Class 1) is becoming more standard and has cost implications.

The cost of donor stem cell procurement is borne by the transplanting hospital for related donors that reside within Australia. This can result in travel costs to collect stem cells and lost productivity or staff time as highly trained nursing personnel are those most often sent from hospitals to collect stem cells.

Haematology/Oncology Units in large rural centres often meet the costs of work-up and the costs of post transplant management (particularly drug costs) even though the transplant episode may not have occurred in this facility. This issue was raised particularly by Newcastle Mater and John Hunter Hospital who send all allogeneic transplant patients to Sydney. This occurs also in smaller BMT centres that may only do autografts yet assist with pre and post management of patients requiring allografts. NSW Health policy currently states that after one year post treatment the cost of drugs will be met by the patient's area of residence.

In paediatric care, the transplant team often needs to manage the entire family through the transplant process. This requires significant time from senior clinicians and allied health personnel. Paediatric cancer patients tend to have ongoing involvement of their paediatric oncologist or haematologist and there are challenges in transitioning these patients to adult

services. This is driving an emerging trend to 'shared care models' between paediatric oncologists and adult oncologists.

In the case of Sydney Children's Hospital (SCH), children sometimes travel from South Australia for a BMT. In these cases, SCH may only meet a proportion of the costs because the pre and post transplant management occurs in the child's home state. The converse experience occurs with children referred from the ACT, as all stages of the patient journey are managed at SCH.

The development of pre transplant genetics may extend the potential for unrelated donor transplants in the future. This is already being seen overseas in families with a congenital history of thalassemia.

5 Data collection and the development of a BMT study dataset

The primary aim of this project was to develop cost estimates for the various care processes involved in the delivery of BMT services. As such, it was important to obtain data relating to the cost of BMT episodes, related inpatient episodes and a range of outpatient BMT services.

The scope and timeframe of the study precluded a prospective costing study being undertaken. Instead, the data collection protocol developed for the study was based around retrospective data available from hospitals that provide BMT services.

Each of the eight hospitals with clinical cost data was contacted to discuss their capacity to provide data. Three types of data were potentially required:

- Costs of inpatient and outpatient services provided to BMT patients;
- Service utilisation data in relation to outpatient services provided to BMT patients;
- Clinical information comprising diagnosis and procedure data for BMT inpatient episodes.

The study team worked with each facility to obtain the range of required information related to BMT services. This process took many weeks and often involved several iterations of data being provided to the study team. During this process, several methodological issues arose in relation to the structure of the study dataset and the proposed data analysis approach. The key issues and the agreed outcome are discussed briefly below.

5.1 Inpatient cost data - clinical costing versus cost modelling data

This issue was identified in our project proposal and subsequently discussed in our Interim Report. NSW public hospitals routinely participate in an annual hospital inpatient cost data collection that involves an annual submission of cost data to NSW Health. The outcome of this process is the development of AR-DRG costs for separations that occurred in the previous financial year.

Hospitals rely on two basic types of costing systems to produce data for this annual hospital cost data collection. Firstly, an increasing number of hospitals have implemented what are referred to as ‘clinical costing’ systems. Other hospitals rely on what is referred to as a ‘cost modelling’ approach to producing costing information.

In the current study, we are aiming to produce costs for two types of inpatient episode:

- BMT episodes;
- Other inpatient episodes related to the BMT treatment.

In the context of this study, there is an important difference in the capacity to use data extracted from each type of costing system. Clinical costing systems produce a cost for individual episodes of care by costing the various elements of care provided during an episode. These costs can be analysed individually or rolled up to produce an average AR-DRG cost. Importantly, it is straightforward to identify and obtain cost data for related inpatient episodes provided to BMT patients.

Cost modelling systems produce cost estimates through a ‘top down’ process in which costs are allocated to AR-DRGs using a set of existing relativities. The end result of the cost modelling process is an average cost for each AR-DRG. The process does not produce costs at the individual episode level.

The key issue in the context of this study is that cost modelling systems do not allow the costs of BMT related episodes to be identified. Data from these hospitals can only be used to analyse the cost of BMT episodes. This is because a BMT related episode could be assigned to virtually any AR-DRG. BMT patients would comprise only a small proportion of the patients contributing data to

that AR-DRG. As such, the average AR-DRG cost would be meaningless in terms of understanding costs of episodes related to the BMT.

Given the limitation of data extracted from cost modelling systems, it was agreed to utilise data from hospitals with clinical costing systems as the primary data source for inpatient cost data for the study. Clinical costing data were available from eight of the fifteen hospitals that provide BMT services. These facilities therefore formed the basis of the study dataset.

Importantly, of the six hospitals that undertake allogeneic BMT, Royal Prince Alfred Hospital is the only facility that could not provide clinical costing data. As noted earlier, based on the average number of BMT episodes currently undertaken in NSW annually for adults, the study captured data on 90.1% of allogeneic transplants and 58.1% of autologous transplants. We are confident that this is a representative sample of BMT episodes across NSW.

Table 3 below shows fifteen BMT hospitals and which of these have the type of costing system in use during the study period at each of the BMT hospitals.

Table 3: Types of costing systems in NSW BMT hospitals

Hospital	Type of Costing System	Type of BMT Provided
St Vincent's Hospital*	Clinical costing	Allogeneic and autologous
Westmead Hospital*	Clinical costing	Allogeneic and autologous
Royal North Shore Hospital*	Clinical costing	Allogeneic and autologous
Royal Prince Alfred Hospital	Cost modelling	Allogeneic and autologous
Sydney Children's Hospital*	Clinical costing	Allogeneic and autologous
Children's Hospital Westmead*	Clinical costing	Allogeneic and autologous
Concord Hospital	Cost modelling	Autologous
Gosford Hospital	Cost modelling	Autologous
John Hunter Hospital	Cost modelling	Autologous
Liverpool Hospital	Cost modelling	Autologous
Nepean Hospital*	Clinical costing	Autologous
Newcastle Mater Hospital	Cost modelling	Autologous
Prince of Wales Hospital*	Clinical costing	Autologous
St George Hospital*	Clinical costing	Autologous
Wollongong Hospital	Cost modelling	Autologous

* Contributed data to the study dataset

5.2 Use of costing data from a different number of years

As noted, eight hospitals contributed data to the study dataset. These hospitals were able to provide data for one, two or three financial years. The differing capacity to provide data between hospitals was largely determined by the period of time that each hospital has been operating a clinical costing system.

Four hospitals provided three years of data (2004/05,2005/06 and 2006/07), one hospital provided two years of data (2005/06 and 2006/07) and three hospitals provided one year of cost data (2006/07) as shown in Table 4 below. It was agreed not to consider using data from periods earlier than 2004/05 because of the cost implications of changes that may have occurred in clinical practice since that time.

Table 4: Available inpatient cost data from hospitals in study dataset

Hospital	Available Inpatient Cost Data
St Vincent's Hospital*	2005/06, 2006/07
Westmead Hospital	2006/07
Royal North Shore Hospital	2006/07
Prince of Wales Hospital	2004/05, 2005/06, 2006/07
St George Hospital	2004/05, 2005/06, 2006/07
Nepean Hospital	2006/07
Sydney Children's Hospital	2004/05, 2005/06, 2006/07
Children's Hospital Westmead	2004/05, 2005/06, 2006/07

* St Vincent's also provided clinical data for 2007/08

A methodological issue that arose was whether to include data for a different time period from different hospitals in the study dataset. At one level, it could be argued that a simple approach would be to limit the study dataset to one year. However, BMT services are clearly a high cost/low volume activity. As such, obtaining a sufficient sample size to derive reliable cost estimates was a critical concern for the study.

Further, the hospitals that could provide three years of data tended also to be hospitals that provided a small number of BMT episodes on an annual basis. In some cases, it would not have been possible to produce meaningful cost estimates at the hospital level based on only one year's data.

For this reason, it was decided to include all available data from each facility between 2004/05 and 2006/07. Data from 2004/05 and 2005/06 were inflated to 2006/07 terms using rates provided by the NSW Department of Health. In adopting this approach, it was important to ensure that hospital's with two or three year's data were not over represented when calculating average BMT costs across multiple hospitals.

The method adopted for the analysis was to calculate any multiple hospital average cost as the average cost of those hospitals that contributed to that average weighted by each hospital's average number of BMT episodes per year. Clearly, it was not necessary to apply this weighting when averages were being calculated for individual hospitals.

A final point is worth noting in relation to this issue. As both of the paediatric facilities were able to provide three years of cost data, any averages calculated only for these facilities will not be affected by the weighting approach. Similarly, for the three adult hospitals, as two provided one year's data and one provided two year's data, the impact of the weighting approach will be minimal. The only circumstance when the weighting will have an effect is if combined average costs are produced across both paediatric and adult hospitals.

Overall, in our view, the approach adopted represents the most appropriate method to maximise the available data whilst ensuring that each hospital is appropriately represented in the calculation of average costs.

5.3 Collection of inpatient cost data

As noted, the primary source of inpatient cost data for the study was clinical cost data produced by each of the eight hospitals as part of the NSW Health annual hospital cost data collection process.

Each hospital was asked to provide a dataset that contained episode level cost data for the following two types of inpatient episodes:

- BMT episodes where the separation date was in the financial year/s being costed by that hospital;

- Any other inpatient episode for these patients that occurred in any of the financial year/s for which cost data were being provided by that hospital.

Relevant details such as episode dates and AR-DRG together with cost data for each episode broken into the following cost buckets was provided by each hospital:

- Clinical (medical) costs
- Ward (nursing) costs
- Allied health costs
- Pharmacy costs
- Intensive care unit costs
- Imaging costs
- Pathology costs
- Operating room costs
- Emergency department costs
- On costs
- Depreciation costs
- Total costs

As outlined in Section 6.1, on receipt of each dataset, a range of edit checks were undertaken to identify any potential anomalies in the data. Where necessary, hospitals were contacted to clarify issues and any necessary re-submisson of data was arranged.

5.3.1 Pharmacy cost data

The importance of identifying the cost of pharmaceuticals was raised at each consultation as it represents a significant proportion of both inpatient and outpatient BMT services.

For inpatients, sites provided patient level drug costs for patients in the study cohort. An issue was identified by hospital pharmacists and other staff about the capacity to cost 'imprest' drugs (drugs not dispensed to individual patients). In costing systems, a share of the cost of these drugs is allocated to BMT patients on a per diem basis using AR-DRG based relative value scales. This issue was discussed with each site's costing staff (and pharmacy staff where necessary), during the data preparation process. As a result of these discussions, we are confident that the cost of imprest drugs has been accurately allocated to BMT patients.

In relation to outpatients, it was equally important to obtain patient level costs for drugs dispensed to BMT patients. In this case, the issue of imprest drugs did not arise as all outpatient drugs are dispensed on an individual patient basis. Here, an effort has been made to identify drugs that fall under the Section 100 scheme as well as any drugs that are dispensed through the PBS.

At an initial meeting of the Study Reference Group, it was suggested that the process of costing BMT drugs may be expedited by identifying the top 10 to 20 high cost BMT drugs. To this end, several hospitals were able to provide separate cost data on the high volume drugs dispensed to BMT patients. This information has been compiled and is presented in Section 7.3.2.

5.4 Collection of inpatient clinical data

Each of the eight hospitals provided ICD 10 diagnosis and procedure data for each of the years for which financial data were provided. In one case, clinical data were provided for a year (2007/08) for which cost data were not available. The clinical data included several (ranging from 3 to 10) ICD 10 diagnoses codes and one procedure code.

These data were used for several purposes in the preparatory analysis process as discussed in Section 6.2. Most notably, this information provided an important clinical profile of inpatient services provided to BMT patients before and after their transplantation episode.

5.5 Collection of outpatient data

During the consultation process, BMT clinicians and other staff were asked to provide a profile of the range of pre and post transplantation services that are provided to BMT patients on an outpatient basis. Some differences were identified in models of care between hospitals that impact on the type and level of outpatient services that are typically provided.

The availability of outpatient activity and corresponding cost data was substantially less than for inpatient services. This finding was expected given that the systems required to routinely generate this information are not generally in place. This issue was flagged at the outset of the study. It was agreed that where data were not available, cost estimates would be developed based on a combination of service utilisation and the best available financial information.

A study protocol was developed and hospital's asked to provide the details shown in Table 5 below in relation to outpatient activity:

Table 5: Outpatient data collection

Outpatient Clinics	**Drugs**	**Pathology**
MRN	MRN	MRN
Date of service	Date dispensed	Date of test
Duration of service	Drug name	Test type
Clinic description	Drug cost	Cost of test
Clinician seen		
Cost of service		
Imaging	**Radiotherapy**	**Other Outpatient Services**
MRN	MRN	MRN
Date of test	Date of service	Date of service
Test type	Cost of service	Description of service
Cost of test		Cost of service

In practice, some hospitals were able to provide costed activity data for most of the outpatient services identified above. However, most hospitals were able to provide activity data for only some of the above services and very few hospitals were able to provide detailed cost data.

The exception to this was in the area of drugs where all but one hospital, (that provides a low volume of adult autologous transplants), was able to provide the required drug data. This is important as it represents the most expensive element of BMT outpatient services. For the remaining services, cost estimates were developed base on the data that were available in each area. The results are provided in Section 7.3. We stress that the areas in which data were not available represent a relatively small component of the total cost of providing BMT services.

5.6 Data quality

We have accepted data provided to us by each hospital as being both accurate and representing the best data available for the purposes of the study. In our view, the quality of the data provided by hospitals is of a high standard. We have not been given any reason to form the view that the financial information is not an accurate reflection of each hospital's current cost structures.

The validity of the inpatient data is supported by the fact that the inpatient cost data are costed as part of the NSW Department of Health's Program and Product Data Collection. Further, each hospital is required to account for all expenses by an identified Program in the Unaudited Annual Return and an appropriate reconciliation is undertaken as part of this process.

We recognise that some of the outpatient cost estimates are not as robust as the equivalent inpatient costs. This is a function of the fact that outpatient costing systems and processes are not as sophisticated as inpatient systems. However, we believe that these results are more than adequate for the purposes of the current study and note that these estimates represent a relatively small component of the total cost of BMT services.

6 Preparatory data analysis

Prior to the analysis, a series of preparatory data analysis tasks were undertaken. An outline of these tasks is provided below. The end result was an edited study dataset that formed the basis of the costing analysis.

6.1 Data edit checking

On receipt of data from each hospital, a set of edit checks were undertaken to identify systematic data inconsistencies. In several cases, anomalies were detected and revised data were submitted by the hospital concerned.

In addition, an edit check was undertaken to identify any individual episodes that appeared to be outliers from a cost perspective. This process identified considerable variation in the average cost of both transplant and related inpatient episodes. Where individual episodes were significantly higher than the average, advice was sought from the hospital about whether to include these episodes in the study dataset. As a result, no individual episode was excluded from the analysis on the basis of cost.

6.2 Identifying inpatient episodes that are related to the BMT

An important methodological issue was to determine which non-BMT inpatient episodes to include in the costing analysis. A total of 3,663 non-BMT inpatient episodes were submitted by the eight hospitals. The number of episodes by hospital, BMT type and pre and post transplant episode is shown in Table 6 below.

Table 6: Number of episodes by hospital, BMT type, pre and post transplant

Hospital	No. Pre-Transplant Allogeneic Episodes	No. Post-Transplant Allogeneic Episodes	No. Pre-Transplant Autologous Episodes	No. Post-Transplant Autologous Episodes
St Vincent's Hospital	29	302	204	164
Westmead Hospital	48	51	32	16
Royal North Shore Hospital	30	15	66	23
Prince of Wales Hospital	0	0	243	155
St George Hospital	0	0	133	32
Nepean Hospital	0	0	53	9
Sydney Children's Hospital	303	189	312	204
Children's Hospital Westmead	180	106	453	282
Total	**590**	**663**	**1496**	**885**

This issue essentially revolves around forming a clinical view about whether an inpatient episode is sufficiently related to the BMT to be included in the analysis of BMT costs. Ideally, each inpatient episode could be considered individually and a decision made about whether it should be included. In practice, however, this would require a detailed clinical review that was clearly beyond the scope of this study. Instead, we were guided by the clinical consultation process and a data analysis of inpatient episodes submitted by the eight hospitals.

During the clinical consultation (refer Section 2), advice was sought in relation to patterns of clinical care and the number of inpatient episodes that would typically occur before and after a transplantation episode.

In summary, the predominant view was that for adult allogeneic transplant patients, most pre-transplant related episodes occur in a 30-60 day window prior to the transplant. Following the transplant episode, most related acute admissions will occur within a twelve month period.

For paediatric allogeneic transplants, it was suggested that children are managed by the transplant team from the time a transplant is indicated. It was suggested that in some cases (such as neuroblastoma), this would occur from the point of initial diagnosis, even though the treatment pathway may extend for some time prior to transplant. This philosophy was quite different to that found in adult hospitals. A key difference appears to be that with adults, virtually all patients are referred to the transplant physician from a haematologist or oncologist who was already treating the patient's underlying disease.

As children do not usually have the comorbidities of adults, related inpatient episodes post transplant are usually due to the underlying disease or the BMT and occur most frequently in the 12 months post transplant. Whilst children are followed up for much longer than 12 months, particularly to identify the effects of chemotherapy toxicity on their development, this usually occurs relatively infrequently on an outpatient basis.

In relation to autologous BMT's, the adult services indicated that most services are typically provided in the 30 days prior to transplant to ensure the patient's readiness for transplant. Work up, mobilisation and stem cell harvest and processing primarily occur on an outpatient basis. However, inpatient admissions do occur for mobilisation in some cases in the two weeks prior to transplant. In terms of post-transplant services, the clinicians suggested that most admissions occur within a three month period. Following this, the patient is referred back to their original treating haematologist/oncologist.

For paediatric autologous transplants, our advice was that related inpatient episodes do occur pre transplant particularly for mobilisation and stem cell harvest (the latter requires general anaesthetic). No distinct pattern of activity was identified during the consultation process. Post transplant most related readmissions and/or outpatient services were reported as occurring in a one to six months period.

Following receipt of data from each hospital, a detailed analysis of transplant episodes and other inpatient episodes was undertaken. The analysis examined the frequency of days by time periods before and after a BMT episode. In addition, the ICD 10 diagnoses associated with these episodes were analysed to assess the likelihood that an episode was related to the BMT.

The following key findings emerged from this analysis:

- Across all hospitals, the vast majority of days occurred during the BMT episode;
- For adult hospitals, the vast majority of non-BMT inpatient days occurred within 60 days prior to and 90 days following the BMT episode;
- For paediatric hospitals, although a larger proportion of non-BMT inpatient days occurred prior to 60 days pre transplant than did for the adult hospitals a large majority of days still occurred within 60 days prior to and 90 days following the BMT episode;
- There was lower incidence of inpatient episodes associated with GVHD that had been expected;
- The majority of post transplant inpatient episodes related to infections than were demonstrably related to the BMT.

Based on the clinical consultation and data analysis, we formed the view that at one level, this issue can perhaps be considered as a philosophical issue about the point at which BMT services commence. There were clearly differing views on this matter between clinicians and between adult and paediatric services.

In the context of this study, we would stress that our objective was simply to develop a business rule that would allow BMT costs to be reasonably estimated. On this basis, the business rule below was developed in relation to the inclusion of non-BMT inpatient episodes for both adult and paediatric hospitals.

Business rule for inclusion of inpatient episodes in the costing analysis

The following inpatient episodes were excluded from the costing analysis:

- episodes where the separation date was more than 60 days earlier than the admission date for the BMT episode; and
- episodes where both the admission date was more than 90 days after the separation date from the BMT episode and the diagnoses for the episode were not related to the BMT; and
- any episodes where the admission date was more than 12 months after the separation date from the BMT.

Overall, it is our view that the business rule we have applied is appropriate in the context of the current study.

6.3 Grouping of related inpatient episodes for costing purposes

This is a technical issue that is outlined here as it was considered during the preparatory analysis phase of the project.

Inpatient episodes related to a BMT may occur in the same year as the BMT or in a previous or subsequent year. That is, for a given year, the estimated cost of related BMT episodes will include:

- Inpatient episodes related to a BMT that occurred in that year;
- Inpatient episodes related to a BMT that occurred in the previous year;
- Inpatient episodes related to a BMT that occurred in the following year.

For example, 2005/06 datasets will include related inpatient episodes where the transplant occurred in 2004/05 but will also include related inpatient episodes where the transplant did not occur until 2006/07. The same applies to both 2005/06 and 2006/07 datasets.

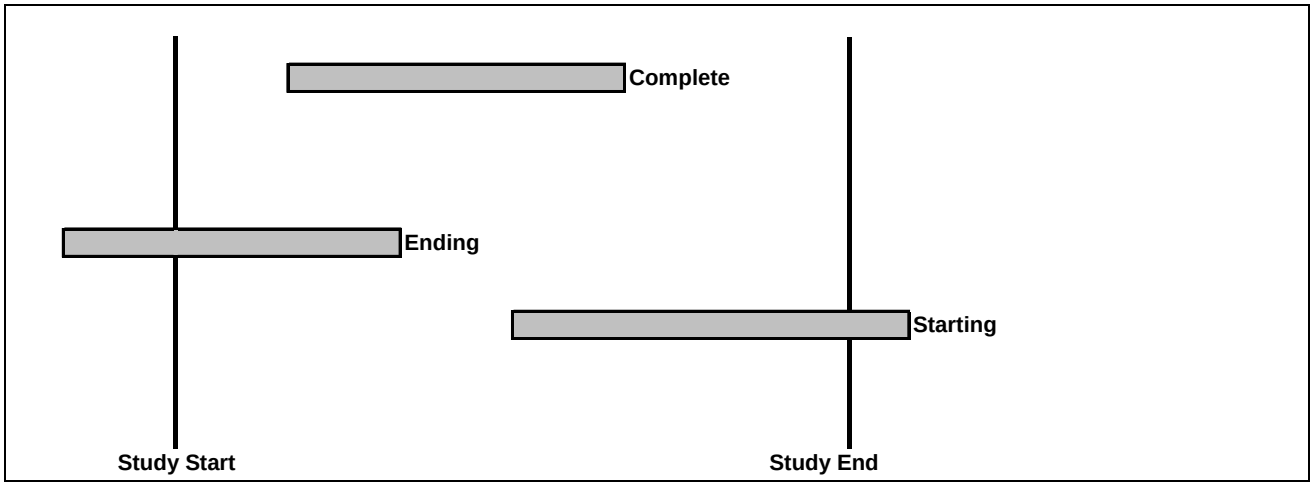
This data structure needs to be borne in mind when looking at results in this report that relate to cost estimates for a particular year. That is, we have reported the cost of related inpatients episodes that occurred in a particular year regardless of when that transplant occurred. In our view, it is sensible to produce annual cost estimates in this way as it allows for planning and funding processes to be based around the annual cost of BMT activity.

A related issue arises as we have used data from one, two and three years from different hospitals. Specifically, hospitals that have provided three years data will have provided a complete dataset for 2005/06 (i.e. the middle year). A proportion of prior episodes that occurred in 2003/04 and a proportion of subsequent episodes that occurred in 2007/08 will not be included. Hospitals that have provided one year of data will not include a proportion of episodes from both the previous (2004/05) and subsequent year (2007/08). The hospital that provided two years data (2005/06 and 2006/07) will not include a proportion of data from 2004/05 and 2007/08. The overall effect is that the hospitals with more than one year's data will be missing a smaller proportion of related inpatient episode data. We have carefully considered this issue in the context of its likely impact on the study results. Our proposed approach is not to make any adjustments in the primary cost results that are reported.

6.4 Treatment of incomplete inpatient episodes for costing purposes

The study dataset comprised three subsets of episodes as shown in Figure 5 below. It is theoretically possible that episodes that commenced prior to the study start may not have ended by the study end. However, we are aware of no such episodes occurring at any of the study hospitals.

Figure 5: Incomplete episodes during the study period



For costing purposes, it was necessary to apply a set of business rules regarding the treatment of the small number of inpatient episodes that straddled the study period. This was necessary for both BMT episodes and related inpatient episodes. Further, it was necessary regardless of whether data were provided for a one, two or three year period.

In this study, three types of cost results are of primary interest:

- Episode level costs such as the average cost per allogeneic BMT;
- Per diem costs such as the average daily cost of an allogeneic transplant patient;
- Annual costs such as total expenditure on BMT in a financial year by a given hospital.

No cost data were available for episodes in the starting cohort. For this reason it was necessary to exclude them from all analyses. This will not impact on the calculation of episode level or per diem costs other than by slightly reducing the overall sample size. However, it will have a small impact on the calculation of annual costs for the study period.

The remaining two episode subsets were included in the analyses as follows:

<u>The complete cohort</u>

These are episodes that started and ended within the study period. Cost data were available for the whole episode. These episodes were used in all analyses. Importantly, this subset represents the vast majority of episodes in the study dataset.

<u>The ending cohort</u>

These are episodes that commenced prior to study start but ended during the study period. Cost data were available for days after the study start but are not available for days prior to the study start. With this subset, episodes where 90% or more of the episode fell in the study period were used to calculate average per diem and average episode costs.

As shown in Table 7 below, the ending episodes represent only a small percentage of all episodes and therefore only a minor proportion of costs have been estimated. This proportion is slightly higher for hospitals which provided a single year of inpatient data (Nepean Hospital, Royal North Shore Hospital and Westmead Hospital).

Annual costs were then calculated by multiplying the average episode costs by the number of episodes per year. This is equivalent to estimating the costs of ending episodes using the complete episodes.

Table 7: Breakdown of transplant episode by hospital

Hospital	Complete Episodes	Ending Episodes
St Vincent's Hospital	98.0%	2.0%
Westmead Hospital	89.2%	10.8%
Royal North Shore Hospital	92.9%	7.1%
Prince of Wales Hospital	96.4%	3.6%
Nepean Hospital	91.7%	8.3%
St George Hospital	100.0%	0.0%
Sydney Children's	96.8%	3.2%
Children's Hospital Westmead	99.0%	1.0%
All	**95.8%**	**4.2%**

6.5 Inclusion of outpatient data in the study dataset

The advice received during the clinical consultation process enabled a profile to be developed of typical patterns of outpatient care for BMT services (see Section 4). Whilst minor variations were noted between hospitals, an overall high level of consistency was reported.

For the costing process, a business rule was required around the period before and after transplantation that would determine which outpatient data would be included in the study dataset. This issue was discussed with the Study Reference Group and the NSW BMT Service Plan Development Working Party. It was agreed that subject to an analysis of the relevant data, a period of twelve months would be applied. The data received by hospitals confirmed that the vast majority of outpatient activity did occur within a twelve month period.

The study dataset for outpatient services was therefore developed on this basis. In applying this business rule, we recognise that the data provided by hospitals will not include all outpatient services for a twelve month period for all transplant patients. The same issues arise for outpatient services that were discussed in relation to related inpatient episodes in Section 6.3.

Again, we have considered this issue in the context of its likely impact on the study results. Our proposed approach is not to make any adjustments in the primary cost results that are reported. We have estimated a cost for that proportion of activity that is not available from the sites that have one and two year's data and have included this in the results reported in Section 7.3.

6.6 The final study data set

After the adjustments described above, the final study dataset comprised 16,960 records made up of:

- 508 BMT episodes
- 2,258 related inpatient episodes
- 7,485 outpatient medical, nursing and allied health clinic occasions of service
- 6,272 outpatient dispensed drugs
- 435 other outpatient treatments.

This dataset formed the basis of the cost estimates that are presented in the following section.

7 Analysis and results

As noted earlier, the project brief required the following questions to be addressed in relation to the cost of providing BMT services in NSW:

- What is the average per patient cost of autologous and allogeneic BMT?
- What is the breakdown of costs for each of these, in terms of the inpatient and ambulatory phase of treatment?
- Are there available costings from other States in Australia with which to compare, and if significantly different, why?
- What proportion of BMT costs do pharmaceuticals represent?
- What, if any, difference is there between costs for adult patients and paediatric BMT?
- What are the financial implications of the projected increase in BMT activity in NSW by 2011?

The study dataset contained a large volume of data with which to consider these questions. The results are set out below as follows:

Section 7.1 - Presents a profile and cost results for the 508 BMT transplant episodes in the study dataset;

Section 7.2 - Presents a profile and cost results for the 2,258 related inpatient episodes in the study dataset;

Section 7.3 - Presents a profile and related results for the 14,192 outpatient records included in the study dataset;

Section 7.4 - Discusses a set of costing issues that were identified during the study.

Section 7.5 - Presents a set of cost projections for NSW BMT services based on activity projection data provided by the NSW Department of Health

Section 7.6 - Combines all of the study results to present an overall profile of the cost of BMT services in NSW.

7.1 BMT episodes

A total of 508 transplant episodes were included in the BMT inpatient study dataset. We are confident this sample of transplant episodes is large enough to base the cost estimates that follow. As discussed in Section 5.2, we have adjusted the data to reflect the fact that data from different periods have been included in the dataset. These adjustments are noted in the remainder of this section where relevant.

The breakdown of the 508 episodes is shown in Table 8 below. This table shows episodes for all years for which data were provided by the eight hospitals. Of these 508 episodes, 60% were autologous and 40% allogeneic. The ratio of autologous to allogeneic transplants is consistent with levels of activity reported elsewhere.

Table 8: Number of transplant episodes in the study dataset

Hospital	Autologous	Allogeneic	Total Transplant Episodes	Number of Years of Source Data
St Vincent's Hospital	45	53	98	2
Westmead Hospital	26	57	83	1
Royal North Shore Hospital	39	17	56	1
Prince of Wales Hospital	28	0	28	3
St George Hospital	32	0	32	3
Nepean Hospital	12	0	12	1
Sydney Children's Hospital	48	45	93	3
Children's Hospital Westmead	52	54	106	3
Total	**282**	**226**	**508**	**17**

7.1.1 Allogeneic transplant episodes

Table 9 below presents length of stay data for the 226 allogeneic transplant episodes from the five hospitals that contributed to the study dataset.

Table 9: Allogeneic transplants - average length of stay

Hospital	No. of Episodes in study dataset	Mean LOS	Median LOS	Min	Max
St Vincent's Hospital	53	35	26	19	177
Westmead Hospital	57	37	31	4	90
Royal North Shore Hospital	17	23	21	16	35
Adult Hospitals*	**127**	**34**	**28**	**4**	**177**
Sydney Children's Hospital	45	54	42	4	202
Children's Hospital Westmead	54	82	62	16	254
Paediatric Hospitals	**99**	**69.49**	**47**	**4**	**254**

*Has been weighted to adjust for the number of year's data submitted by each hospital.

There is considerable variation in length of stay both within and between facilities which reflects variations in the clinical profile of patients. The considerably longer length of stay at the two paediatric facilities is notable but is consistent with the issues raised during the clinical consultation and discussed in Section 4.4. The longer length of stay at the paediatric hospitals confirms the view that the conditioning regime for children can be aggressive and is predominantly undertaken on an inpatient process and reflects the longer engraftment period associated with cord blood transplants.

Table 10 below shows the costs of allogeneic BMTs from the five hospitals that contributed to the study dataset. The most notable result is that for each hospital there is a large variation in cost between the least and most expensive episode. This finding was supported by the views expressed during the consultation about the clinical variation between individual BMT patients.

For this reason, it is sensible to examine the median, as well as the mean cost. For the adult hospitals, this shows a consistent result between the two hospitals that undertake unrelated transplants (St Vincent's and Westmead) and a slightly lower cost for Royal North Shore Hospital which undertakes only sibling related allogeneic transplants. The lower average cost per allogeneic transplant at Royal North Shore Hospital was expected. For the paediatric hospitals, the median cost is considerably higher that for the adult hospitals, but quite similar between the two hospitals.

Table 10: Allogeneic transplants - episode costs

Hospital	Mean Cost	Median Cost	Standard Deviation of Cost	Min	Max
St Vincent's Hospital	$85,853	$68,303	$56,404	$51,886	$403,549
Westmead Hospital	$92,440	$70,120	$73,816	$11,461	$402,035
Royal North Shore Hospital#	$65,368	$62,589	$22,730	$14,551	$116,207
Adult Hospitals*	**$86,124**	**$68,367**	**$61,942**	**$11,461**	**$403,549**
Sydney Children's Hospital	$144,184	$106,050	$125,161	$9,181	$679,370
Children's Hospital Westmead	$176,955	$115,956	$135,892	$41,571	$626,656
Paediatric Hospitals	**$161,986**	**$110,610**	**$131,320**	**$9,181**	**$679,370**

* Has been weighted to adjust for the number of year's data submitted by each hospital.
# Royal North Shore does not undertake unrelated BMTs.

As total episode costs are largely a function of length of stay, it is useful to examine costs on a per diem basis. Table 11 shows per diem costs for allogeneic transplants for the five hospitals that contributed to the study dataset. Again, for all hospitals, the considerable variation between the least and most expensive patient is consistent with comments provided during the clinical consultation. However, the median per diem cost is quite consistent across the five hospitals. The significant difference between adult and paediatric facilities is not evident here. Royal North Shore Hospital has a slightly higher median per diem cost than the other hospitals.

Table 11: Allogeneic transplants - per diem costs

Hospital	Mean Per Diem Cost	Median Cost	Standard Deviation of Cost	Min	Max
St Vincent's Hospital	$2,582	$2,566	$284	$2,132	$4,090
Westmead Hospital	$2,408	$2,372	$921	$782	$5,507
Royal North Shore Hospital#	$2,842	$2,956	$638	$728	$3,498
Adult Hospitals*	**$2,527**	**$2,522**	**$695**	**$728**	**$5,507**
Sydney Children's Hospital	$2,616	$2,587	$1,017	$1,358	$7,098
Children's Hospital Westmead	$2,340	$2,325	$467	$904	$3,575
Paediatric Hospitals	**$2,466**	**$2,447**	**$776**	**$904**	**$7,098**

* Has been weighted to adjust for the number of year's data submitted by each hospital.
** Royal North Shore does not undertake unrelated BMTs.

Table 12 below shows the average cost of each cost bucket across all five hospitals that contributed episodes to the study dataset. The cost buckets are the standard 'buckets' used in costing studies undertaken by the NSW Department of Health. This information is provided for each hospital individually in Appendix 3. Ward costs account for 36% of costs in adult hospitals and 37% of costs in paediatric hospitals. Pharmacy costs account for the second highest "bucket" of costs with 33% in adult hospitals and 25% in paediatric hospitals.

Table 12: Allogeneic transplants – average cost by cost bucket all hospitals

	Adult Hospitals*		Paediatric Hospitals	
Cost bucket	**Mean**	**% of Total**	**Mean**	**% of Total**
Ward costs	$31,232	36%	$60,623	37%
Pharmacy costs	$28,045	33%	$40,701	25%
ICU costs	$5,867	7%	$19,199	12%
Pathology costs	$5,748	7%	$9,629	6%
Medical costs	$5,435	6%	$12,840	8%
Oncosts	$3,849	4%	$6,010	4%
Allied health costs	$2,666	3%	$3,548	2%
Other costs	$2,626	3%	$7,570	5%
Imaging costs	$639	0.7%	$1,840	1%
Emergency dept costs	$17	0.02%	$26	0.02%
Total costs	**$86,124**	**100.00%**	**$161,986**	**100.00%**

*Has been weighted to adjust for the number of year's data submitted by each hospital.

We note that transportation costs related to specimens sent from a hospital without an appropriate laboratory and donor costs are not included in the cost buckets in Table 12 above. These costs would be very small relative to the overall cost of the episode. It is recognised however, that there remains a cost to the facilities affected. A donor may be managed as an outpatient or admitted, the collection may occur in a NSW hospital or outside of this State. As there is no unique DRG for admission of a stem cell donor it has not been possible to capture data relating specifically to donor collection in NSW hospitals.

7.1.2 Cost of 'matched sibling' versus 'other' BMT episodes

In addition to the above results, we examined cost differences between 'matched sibling' and 'other' transplant episodes. We note that we have compared 'matched sibling' episodes with 'all other' episodes rather than comparing 'related' and 'unrelated' episodes. The rationale for this was based on clinical advice that mismatched related donor episodes (such as haploidentical transplants) are more similar in terms of clinical complexity (and therefore cost) to unrelated transplants that matched sibling transplants. However, we also note that the proportion of mismatched related episodes in the 'other' group is very low.

Table 13 below shows the cost of matched sibling versus other transplants for each hospital. In terms of the mean cost per episode, the most notable finding is the significant difference between 'matched sibling' and 'other' transplant episodes in the two paediatric hospitals. The cost differential is similar for each hospital. There is a smaller, but noticeable mean cost difference between two of the adult hospitals. This cost difference for the adult hospitals is much less when the median cost per episode is compared.

Table 13 'Matched sibling' versus 'other' transplant episode costs

Hospital	*Sample size*		Mean cost		Median cost		Min cost		Max cost	
	Matched sibling	*Other*	Matched sibling	Other	Matched sibling	Other	Matched sibling	Other	Matched sibling	Other
Royal North Shore	*n = 14*	*n = 3*	$65,199	$66,157	$61,930	$67,713	$47,186	$14,551	$95,268	$116,207
Westmead	*n = 28*	*n = 24*	$85,913	$100,055	$69,538	$71,522	$21,112	$11,461	$402,035	$329,067
St Vincent's	*n = 17*	*n = 31*	$69,472	$94,835	$65,196	$69,459	$52,130	$51,886	$100,621	$403,549
Adult	***n=59***	***n=58***	**$76,261**	**$95,512**	**$65,758**	**$69,962**	**$21,112**	**$11,461**	**$402,035**	**$403,549**
Children's Westmead	*n = 16*	*n = 28*	$86,561	$228,609	$79,959	$160,860	$41,571	$82,316	$232,844	$626,656
Sydney Chilrdren's	*n = 16*	*n = 21*	$79,622	$193,374	$65,732	$169,860	$9,181	$45,483	$167,949	$679,370
Paediatric	***n=32***	***n=49***	**$83,092**	**$213,508**	**$79,541**	**$167,277**	**$9,181**	**$45,483**	**$232,844**	**$679,370**

Table 14 below presents the same comparison based on per diem costs. The results here suggest that there is very little difference in cost between matched sibling and other episodes on a per diem basis for any of the five hospitals. Similarly, there is also little difference in the mean or median per diem cost across the five hospitals. This is consistent with the results above and suggests that differences in cost primarily reflect variation in length of stay both between matched sibling and other transplant episodes and also between hospitals.

Table 14 'Matched sibling' versus 'other' transplant per diem costs

Hospital	*Sample size*		Mean per diem		Median per diem		Min per diem		Max per diem	
	Matched sibling	*Other*	Matched sibling	Other	Matched sibling	Other	Matched sibling	Other	Matched sibling	Other
Royal North Shore	*n = 14*	*n = 3*	$3,000	$2,102	$2,960	$2,257	$2,273	$728	$3,498	$3,320
Westmead	*n = 28*	*n = 24*	$2,299	$2,533	$2,275	$2,642	$782	$1,169	$5,507	$3,664
St Vincent's	*n = 17*	*n = 31*	$2,603	$2,563	$2,570	$2,550	$2,360	$2,132	$2,874	$4,090
Adult	***n=59***	***n=58***	**$2,553**	**$2,527**	**$2,570**	**$2,557**	**$782**	**$728**	**$5,507**	**$4,090**
Children's Westmead	*n = 16*	*n = 28*	$2,206	$2,439	$2,321	$2,392	$924	$1,486	$2,677	$3,575
Sydney Chilrdren's	*N = 16*	*n = 21*	$2,162	$2,962	$2,236	$2,745	$1,358	$1,487	$2,838	$7,098
Paediatric	***n=32***	***n=49***	**$2,184**	**$2,663**	**$2,278**	**$2,587**	**$924**	**$1,486**	**$2,677**	**$7,098**

7.1.3 Autologous transplants

Table 15 below shows length of stay statistics for the 282 autologous transplant episodes from the eight hospitals that contributed to the study dataset. Again, there is considerable variation between minimum and maximum average lengths of stay within each hospital. Whilst there is less variation in length of stay between hospitals than for allogeneic transplants, it is notable that Sydney Children's Hospital has a shorter median length of stay than any other hospital.

An analysis of the data from this hospital has identified a different length of stay distribution with a larger proportion of patients having a length of stay of between 1 and 3 days than at other hospitals. Our discussions suggest that this may result from differing coding practices whereby

episodes being assigned to the autologous AR-DRG at Sydney Children's Hospital are not being assigned to a BMT AR-DRG at other hospitals. This requires review as if this is the case this presents a confounding factor in this study. This will require clarification with possible follow-up action by NSW Health.

Table 15: Autologous transplants - average length of stay

Hospital	No. of Episodes	Mean LOS	Median LOS	Min	Max
St Vincent's Hospital	45	25	24	4	85
Westmead Hospital	26	27	22	3	98
Royal North Shore Hospital	39	29	21	3	185
Prince of Wales Hospital	28	21	19	2	56
St George Hospital	32	23	24	1	43
Nepean Hospital	12	22	20	12	35
Adult Hospitals*	**182**	**26**	**22**	**1**	**185**
Sydney Children's Hospital	48	16	5	1	86
Children's Hospital Westmead	52	20	11	1	88
Paediatric Hospitals*	**100**	**18**	**6.5**	**1**	**88**

* Has been weighted to adjust for the number of year's data submitted by each hospital.

Table 16 below shows the cost of autologous BMTs from the eight hospitals that contributed to the study dataset.

Table 16: Autologous transplants - episode costs

Hospital	Mean Cost	Median Cost	Standard Deviation of Mean	Min	Max
St Vincent's Hospital	$47,818	$39,739	$37,336	$10,279	$258,147
Westmead Hospital	$36,688	$32,344	$22,810	$9,622	$89,650
Royal North Shore Hospital	$48,892	$45,574	$24,464	$11,909	$128,039
Prince of Wales Hospital	$53,011	$41,674	$38,268	$4,066	$216,821
St George Hospital	$33,133	$35,081	$16,820	$3,330	$75,902
Nepean Hospital	$34,415	$28,252	$16,326	$14,804	$61,459
Adult Hospitals*	**$43,496**	**$38,616**	**$29,657**	**$3,330**	**$258,147**
Sydney Children's Hospital	$36,841	$12,026	$56,975	$1,076	$244,576
Children's Hospital Westmead	$38,117	$18,617	$34,733	$2,528	$151,782
Paediatric Hospitals*	**$37,505**	**$13,691**	**$46,479**	**$1,076**	**$244,576**

* Has been weighted to adjust for the number of year's data submitted by each hospital.

As expected, autologous transplants are considerably less expensive than allogeneic transplants. As some autologous patients have very short lengths of stay (1-2 days), there is again a large variation between the least and most expensive patient.

The median cost for autologous transplants actually shows more variation between hospitals than the allogeneic transplants. This will be caused partly by the fact that there are more hospitals in this group. The shorter mean length of stay at Sydney Children's Hospital is reflected in a correspondingly lower median cost here than at other hospitals, although this difference is not evident in the mean cost per transplant at this hospital.

There is no clear pattern to suggest that autologous transplants are more (or less) expensive in facilities that also undertake allogeneic transplants. This may have implications in a planning context.

Table 17 below shows the per diem costs of autologous transplant episodes from the eight hospitals that contributed to the study dataset.

Table 17: Autologous transplants - per diem costs

Hospital	Mean Per Diem Cost	Median Per Diem Cost	Standard Deviation of Mean	Min	Max
St Vincent's Hospital	$1,815	$1,862	$356	$1,381	$3,037
Westmead Hospital	$1,558	$1,638	$710	$655	$3,207
Royal North Shore Hospital	$2,117	$2,051	$518	$1,169	$3,970
Prince of Wales Hospital	$2,519	$2,303	$833	$1,731	$5,599
St George Hospital	$1,519	$1,452	$408	$1,028	$3,330
Nepean Hospital	$1,541	$1,729	$326	$1,188	$2,028
Adult Hospitals*	**$1,859**	**$1,859**	**$645**	**$655**	**$5,599**
Sydney Children's Hospital	$2,222	$2,189	$639	$1,076	$4,322
Children's Hospital Westmead	$2,143	$2,023	$572	$1,191	$4,769
Paediatric Hospitals*	**$2,181**	**$2,062**	**$603**	**$1,076**	**$4,769**

* Has been weighted to adjust for the number of year's data submitted by each hospital.

It can be seen that there is still considerable (but less than for allogeneic transplants) variation between the least and most expensive patient within hospitals. Between hospitals, there is greater variation in per diem cost than for allogeneic transplants. It is difficult to identify any particular pattern that could reasonably be explained by the range of BMT services provided at each hospital.

The two children's hospitals are very similar in terms of per diem cost. This confirms the lower median episode cost at Sydney Children's Hospital is a function of its shorter length of stay for autologous transplant patients. Prince of Wales has the highest per diem cost for autologous transplant patients. This may be the result of the coding issue raised above. At Prince of Wales Hospital only 4% of patients had a length of stay of less than 14 days, compared with Sydney Children's Hospital, for example, where 36% had a length of stay of less than 14 days.

Table 18 and Table 19 below show the cost of autologous transplants broken down by the two BMT AR-DRGs. As would be expected AR-DRG A08A (Autologous BMT with catastrophic complications or comorbidities) has a higher mean and median cost for all hospitals than AR-DRG A08B. Again, the cost of paediatric hospitals is higher than for the adult hospitals. There is no particular difference in the cost of autologous transplants at the three hospitals that also undertake allogeneic transplants. In fact, the cost at Prince of Wales is higher than at any other adult hospital.

*Table 18: Autologous transplant costs - AR-DRG AO8A***

Hospital	Mean Cost	Median Cost	Standard Deviation of Mean	Min	Max
St Vincent's Hospital	$59,123	$48,503	$45,509	$37,152	$258,147
Westmead Hospital	$38,563	$20,540	$27,715	$9,622	$89,650
Royal North Shore Hospital	$57,605	$51,541	$24,330	$21,791	$128,039
Prince of Wales Hospital	$68,086	$51,866	$47,530	$33,700	$216,821
St George Hospital	$40,510	$38,621	$13,954	$22,130	$75,902
Nepean Hospital	$46,375	$47,081	$12,185	$28,252	$61,459
Adult Hospitals*	**$51,913**	**$42,649**	**$33,882**	**$9,622**	**$258,147**
Sydney Children's Hospital	$102,023	$76,723	$74,885	$13,562	$244,576
Children's Hospital Westmead	$60,012	$66,980	$28,968	$8,034	$100,600
Paediatric Hospitals*	**$80,240**	**$69,939**	**$58,867**	**$8,034**	**$244,576**

*Has been weighted to adjust for the number of year's data submitted by each hospital.
**AR-DRG AO8A = Autologous Bone Marrow Transplant with catastrophic complications or comorbidities.

For AR-DRG AO8B (no complications of comorbidities), Table 19 shows a high level of consistency in terms of mean cost and median cost across the adult hospitals. Here, both the paediatric hospitals have a lower median cost than the adult hospitals. We would suggest that the noticeable difference in mean cost between the paediatric hospitals is a reflection of the higher proportion of patients with a very low length of stay at Sydney Children's Hospital that would mostly be assigned to this AR-DRG.

*Table 19: Autologous transplant costs - AR-DRG AO8B***

Hospital	Mean Cost	Median Cost	Standard Deviation of Mean	Min	Max
St Vincent's Hospital	$34,817	$30,350	$18,730	$10,279	$109,043
Westmead Hospital	$34,251	$32,572	$15,363	$11,135	$57,331
Royal North Shore Hospital	$29,883	$30,177	$9,687	$11,909	$49,471
Prince of Wales Hospital	$36,777	$38,000	$13,226	$4,066	$59,468
St George Hospital	$22,352	$27,416	$15,056	$3,330	$42,726
Nepean Hospital	$20,063	$21,384	$2,952	$14,804	$21,719
Adult Hospitals	**$30,643**	**$30,212**	**$15,472**	**$3,330**	**$109,043**
Sydney Children's Hospital	$11,164	$9,380	$7,479	$1,076	$34,189
Children's Hospital Westmead	$29,602	$13,131	$33,331	$2,528	$151,782
Paediatric Hospitals	**$39,640**	**$11,820**	**$26,157**	**$1,076**	**$151,782**

*Has been weighted to adjust for the number of year's data submitted by each hospital.
**AR-DRG AO8B = Autologous Bone Marrow Transplant without catastrophic complications or comorbidities

Table 20 below shows the average cost of each cost bucket across all five hospitals that contributed episodes to the study dataset. This information is provided for each hospital individually in Appendix 4.

The results show that ward and pharmacy costs comprise the vast majority of total costs. As was expected, pharmacy costs represent a higher proportion of total costs than most other AR-DRGs. The relatively small proportion of costs (4%) related to intensive care services in adult hospitals confirms the expectations expressed in the clinical consultations. This proportion was 11% in paediatric hospitals, which was also in line with expectations expressed in the clinical consultations.

Table 20: Autologous transplants - cost by cost bucket

Hospital	Adult hospitals*		Paediatric hospitals	
	Mean	% of Total	Mean	% of Total
Ward costs	$18,360	42%	$14,636	39%
Pharmacy cost	$13,240	30%	$8,071	22%
Pathology costs	$2,640	6%	$2,103	6%
Medical cost	$2,087	5%	$3,522	9%
Oncosts	$1,840	4%	$1,327	4%
ICU costs	$1,648	4%	$4,058	11%
Other costs	$1,573	4%	$2,252	6%
Allied Health costs	$1,331	3%	$953	3%
Imaging costs	$725	2%	$584	2%
Total cost	**$43,496**	**100%**	**$37,505**	**100%**

*Has been weighted to adjust for the number of year's data submitted by each hospital.

7.1.4 Estimated annual cost of transplant episodes

The annual cost of transplantation episodes (allogeneic and autologous) is presented in Table 21 and Table 22. The average number of transplants per year is multiplied by the average cost per transplant (values in Table 21) to produce an estimate of the total cost of transplants as shown in Table 22. It shows that total annual expenditure on BMT transplants at the study hospital's is $19.67m per annum comprising $12.62m spent on allogeneic transplants and $7.05m spent on autologous transplants.

Table 21: Average annual cost of transplant episodes

Hospital	Average Number of Allogeneic Transplants per Year	Average Number of Autologous Transplants per Year	Average Cost per Allogeneic Transplant*	Average Cost per Autologous Transplant*
St Vincent's Hospital	27	23	$85,853	$47,818
Westmead Hospital	57	26	$92,440	$36,688
Royal North Shore Hospital	17	39	$65,368	$48,892
Prince of Wales Hospital	0	9	$0	$53,011
St George Hospital	0	11	$0	$33,133
Nepean Hospital	0	12	$0	$34,415
Sydney Children's Hospital	15	16	$144,184	$36,841
Children's Hospital Westmead	18	17	$176,955	$38,117

*Average here refers to the mean cost per transplant and not than the median cost.

Table 22: Total annual cost of transplant episodes

Hospital	Total Annual Cost Allogeneic Transplants	Total Annual Cost Autologous Transplants	Total Annual Cost All Transplants
St Vincent's Hospital	$2,318,031	$1,099,814	$3,417,845
Westmead Hospital	$5,269,080	$953,888	$6,222,968
Royal North Shore Hospital	$1,111,256	$1,906,788	$3,018,044
Prince of Wales Hospital	$0	$477,099	$477,099
St George Hospital	$0	$364,463	$364,463
Nepean Hospital	$0	$412,980	$412,980
Sydney Children's Hospital	$2,162,760	$589,456	$2,752,216
Children's Hospital Westmead	$3,185,190	$660,695	$3,845,885
Total	**$14,046,317**	**$6,465,183**	**$20,511,500**

7.2 Related inpatient episodes

A total of 3,663 episodes were included in the initial related inpatient episode dataset. Of these, 1,405 episodes were excluded from further analysis in line with the adjustments discussed in Sections 5 and 6. This left 2,258 related inpatient episodes in the study dataset.

Table 23 below shows the total number of related inpatient episodes relative to the number of transplant episodes. The numbers in this table have not been adjusted for the fact that different hospitals contributed data for different periods. The frequency of related inpatient episodes per transplant is higher at both paediatric hospitals as well as being very similar between these hospitals. This finding is consistent with advice received during the clinical consultation process about the need for a greater proportion of services to be provided to children on an inpatient basis.

Table 23: Number of related inpatient episodes

Hospital	Number of Transplant Episodes	Number of Related Inpatient Episodes
St Vincent's Hospital	98	527
Westmead Hospital	83	119
Royal North Shore Hospital	56	85
Prince of Wales Hospital	28	216
St George Hospital	32	74
Nepean Hospital	12	30
Sydney Children's Hospital	93	638
Children's Hospital Westmead	106	569
Total	**508**	**2258**

Table 24 below shows the average number of related inpatient episodes per patient. The proportion of patients that had at least one related inpatient episode varied from 58% at Westmead Hospital to 92% at Nepean Hospital. The number of related inpatient episodes per patient is also greater at the two paediatric hospitals.

Table 24: Average number of related inpatient episodes

Hospital	Total Transplant Episodes	Number of Patients with Related Inpatient Episode	Average Number of Related Inpatient Episodes per Patient
St Vincent's Hospital	98	76	6.9
Westmead Hospital	83	48	2.5
Royal North Shore Hospital	56	35	2.4
Prince of Wales Hospital	28	24	9.0
St George Hospital	32	28	2.6
Nepean Hospital	12	11	2.7
Sydney Children's Hospital	93	68	9.4
Children's Hospital Westmead	106	82	6.9
All	**508**	**365**	**6.5**

As discussed in Section 6.3, the annual cost and number of episodes are slightly underestimated for hospitals that submitted data for one year as they are missing a higher proportion of episodes outside the reporting period.

Table 25 below shows the average length of stay, including and excluding sameday episodes by hospital. This shows a surprising variation in the proportion of sameday related inpatient episodes across adult hospitals. This may be a reflection of administrative practices and/or clinical management preferences. The particularly high proportion of sameday episodes at St Vincent's Hospital is partly due to one patient with renal failure that had a large number of same day episodes during the study period. The paediatric hospitals have less variation in their respective proportions of same day episodes.

Table 25: Average length of stay - related inpatient episodes

Facility	Average Length of Stay All Episodes	Average Length of Stay Excluding Same Day Episodes	Percentage of Same Day Episodes
St Vincent's Hospital	3.5	14.0	81
Westmead Hospital	6.3	10.2	42
Royal North Shore Hospital	8.5	9.6	13
Prince of Wales Hospital	2.0	5.3	76
St George Hospital	4.9	5.4	11
Nepean Hospital	7.8	9.9	23
Sydney Children's Hospital	5.4	9.1	46
Children's Hospital Westmead	5.6	8.4	38
All	**5.1**	**10.1**	**51.4**

7.2.1 Annual cost of related inpatient episodes

The above results highlight the importance of examining the casemix of related episodes to understand their associated costs. Table 26 below show the twenty most expensive AR-DRGs in terms of total cost across all hospitals. Here, episode costs have been adjusted to reflect the average annual cost of related inpatient episodes. It can be seen that the most expensive AR-DRG was Q60A Reticuloendothelial and Immunity Disorders W Catastrophic or Severe CC. Advice from clinical and casemix staff confirm that this DRG is where episodes related to GVHD are most commonly recorded. provides the same information for all AR-DRGs.

Table 26: Related inpatient episodes - Top 20 AR-DRGs by cost

DRG	DRG Description	Number of Episodes	Total Cost	Per Diem Cost	Average Length of Stay
Q60A	Reticuloendothelial and Immunity Disorders W Catastrophic or Severe CC	45.3	$912,264	$1,415	14.22
R60A	Acute Leukaemia W Catastrophic CC	14.8	$741,796	$2,111	23.7
R60C	Acute Leukaemia W/O Catastrophic or Severe CC	181.8	$665,420	$1,644	2.2
R61B	Lymphoma and Non-Acute Leukaemia W/O Catastrophic CC	86.3	$594,017	$1,513	4.5
A06Z	Tracheostomy or Ventilation >95 hours	4.2	$362,841	$2,452	35.5
T60A	Septicaemia W Catastrophic or Severe CC	23.5	$326,041	$1,672	8.3
R61A	Lymphoma and Non-Acute Leukaemia W Catastrophic CC	11.3	$310,478	$1,568	17.5
R60B	Acute Leukaemia W Severe CC	19.8	$266,755	$1,524	8.8
T62A	Fever of Unknown Origin W CC	29.0	$244,690	$1,537	5.5
R03A	Lymphoma and Leukaemia with other OR procedures W catastrophic or severe CC	4.2	$181,917	$1,487	29.4
B66B	Nervous System Neoplasm W/O Catastrophic or Severe CC	31.0	$140,497	$1,489	3.0
B60B	Established Paraplegia/Quadriplegia W or W/O O.R. Procs W/O Catastrophic CC	1.0	$136,776	$1,169	117.0
B02A	Craniotomy W Catastrophic CC	1.0	$124,249	$2,845	43.7
B66A	Nervous System Neoplasm W Catastrophic or Severe CC	11.0	$119,202	$1,568	6.9
F75B	Other Circulatory System Diagnoses W Severe CC	9.3	$97,569	$1,517	6.9
E62B	Respiratory Infections/Inflammations W Severe or Moderate CC	6.5	$79,850	$1,369	9.0
Q60B	Reticuloendothelial and Immunity Disorders	9.0	$76,778	$1,525	5.6

DRG	DRG Description	Number of Episodes	Total Cost	Per Diem Cost	Average Length of Stay
	W/O Cat or Severe CC W Malignancy				
R61C	Lymphoma and Non-Acute Leukaemia, Same Day	128.7	$71,729	$557	1.0
G02A	Major Small and Large Bowel Procedures W Catastrophic CC	1.0	$70,473	$1,499	47.0
Other DRGs		377.8	$2,305,165	$796	7.8
All		**996.5**	**$7,828,507**	**$1,538**	**4.9**

The number of related inpatient episodes per transplant was slightly less than anecdotal estimates. Our analysis of the ICD 10 diagnosis data suggests that many of the complications arising from transplantation are actually dealt with during the BMT episode. This appears to be the case with acute GVHD. Nevertheless, after the data were adjusted, there were still a total 996 related inpatient episodes during the study period representing a cost of $7.82m. The top twenty AR-DRGs accounted for $5.52m or 71% of this amount.

The information on related inpatient episodes is consolidated in Table 27 below to provide an estimate of the annual cost of related inpatient episodes at each hospital. This has been calculated as the average number of episodes per year at each hospital multiplied by the average cost per patient of a related inpatient episode at that hospital.

Table 27: Annual cost of related inpatient episodes

Hospital	Average Number of Related Inpatient Episodes per Year	Average Cost per Related Inpatient Episode	Average Annual Cost of Related Inpatient Episodes
St Vincent's Hospital	264	$4,435	$1,168,626
Westmead Hospital	119	$9,247	$1,100,357
Royal North Shore Hospital	85	$10,176	$864,954
Prince of Wales Hospital	72	$2,063	$148,544
St George Hospital	25	$7,031	$173,437
Nepean Hospital	30	$9,373	$281,182
Sydney Children's Hospital	213	$9,770	$2,077,682
Children's Hospital Westmead	190	$10,375	$1,967,792

* As discussed in Section 6.3, the annual cost and number of episodes are slightly underestimated for hospitals that submitted data for one year as they are missing a higher proportion of episodes outside the reporting period.

The number of related inpatient episodes per year and the average cost of these episodes varies between hospitals. This is not surprising given the differences in length of stay (including the proportion of same day episodes) noted above. Overall, however, the results show a very consistent result by type of hospital and BMT service provided. The average annual cost of related inpatient episodes is very similar at St Vincent's and Westmead Hospitals, the two hospitals that provide adult unrelated allogeneic transplants. This similarity was also evident in the cost of allogeneic transplants at these hospitals.

Further, the cost of related inpatient episodes is similarly less at Royal North Shore Hospital, which does not undertake unrelated BMTs. As would be expected, the annual cost of related inpatient episodes at the three adult hospitals that provide only autologous transplant is significantly less than for the other hospitals.

The annual cost of related inpatient episodes at the two paediatric hospitals is significantly higher that for the adult hospitals. Again, this mirrors the experience of the transplant episodes. Costs are also very similar at each hospital in terms of total annual cost, number of annual episodes and average cost per episode.

7.3 Outpatient analysis and results

Outpatient services play a critical part in the process of providing BMT services. Whilst they represent a smaller proportion of total costs than inpatient services, they are often provided over a longer period of time. In some cases, such as drugs, they can also represent an ongoing cost to hospitals.

A range of services are provided in outpatient clinics. Whilst these clinics predominantly involve patients being seen by BMT Physicians, services are also provided by allied health and nursing staff. In some cases, clinics operate specifically for BMT patients. In other cases, BMT patients are seen in general outpatient clinics.

Hospitals were asked to provide activity and cost data on the range of outpatient services provided to BMT patients (as outlined in Section 5.5). Seven of the eight hospitals provided data to form a study dataset that comprised 7,485 outpatient clinic attendances, 6,272 dispensed drugs, 1,087 diagnostic tests and 435 other outpatient treatments. As was the case with inpatient data, different hospitals also provided outpatient data across different time periods. In most cases, this covered the same period as the inpatient data.

All but one hospital (that provides a low volume of adult autologous transplants) provided costed patient level data for drugs dispensed in the outpatient setting. This is important as it represents a large outpatient cost and potentially varies significantly between hospitals. For the other services, the availability of outpatient data was substantially less than for inpatient services. A small number of hospitals were able to provide costed activity data for most outpatient services identified above. However, most hospitals were able to provide activity data for only some of the above services and very few hospitals were able to provide detailed cost data.

The following is a summary of the data that were obtained for each outpatient service area and the approach that was applied in developing corresponding cost estimates.

Drug costs

The cost of each outpatient drug dispensed to each BMT patient during the study period was available for inclusion in the study dataset. Data from each hospital were collated into a single data set and records which occurred outside of the reporting period were removed. Records were kept if the date that a drug was dispensed occurred either within 60 days prior to transplant or within 365 days post transplant. Any records that fell during a transplant episode or a related inpatient episode as well as records which could not be linked by MRN with a transplant episode were excluded.

Outpatient clinic costs

Six of the eight hospitals were able to provide details of the number of occasions of service, duration of service and relevant clinic details. However, only two hospitals were able to provide cost estimates at the occasion of service level.

For one hospital, the cost data were based only on the hourly salary rate of the clinician attending the clinic. For the other hospital, the cost data were based on the hourly salary rate of the clinician plus the overhead costs of the relevant clinical department. The data from the second hospital clearly represented a more comprehensive estimate of the total cost of operating an outpatient clinic.

This information was used to develop hourly rates for medical, nursing and allied health outpatient clinic attendances. These rates were discussed with staff from the other hospitals to determine if they could reasonably be applied across all hospitals. The emerging view was that this would be a reasonable approach given the lack of routinely available cost data.

On this basis, an hourly rate of $78 for nursing and allied health and $301 for medical occasions of service was applied to the 7,485 occasions of service in the study dataset.

Outpatient treatments

The outpatient data received from hospitals included a relatively small number of treatment services such as intravenous drug infusions that were provided in an outpatient setting. The duration of these treatments was not provided. For costing purposes, we have applied a duration of 60 minutes and used the nursing hourly rate, as clinical advice indicated that these treatments would normally be undertaken by nursing staff. These treatments represent less that $50,000 in cost across all hospitals and have been included in outpatient clinic cost results.

Diagnostic tests

Three of the eight hospitals were able to provide details of pathology and/or diagnostic imaging services provided to BMT patients on an outpatient basis. The data from these facilities confirms that this does not represent a large cost component for BMT patients.

The method developed to cost diagnostic tests (as a component of outpatient services) was derived from a review of these data and advice provided during clinical consultations regarding the likely range of diagnostic tests that a BMT patient would receive. We note that clinicians consistently advised that whilst there was an accepted range of tests required during the "work up" phase pre BMT, the additional diagnostic tests required by patients' pre transplant would be dependent on the clinical status and underlying condition of each patient.

In addition, whilst most routine post transplant outpatient visits would generate a similar range of diagnostic tests, each patient may require more complex diagnostic procedures based on clinical progress and their underlying condition. It was suggested however, that all BMT patients would have a more comprehensive review of their progress (which means potentially more diagnostic investigations) at least once within the twelve month period post BMT.

Based on the data received from hospitals and the clinical advice received during the consultation, diagnostic profiles were developed for each of the following:

- Routine pre transplant outpatient occasion of service
- Pre transplant work up outpatient occasion of service
- Routine post transplant outpatient occasion of service
- Extended post transplant outpatient occasion of service

In the absence of reliable cost data from a sufficient sample of hospitals, the Commonwealth Medical Benefits Schedule was used as a proxy for cost. Where service utilisation data was available from hospitals, it was used to form a template for the number of diagnostic tests in each of the above categories of activity. This resulted in an estimated total cost of outpatient diagnostic tests for each hospital. As this methodology is less robust than other elements of the study, they are deliberately conservative in terms of over estimating the range and number of diagnostic tests likely to be undertaken.

Further, as this approach involves some assumptions, we have not attempted to separately cost adults and children or allogeneic and autologous transplants. It is recognised that paediatric patients (particularly those who have myeloblative conditioning protocols), may require more frequent and complex diagnostic tests post transplant to assess the impact of chemotherapy toxicity on their growth and development.

7.3.1 Outpatient cost results

The results of the outpatient costing process are presented in Table 28 and Table 29 below for allogeneic and autologous patients respectively. Overall, the results are consistent with anecdotal expectations - with total cost at each facility largely reflecting the volume of activity that is undertaken.

There is some variation in the annual cost of outpatient clinics between the two paediatric hospitals. This may reflect a higher volume of clinic activity at Children's Hospital Westmead or may suggest that the outpatient clinic data from Sydney Children's Hospital is incomplete.

Table 28: Average annual cost of outpatient services - allogeneic transplant patients

Hospital	Annual Cost Outpatient Clinics	Annual Cost Drugs	Annual Cost Diagnostics	Annual Total
St Vincent's Hospital	Data unavailable	$103,246	$89,032	$192,278
Westmead Hospital	$63,634	$243,063	$191,503	$498,200
Royal North Shore Hospital	$97,096	Data unavailable	$57,115	$154,211
Adult hospitals	**$160,730**	**$346,309**	**$337,650**	**$844,689**
Sydney Children's Hospital	$36,726	$175,937	$50,396	$263,059
Children's Hospital Westmead	$49,643	$68,478	$33,597	$151,718
Paediatric hospitals	**$86,369**	**$244,415**	**$83,993**	**$414,777**

Table 29: Average annual cost of outpatient services - autologous transplant patients

Hospital	Annual Cost Outpatient Clinics	Annual Cost Drugs	Annual Cost Diagnostics	Annual Total
St Vincent's Hospital	Data unavailable	$57,669	$75,593	$133,262
Westmead Hospital	$9,643	$47,005	$87,352	$144,000
Royal North Shore Hospital	$68,303	Data unavailable	$131,028	$199,331
St George Hospital	$9,829	$28,798	$35,837	$74,464
Nepean Hospital	$15,134	$8,579	$40,316	$64,029
Adult Hospitals	**$102,909**	**$142,051**	**$370,126**	**$615,086**
Sydney Children's Hospital	$22,283	$81,177	$53,755	$157,215
Children's Hospital Westmead	$94,506	$71,726	$77,273	$243,505
Paediatric Hospitals	**$116,789**	**$152,903**	**$131,028**	**$400,720**

7.3.2 Pharmaceutical costs

Pharmaceuticals represent a significant component of the cost of BMT services. For this reason, in addition to the data used for the primary costing, hospitals were asked to provide a breakdown of individuals prescriptions issued to patients that received a BMT during the study period and any available documentation relating to BMT regimen' that are routinely used.

As expected, only some hospitals were able to provide the very detailed information required to undertake an analysis by individual drugs. However, we have undertaken an exploration of the

available data. Drugs are grouped into pharmacological categories and Table 30 below shows the proportion of annual inpatient and outpatient drug expenditure by hospital and category for the four hospitals that provided data in this area. We would note the following points in relation to this analysis:

- The data includes both inpatient and outpatient drugs;
- The results reported here do not include any drugs dispensed through a hospital imprest system;
- The analysis here includes all drug records provided by hospitals. That is, no records have been excluded on the basis of the business rules used in the primary costing;
- Only the top 20 most expensive drugs were categorised - other drugs are included in the other category;
- Where hospitals provided data for more than one year, the proportions have been averaged to reflect an annual amount.
- The number of years data provided by hospitals may have a slight impact on the distribution between categories.

Table 30: Drug cost by type by hospital

Pharmacological Category	St Vincent's Hospital	Westmead Hospital	Sydney Children's Hospital	Children's Hospital Westmead
Antifungals	22%	39%	26%	27%
Antivirals	5%	9%	17%	11%
Antibiotics	1%	4%	12%	2%
Immunosuppressants	18%	15%	13%	5%
Colony Stimulating Factors	15%	13%	7%	22%
Monoclonal Antibodies	5%	7%	5%	0%
Chemotherapy Drugs	28%	6%	5%	17%
Nutrition	0%	0%	10%	2%
Others	6%	7%	6%	13%
Total	**100%**	**100%**	**100%**	**100%**

The following points summarise the key findings that arose from this analysis:

Adult hospitals

- There are significant differences in the use of antifungals (Westmead) and chemotherapy agents (St Vincent's) otherwise there is reasonable similarity on a per patient basis;
- The high cost of antifungal agents is heavily influenced by the liposomal delivery of amphotericin as well as the general expense of triazole drugs;
- The use of the chemotherapy drugs is relatively inexpensive in comparison with anti infective agents;
- Parenteral Nutrition is rarely listed in the adult hospitals;
- A lower than expected proportion of drugs were listed under Section 100.

Paediatric

- The two paediatric hospitals are similar in antifungal drug use;
- According to the data provided monoclonal antibodies are rarely used at the Children's Hospital Westmead while colony stimulating factors are three times more significant than at Sydney Children's Hospital.
- A lower than expected proportion of drugs were listed under Section 100.

7.3.3 BMT Laboratory costs

As noted previously there are eight specialist BMT laboratories servicing the fifteen hospitals that provide blood and marrow transplants. These laboratories process and store the stem cells used in BMT. To formulate a costing methodology for this cost component, advice was sought from the Blood and Marrow Transplantation Cost Study Reference Group. This group supplied a copy of information collated by the BMT Network NSW Executive Group in 2003 which provided an estimated costing for 'processing and cryopreservation of autologous PBCS'. This information was subsequently revised using 2007 dollar values.

Further information was obtained from the *NSW Blood and Marrow Transplantation Service Plan (Working Draft – Sep 2008)* on the number of stem cell collections per transplant per hospital, performed by each respective BMT laboratory during 2007. Information was also gathered on the relevant Medicare item numbers for common procedures performed by all eight BMT laboratories in NSW, and information on the associated fee obtained from a search of the Commonwealth Medical Benefits Schedule, (this is summarised in Table 31 below).

Table 31 Medicare items for procedures commonly performed in NSW BMT laboratories

Item Number	Description	MBS Fee
13760	In vitro processing (and cryopreservation) of bone marrow or peripheral blood for autologous stem cell transplantation	$ 704.60
71146	Enumeration of CD34+ cells, only for the purposes of autologous or allogeneic haemopoietic stem cell transplantation, including a total white cell count on the aphaeresis collection*	$ 105.85

* This test is performed 3 times per patient (morning PB CD34 test, bag CD34 count and thawed pilot vial CD34 counts)=$317.55

This information shows that a laboratory performing one common autologous cryopreservation procedure would be eligible for approximately $ 1022.15 from Medicare. This fee does not represent the full cost of staff time needed to process a product, storage and maintenance of cells in liquid nitrogen tanks, other compulsory tests required to be performed on each product like microbial studies, confirmatory blood group testing, colony assays etc.

Additional expert advice was sourced from the Scientific Director, Sydney Cellular Therapies Laboratory at Westmead Hospital as this laboratory receives the highest number of stem cell products for processing, manipulation and storage per year in NSW.

The Sydney Cellular Therapies Laboratory at Westmead Hospital represents the spectrum of laboratory work required in BMT. For example:

- Products collected are use in autologous, allogeneic and unrelated transplants
- Products used for transplantation include bone marrow, peripheral blood stem cells and cord blood
- Products used are specifically intended for adults and paediatric transplant patients in NSW
- Procedures performed in this laboratory include routine and specialised procedures (such as CD34+ selection procedures)
- A full time BMT Laboratory service is provided for other BMT hospitals in NSW (other than an on-site service)

Data were examined for this laboratory for the previous three years, demonstrating consistent cost patterns. The cost information supplied incorporated the running costs of the laboratory such as: staff, consumables and reagents, equipment and maintenance as well as the routine tests performed on each product.

The laboratory cost per product was calculated to be $2085 for the Sydney Cellular Therapies Laboratory at Westmead Hospital for 2007/08. This figure is considered a realistic estimate of the current cost of cell processing across NSW BMT laboratories. On this basis, it has been used to generate current cost estimates. Activity data from 2007 has been used in this calculation. The

results are shown in Table 32 by hospital and by laboratory. It shows the annual BMT laboratory costs for NSW as being $1.651M. We note that all eight BMT laboratories have been included in this Table.

Table 32 BMT laboratory costs estimated by volume of products processed in 2007

Laboratory	Hospital utilising laboratory	Number of products		Total cost per annum	
		Per Hospital	Total per laboratory	Per Hospital	Total per laboratory
Westmead	Children's Hospital	65		$135,532	
	Westmead	105		$218,936	
	Nepean	15		$31,277	
	Wollongong	41	226	$85,489	$471,233
St Vincent's	St Vincent's	118		$246,042	
	Gosford	14	132	$29,191	$275,233
Royal Prince Alfred	Royal Prince Alfred	63		$131,361	
	Concord	24	87	$50,042	$181,404
Sydney Children's	Sydney Children's	57		$118,851	
	Prince of Wales	19	76	$39,617	$158,468
Royal North Shore	Royal North Shore	155	155	$323,191	$323,191
Liverpool	Liverpool	51	51	$106,340	$106,340
St George	St George	20	20	$41,702	$41,702
Calvary Mater Newcastle	Calvary Mater Newcastle	42		$87,574	
	John Hunter Children's	3	45	$6,255	$93,830
Total		**792**	**792**		**$1,651,399**

7.4 Costs not included in this study

This study has aimed to cost the primary activities associated with the provision of BMT services in NSW. As the study had a limited scope and timeframe, it was not possible to capture data on the full range of activities associated with BMT services. In particular some indirect services have not been included. We have identified these services below. We would note, however, that there was a wide range of views expressed during the study about whether it is appropriate to include these activities in a costing study of BMT services.

Services on which cost data was not captured in this study:

- costs attributable to cell processing, transport and storage borne by the treating hospital;
- costs associated with pre transplant genetics and/or research;
- family members who travel and stay close to the patient for long periods of time in accommodation that may be provided in association with hospitals;
- blood and blood products;
- tissue typing (particularly extended tissue typing);
- costs associated with donor stem cell collection (for NSW, national and international transplant recipients);
- ‘rainy day harvests’;
- patients prepared for transplant who do not then proceed to transplant;

- Haematology/oncology units in large rural centres which have met the costs of work-up and the costs of post transplant management (particularly drug costs) even though the transplant episode may not have occurred in this facility;
- parts of the patient journey for selected interstate patients;
- outpatient consultations or community outreach services provided by non BMT physicians/clinicians;
- additional patient education and support programs;
- specialty bone marrow services that may be unique to one facility e.g. the Australasian Bone Marrow Transplant Recipient Registry at St. Vincent's Hospital;
- service development elements of bone marrow services that are provided by NSW Health e.g. the Greater Metropolitan Clinical Taskforce Bone Marrow Transplant Network;
- treatment that may be provided interstate e.g. provision of extracorporeal phosphoresis by the Peter McCallum Cancer Centre;
- costs involved in the ongoing treatment of chronic GVHD post 365 days transplant which applies to a significant proportion of allogeneic transplant patients long term treatment.

7.4.1 Revenue

We have not undertaken a detailed review of sources of revenue associated with BMT services as this was outside the terms of reference for this project. We would, however note the following two points that were identified during the consultation stage of the project.

- All BMT hospitals indicated that the vast majority of outpatient services provided to BMT patients are billed to Medicare. Further, some hospitals indicated that at some point following transplantation, patients may be seen in doctor's private rooms. In this latter case, both the cost and the activity would have been excluded from this study.

- Very few patients that receive a BMT are treated as private inpatients. While this proportion is much lower than the actual proportion in the population, it is not uncommon for persons requiring expensive and long-standing health care to elect non-chargeable status.

7.5 Estimated cost of BMT projections in NSW

The NSW Department of Health is currently working with the NSW BMT Service Plan Development Working Group to develop a Statewide plan for BMT services. We have applied the results of this study to produce cost estimates base on the current projections developed by this group.

In producing these estimates, we would make the following points:

- Our costing is based on the projections set out on page 49 of the NSW Blood and Marrow Transplantation Service Plan dated September 2008.

- We have not attempted to adjust the average cost per patient other than keeping constant dollars. The Service Plan document indicates that costs can be expected to rise with new technology but quantification of the effect of that technology is not provided. It was also beyond the scope of our study to attempt to cost these potential changes.

- The projections indicate an increase in unrelated BMT relative to related donors. This implies a higher cost because of the higher price of the unrelated transplants. This change has not been factored into our costing.

- The projections imply but do not explicitly state that both autologous and allogeneic BMT for paediatric cases are expected to be constant over time.

Table 33 below provides an estimate of the cost of BMT services in NSW based on constant 2007 dollars and constant real cost per patient. Estimated costs for 2011 are $46.84m which will increase in 2016 to $53.92m.

Table 33: Projections for BMT for NSW residents

Transplant Type	2006/07 Cost per transplant	*2011 NSW Total cost*	*2016 NSW Total cost*
Adult Allogeneic	$114,316	$16,118,556	$18,747,824
Adult Autologous	$62,812	$18,843,600	$23,303,252
Paediatric Allogeneic	$227,286	$7,955,010	$7,955,010
Paediatric Autologous	$119,367	$3,581,010	$3,581,010
TOTAL		**$46,498,176**	**$53,587,096**

7.6 Summary of results

This section consolidates the earlier results to provide an overall estimate of the current cost of BMT services in NSW. These results are presented separately for allogeneic and autologous services and for adult and paediatric hospitals.

Firstly, Table 34 shows the total annual cost for allogeneic transplants including the transplant episode, related inpatient episodes and outpatient services. The average number of BMTs at each hospital and the cost per BMT is also shown. Total expenditure on the 134 allogeneic transplants undertaken annually is $19.04m of which $14.04m is spent on transplant episodes, $3.74m on related inpatient episodes and $1.26 m on outpatient services.

The average cost of an adult allogeneic transplant is $114,316 compared with a paediatric transplant with an average cost of $227,286. In our view, the large difference in cost between adult and paediatric transplants means that there is little value in considering the overall average cost of an allogeneic transplant. However, it is shown here ($142,137) for the sake of completeness.

Table 34: Total annual costs of allogeneic transplant – study dataset

Hospital	Annual BMT	Annual RIE	Annual Outpatient	Total Annual	Number BMTs/Year	Cost Per BMT
St Vincent's Hospital	$2,318,031	$743,452	$192,278	$3,253,761	27	$120,510
Westmead Hospital	$5,269,080	$934,157	$498,200	$6,701,437	57	$117,569
Royal North Shore Hospital	$1,111,256	$325,234	$154,211	$1,590,701	17	$93,571
Adult Hospitals	**$8,698,367**	**$2,002,843**	**$844,689**	**$11,545,899**	**101**	**$114,316**
Sydney Children's Hospital	$2,162,760	$1,135,285	$263,059	$3,561,104	15	$237,407
Children's Hospital at Westmead	$3,185,190	$602,415	$151,719	$3,939,324	18	$218,851
Paediatric Hospitals	**$5,347,950**	**$1,737,700**	**$414,777**	**$7,500,428**	**33**	**$227,286**
All	**$14,046,317**	**$3,740,543**	**$1,259,466**	**$19,046,327**	**134**	**$142,137**

BMT = Transplant episode. RIE = Related inpatient episode

Table 35 shows the equivalent information for autologous transplants. Total expenditure on the 159 transplants undertaken annually is $11.98m of which $7.05m is spent on transplant episodes, $3.90m on related inpatient episodes and $1.0 m on outpatient services.

The average cost of an adult autologous transplant is $62,812 compared with a paediatric transplant with an average cost of $113,812. Again, in our view, there is little value in considering the overall average cost of an autologous transplant, but it is shown here ($75,322) for the sake of completeness.

Table 35: Total annual costs of autologous transplant – study dataset

Hospital	Annual BMT	Annual RIE	Annual Outpatient	Total Annual	Number BMTs/Year	Cost Per BMT
St Vincent's Hospital	$1,099,814	$420,739	$133,262	$1,653,815	23	$71,905
Westmead Hospital	$953,888	$156,953	$144,000	$1,254,841	26	$48,263
Royal North Shore Hospital	$1,906,788	$529,545	$199,332	$2,635,664	39	$67,581
Prince of Wales Hospital	$477,099	$147,857		$624,956	9	$69,440
St George Hospital	$364,463	$171,093	$74,464	$610,020	11	$55,456
Nepean Hospital	$412,980	$281,182	$64,029	$758,191	12	$63,183
Adult Hospitals	**$5,215,032**	**$1,707,369**	**$615,087**	**$7,537,487**	**120**	**$62,812**
Sydney Children's Hospital	$589,456	$922,857	$157,215	$1,669,528	16	$104,346
Children's Hospital Westmead	$660,695	$1,365,385	$243,505	$2,629,585	17	$154,681
Paediatric Hospitals	**$1,250,151**	**$2,288,242**	**$400,720**	**$3,939,113**	**33**	**$119,367**
All	**$6,465,183**	**995,611**	**$1,015,807**	**$11,476,601**	**153**	**$75,010**

BMT = Transplant episode. RIE = Related inpatient episode

Finally, Table 36 shows the total annual cost of both allogeneic and autologous transplant services for each hospital that participated in the study. Total cost is $30.88m annually for 134 allogeneic and 153 autologous transplants undertaken across the eight hospitals. Total costs range from $610,020 at St George Hospital which undertakes 11 autologous transplants, to $7.95m at Westmead Hospital which undertakes an average of 57 allogeneic and 26 autologous transplants annually.

Table 36: Total annual cost of allogeneic and autologous transplants – study dataset

Hospital	Cost Per Allogeneic Transplant	Number of Allogeneic Transplants	Cost Per Autologous Transplant	Number of Autologous Transplants	Total Number of Transplants Per Year	Total Annual Cost
St Vincent's Hospital	$120,510	27	$71,905	23	50	$4,907,576
Westmead Hospital	$117,569	57	$48,263	26	83	$7,956,278
Royal North Shore Hospital	$93,571	17	$67,581	39	56	$4,226,365
Prince of Wales Hospital	$0	0	$69,440	9	9	$624,956
St George Hospital	$0	0	$55,456	11	11	$610,020
Nepean Hospital	$0	0	$63,183	12	12	$758,191
Adult Hospitals	**$114,316**	**101**	**$62,812**	**120**	**221**	**$19,083,386**
Sydney Children's Hospital	$237,407	15	$104,346	16	31	$5,230,632
Children's Hospital Westmead	$218,851	18	$154,681	17	35	$6,568,895
Paediatric Hospitals	**$227,286**	**33**	**$119,367**	**33**	**66**	**$11,799,536**
Total	**$142,137**	**134**	**$75,010**	**153**	**287**	**$30,882,930**

Appendix 1 Consultation Summary

Name	Position / Department	Area Health Service	Facility
Clinical Consultations			
Associate Professor Tony Dodds	Director Haematology/BMT, Co-Chair of BMT Network Executive	South Eastern Sydney/Illawarra	St Vincent's Hospital
Annabelle Horne	BMT Transplant Coordinator	South Eastern Sydney/Illawarra	St Vincent's Hospital
Associate Professor Ken Bradstock	Director BMT	Sydney West	Westmead Hospital
Dr Warwick Benson	Director Clinical Haematology	Sydney West	Westmead Hospital
Leng Leng Yee	Acting BMT Transplant Coordinator	Sydney West	Westmead Hospital
Professor Peter Shaw	Director Haematology/Oncology	Sydney West	Children's Hospital, Westmead
Dr Chris Arthur	Director Haematology and BMT	Northern Sydney/Central Coast	Royal North Shore Hospital
Cassandra Reid	BMT Transplant Coordinator	Northern Sydney/Central Coast	Royal North Shore Hospital
Dr Stephen Larson	Haematologist	Sydney South West	Royal Prince Alfred Hospital
Jon Sanders	BMT Transplant Coordinator	Sydney South West	Royal Prince Alfred Hospital
Dr Sundra Ramanathan	Head of Cancer Services	South Eastern Sydney/Illawarra	St George Hospital
Dr David Rosenfeld	Director Haematology/BMT	Sydney South West	Liverpool Hospital
Patricia Ryan	Acting Transplant Coordinator	Sydney South West	Liverpool Hospital
Dr Tracey O'Brien	Head, Cord and Marrow Transplant Program	South Eastern Sydney/Illawarra	Sydney Children's Hospital
Dr Carol Cheung	Staff Specialist, Haematology	South Eastern Sydney/Illawarra	Prince of Wales Hospital
Alison Read	Clinical Nurse Consultant	South Eastern Sydney/Illawarra	St George Hospital
Cassandra Hobbs	Clinical Nurse Consultant	South Eastern Sydney/Illawarra	St George Hospital
Vicki Antonenas	Head Scientist, BMT Laboratory, Co-chair of BMT Network Executive, Chair BMT Network Laboratory Services Working Group	Sydney West	Westmead Hospital
Dr David Gottlieb	Medical Director, BMT Laboratory	Sydney West	Westmead Hospital
Dr Stephen Larsen	Haematologist	Sydney South West	Royal Prince Alfred Hospital
Jon Sanders	BMT Transplant Coordinator	Sydney South West	Royal Prince Alfred Hospital
Genevieve Daly	Senior Pharmacist	South Eastern Sydney/Illawarra	Prince of Wales/ Sydney Children's Hospital
Tom Fong	Acting Deputy Director, Pharmacy	South Eastern Sydney/Illawarra	Prince of Wales/ Sydney Children's Hospital
Rebecca Walsh	Senior Pharmacy Technician	South Eastern Sydney/Illawarra	Prince of Wales/Sydney Children's Hospital
Conducted by Teleconference			
Associate Professor Phillp Rowlings	Senior Staff Specialist Haematologist	Hunter/New England	Calvary Mater Newcastle
Louisa Bray	Transplant Coordinator	Hunter/New England	Calvary Mater Newcastle
Dr Frank Alvaro	Paediatric Haematologist/Oncologist	Hunter/New England	John Hunter Children's Hospital
Dianne Cotterell	Clinical Nurse Consultant	Hunter/New England	John Hunter Children's Hospital
Costing/Casemix/Finance Personnel			
Melita Howes	Casemix Manager	South Eastern Sydney/Illawarra	St Vincent's Hospital
Sue-Ellen Fletcher	Senior Costing Analyst	Sydney West	Westmead Hospital
Winston Piddington	Senior Clinical Costing Officer	Northern Sydney/Central Coast	Royal North Shore Hospital
Penny Ison	Clinical Costing Offier	Northern Sydney/Central Coast	Royal North Shore Hospital
Christine Fan	Clinical Costing Manager	Sydney West	Children's Hospital, Westmead
Micheline Hanna	Clinical Costing Officer	Sydney West	Children's Hospital, Westmead
Jenny McNamee	Casemix Manager	South Eastern Sydney/Illawarra	Sydney Children's Hospital
Chris Ellery	Manager, Performance Information	South Eastern Sydney/Illawarra	Prince of Wales Hospital
Robert Siu	Cancer Service Network Manager	Sydney West	Westmead & Nepean Hospitals
Jenna Balding	Finance and Information Resource Manager	Sydney West	Westmead Hospital
Cara Dickson	Senior Costing Officer	South Eastern Sydney/Illawarra	St George Hospital
Alison Cochrane	Performance Analyst	SESIHS Northern Hospital Network	Prince of Wales Hospital
Vineet Makhija	Casemix Policy Unit, Intergovernment & Funding Strategies Branch	NSW Health	Intergovernment & Funding Strategies Branch
Executive			
Elizabeth Koff	Director Clinical Operations	South Eastern Sydney/Illawarra	Area Administration
Dr Michael Brydon	Director, Clinical Services	South Eastern Sydney/Illawarra	Sydney Children's Hospital
Kathy Meleady	Director, Statewide Services Development Branch	NSW Health	Statewide Services Development Branch
Cristalyn DaCunha	Manager, Casemix Policy Unit, Intergovernment & Funding Strategies	NSW Health	Intergovernment & Funding Strategies Branch

Name	Position / Department	Area Health Service	Facility
	Branch		
Bart Cavalletto	Manager, Clinical Services Planning Unit, Statewide Services	NSW Health	Statewide Services Development Branch
Lou-anne Blunden	Director, Health Services Planning	Sydney South West	Liverpool Hospital
Lyn Olivetti	Clinical Services Planning Unit, Statewide Services Branch	NSW Health	Statewide Services Development Branch
Other Key Stakeholders			
Ms Sally Gordon	Executive Officer		Australian Bone Marrow Donor Registry (ABMDR)
Dr Heather Dunckley	Principal Scientist		Australian Bone Marrow Donor Registry (ABMDR)
NSW BMT Service Plan Development Working Group	Meeting of 24/9/08	NSW Health	NSW Health

Appendix 2 Literature review

A1 Search strategy

The NSW BMT Service Plan Development Working Group (the Working Group) was the starting point for the literature review. The Working Group provided background to the current delivery of blood and marrow transplant (BMT) services in New South Wales including information on:

- trends in service use and expected future service requirements based on population projections for Area Health Services throughout NSW
- research underway and the potential for future research and diagnostic opportunities involving BMT
- the potential for increased demand for BMT services both for new indications, and arising from improvements in practice, technologies and pharmacological products
- the increasing availability of donor stem cells and the resulting impetus for significant increase in some forms of BMT, in particular, alternative donor allogeneic transplants
- changes in clinical practice affecting demand, including different types of service delivery such as early discharge and greater use of outpatient facilities and
- the infrastructure and personnel requirements of BMT services - in particular, laboratory requirements (including for stem cell storage and processing), facilities needed by each BMT unit (including design, operational and data collection requirements) and workforce needs appropriate to the delivery of BMT services.

With this background, the literature review focussed on costing studies that might shed light on these and other issues affecting BMT services in NSW.
Relevant papers were identified by searching the electronic databases Medline, EconLit, Science Direct, Cinahl and Cochrane databases using combinations of the search terms transplant$, blood, bone marrow, stem cell, cord, umbilical, cost$ and method, costing, costing method$, costing model$, cost accounting, and case-mix. Key journals such as *Bone Marrow Transplantation*, *Blood*, *Clinical and Laboratory Haematology* as well as *Cancer Treatment Reviews* and the *European Journal of Cancer* were also searched separately to ensure all references were found. The resulting citations were culled to exclude those that did not focus on either costing or economic evaluation of blood and bone marrow transplantation. Only English language citations were retained. Additional citations were identified by internet searching, reviewing reference lists in recently published work and searching for recent publications by key researchers in the field. A second round of culling was undertaken based on reading the abstract or executive summary of each paper or report. Full text copies of the remaining 34 papers/reports were then reviewed.

A2 Overview

The literature on costing blood and bone marrow transplants comprises only a small number of studies, with the main work undertaken in the USA and Europe, in particular Scandinavia and the Netherlands. The studies are limited in scope, most are targeted to particular indications and underlying disease, and few provide detailed costing of the stages of transplant.

While about a third of the papers were published in the last 5 years, many refer to research undertaken more than a decade ago. For example, a UK study published in 2004 reviewing the costs and cost-effectiveness of new interventions for the treatment of aggressive non-Hodgkin's lymphoma summarised information gathered between 1987 and 1999 (Beard et al 2004). Each of two recent systemic reviews (of the health economics of managing multiple myeloma, and of the comparative costs of high-dose chemotherapy and autologous stem cell transplantation vs. conventional chemotherapy), reported on only five studies examining the cost of BMT services (Moeremans and Annemans 2006, Simnett et al 2000). Another review of economic analyses of acute myeloid leukaemia found only five studies that estimated per patient BMT costs, with only two of these costing different components of BMT (Redaelli et al 2004).

Very little economic analysis of BMT services in light of recent changes in clinical practice and/or advances in new technology and diagnostics in the past few years, in particular in relation to gene

therapy and sources of donor stem cells, is available. A recent systematic review of 'trends and prospects' in stem cell transplantation in Europe between 2005 and 2010 contained no costing detail. Instead, it relied on estimates of activity based on trends in use for different indications and expected developments in practice, to suggest possible expansions in budget (Tan et al 2007). In terms of informing the development of costings for BMT service components, most of the literature was of marginal value.

The terminology used to refer to the economic aspects of BMT services differs throughout the literature, at times affecting interpretation. The terms costs, charges, expenditures, payments and reimbursement can all be found. It was important to distinguish, for example, between charges and costs, in particular in regard to studies undertaken in the United States. Studies reporting the hospital charge for BMT services and products, are not necessarily reporting the actual costs of services. For example, charges in some hospitals may be inflated to cover costs from other departments and third-party payer costs may need to be taken into account (Westerman and Bennett 1996).

The literature review identified several economic evaluations of blood and marrow transplantation. Whilst economic evaluation was outside the scope of this project the studies were reviewed for details of the costing methodologies employed. In most such studies, the costing methodologies were not fully explained, nor were costing details reported, but they were useful for the purposes of shedding light on the overall magnitude of costs of different BMT service types. In general, they took a pragmatic approach, in keeping with the literature. "Analysts and decision makers must consider whether the benefits of more accurate and detailed cost information justify the additional costs incurred in obtaining that information." (Smith and Mogyorosy 2005)

A major difficulty in costing BMT services is that widely differing assumptions and a variety of different inputs may be used to derive costings. This is particularly the case because there are many different treatment methodologies covering both autologous and allogeneic transplants, a variety of donor stem cells, and an increasing range of indications and clinical practice modalities. Moreover, costs do not remain static and, because of the complexity of treatments and indications, even small changes in protocol can lead to a large difference in cost (Freeman et al 1996). This issue is compounded when methodologies reported lack detail, or are ambiguous. Therefore, any comparison of reported costings is difficult. Most studies refer to this matter, in keeping with the general principle that robust cost comparisons can only be made when cost measurement is in reasonable compliance with a standardised costing methodology (Smith and Mogyorosy 2005).

Some of the many possible sources of differences between studies that might lead to bias and/or discrepancies are:

- the type and complexity of the service, for example, service settings, admission practice
- the availability of data and its validity
- the sample size and design - for example, whether randomised, prospective or retrospective (typically, sample size is very small with most studies based on < 50 patients)
- the costing methodology – for example, (i) use of direct and/or indirect costs, whether standard unit costs or fees, charges and/or market prices are used; and (ii) the assumptions underlying cost estimation and/or extrapolation
- the time horizon for a study and the consequent technologies, diagnostics and level of knowledge and sophistication of BMT services available at that time
- the stages or components of BMT included and the practices considered (for example, conditioning regimens)
- the range of items that may or may not be included in costs
- the large variation in unit costs that is possible, particularly between countries
- the variations in price levels between treatment alternatives and treatment items, particularly between countries
- assumptions regarding the static nature of costs (for example, for cycles of chemotherapy)
- whether donor costs are taken into account
- the duration of follow-up period, if any, that is covered in a study

- the indications and type and severity of disease covered by a study (for example, Westerman and Bennett (1996) found that the main cost driver for severe combined immunodeficiency was nursing care, while laboratory and radiology costs were the main drivers for acute myeloid leukaemia, severe aplastic leukaemia and chronic granulocytic leukaemia)
- the study perspective and country in which it was undertaken
- (as already noted) whether reimbursement costs for procedures are reasonable estimates of the real costs borne by the treating facility.

(Beard et al 199, van Agthoven et al 2002, Moeremans and Annemans 2006, Mishra et al 2003, Westerman and Bennett 1996).

The pace of change in BMT is rapid so that conclusions regarding changes in clinical practice and emerging technologies that may impact on service provision, if they are based on retrospective studies, may already be out of date with practices and technologies well-established. For example, several studies refer to the use of high-dose chemotherapy with stem-cell support vs. standard conventional chemotherapy for managing different conditions. Beard et al (2004) referred to 'a definite trend towards reduced costs for high-dose therapy {for patients with aggressive non-Hodgkin's lymphoma}, possibly reflecting increasing technical excellence and improved bone marrow recovery through the use of stem cell transplantation and growth factors'. Moeremans and Annemans (2006) note that the former practice 'has clearly improved disease-free survival' for patients with multiple myeloma. They also note that 'new promising agents…with improved response rates, progression-free and potentially overall survival in different stages of multiple myeloma' are available, but that their acquisition costs are very high compared with some established treatments. Mishra et al (2005) noted that high dose chemotherapy with autologous peripheral blood stem cell support (PBSCT) was 'an established treatment strategy for poor-prognosis malignancies' and that use of PBSCT replaced bone marrow at the Norwegian Radium Hospital (NRH) in 1993 for malignant lymphoma.

The recent paper by Tan et al (2007) aimed to identify trends in Europe in BMT patient numbers and to anticipate transplant rates for the next 5 years. The paper referred to the greater use of reduced-intensity conditioning regimens followed by transplantation (RIC-HSCT) and increasing worldwide donor availability as significant trends likely to lead to increasing use of transplant for a range of indications. The availability of alternative drug treatments was another key factor expected to influence trends in transplantation. The study predicted an increase in autologous transplantation in Europe of 6% between 2005-2010, with particular reference to the treatment of acute leukaemia and auto-immune diseases. An even greater increase of about 20% in allogeneic transplantation was predicted, with rises in use for all indications except chronic myeloid leukaemia, due mainly to the expected increased use of RIC_HSCT in older patients and in patients with co-morbidities.

For specific indications, the following trends were noted:

- For acute lymphoblastic leukaemia (ALL), use of more intense early phase therapy, greater use of RIC with allogeneic transplantation in elderly AML patients (already popular for AML patients aged over 40), use of HSCT as a consolidation treatment or as a treatment option for patients aged between 60 and 75, and an overall expansion in allogeneic transplants for ALL.
- For myeloproliferative disorders, greater use of allogeneic HSCT for myelodysplastic syndrome (MDS), with a possible slight decrease in use of allogeneic HSCT for chronic myeloid leukaemia (CML), depending on new drug treatments for Imatinib resistant CML.
- For lymphoproliferative disorders, a modest increase in allogeneic HSCT based on the increased likelihood of finding a compatible donor and greater use of RIC-HSCT.
- For multiple myeloma, possible use of RIC-HSCT after a preceding autologous transplant, with almost all MM patients aged up to 65 receiving an autologous transplant; allogeneic transplants likely to increase with greater use of RIC, though overall MM patient numbers may drop due to the availability of alternative drug treatments.

- For solid tumours, RIC-HSCT could provide a new approach for renal cell carcinoma, following a marked increase in allogeneic transplantation in the five years from 1997 to 2002 for solid tumours (mainly due to its application in renal cell carcinoma); a 'constant but steady increase [in use of autologous transplantation] for neuroblastoma and Ewing sarcoma, but, due to the introduction of alternative drug treatments and disappointing results from autologous transplantation, especially in the treatment of breast cancer, the role of autologous transplantation in the treatment of other solid tumours could be challenged.
- For non-malignant disease, autologous transplantation currently mainly used for auto-immune diseases but, because 'different opinions prevail', future use is difficult to predict; growth likely in allogeneic transplantation, due to increased use of RIC_HSCT in older patients and those with co-morbidities.

Changes in the characteristics of BMT service delivery and consequent changes in costs and shifts in cost distribution are the subject of discussion in a number of papers. For example, Freeman et al (1999) noted that overall treatment-related costs for BMT for patients diagnosed with non-Hodgkin's lymphoma (NHL) decreased by 35% between 1998 and 1995, and that the distribution of costs changed with reductions in inpatient hospitalisations (71% of total cost in 1992 to 45% in 1995) and concomitant increases in outpatient visits (26% of total costs in 1992 to 49% in 1995).

Citing previous evidence that organisational improvements and technological advances can have large effects on cost improvements, Freeman et al postulated that decreases in average length of stay (ALOS) and inpatient admission costs between 1989 and 1995 for NHL patients arose from three main sources: (i) organisational changes in relation to hospitals (including increased use outpatient facilities, better referral systems and more efficient use of staffing and resource), (ii) improvements in technology (for example, though use of granulocyte colony-stimulating factors or G-CSF mobilised SCT, more cost-effective laboratory procedures and advances in pharmacology), and (iii) improvements in patient case-mix and provider changes. Regarding pharmacy costs, while costs decreased overall, the relative proportion of outpatient pharmaceuticals increased 10-fold.

In terms of disaggregated costing data, the most comprehensive analyses were:

- a 2002 Dutch study of a cost analysis for HLA-identical sibling and voluntary unrelated allogeneic bone marrow and peripheral blood stem cell transplantation in adults with AML or ALL (van Agthoven et al 2002); and
- a 2005 report prepared for the Technology Assessment Unit of the McGill University Health Centre (Canada) on allogeneic transplantation in adults of stem cells from unrelated donors.

A study by Prajogo (2004) reporting the results of a cost comparison of high-dose chemotherapy and autologous bone marrow transplantation vs. standard dose chemotherapy for patients with non-Hodgkin's lymphoma at the Calvary Mater Misericordiae Hospital in Newcastle provided the most relevant Australian analysis (see Section 0).

A3 Regulation, compliance and quality management systems

The Working Group noted the impact that the regulation of BMT services and requirements for compliance with quality management systems will have on laboratories and units providing BMT services. In particular:

- regulation of BMT services by the Therapeutic Goods Administration (TGA) was expected by mid-2009;
- collection units would be required to comply with new National Pathology Accreditation Advisory Council (NAPAAC) standards June 2010, with inspection by the National Association of Testing Laboratories (NATA); and
- if not already achieved, paediatric units were likely to want to obtain international accreditation with the Foundation for Accreditation Cellular Therapy (FACT).

The Working Group indicated the potential staffing, infrastructure and system requirements to implement FACT accreditation requirements, based on two Australian facilities that have already received TGA licences. In doing so it referred to a 2004 estimate of costs (150,000 euros or $A240,000) for implementing processes to meet FACT standards and for compliance with Joint Accreditation Committee – ISCT (International Society for Cellular Therapy) and EBMT (European Bone Marrow Transplant Society) (JACIE) standards (Zahnd 2004).

Estimates were developed by the National Institute for Clinical Excellence (NICE) in 2003 of the additional funds required to implement the JACIE standards throughout England and Wales. Funds of from £25.2 to £51.5 (or $A70.63 - $A144.34 (2007)) were expected to be required, depending on decisions regarding minimum levels of BMT services that might be provided by hospitals (NICE 2003). The additional costs included the costs of providing specialist diagnostic services; of establishing and resourcing multi-disciplinary teams; of resourcing additional Clinical Nurse Consultants to deliver patient centred care; and of providing infrastructure, facilities and resources for high-dose therapy and transplant services.

A4 Stages of transplantation

In undertaking the project, it was necessary to allocate the care of transplant patients into stages or component periods of time based on clinical practice and reasons. While some of the literature reflected the need for categorisation of BMT services, this varied across the range of studies. In general, however, there was little reference, especially in economic evaluations, to the need to distinguish between costs with a direct link to transplantation versus costs that would have been incurred irrespective of whether a transplant was performed or not. Eckstein et al (2007) found that, for heart-lung transplants, there was an argument that the costs incurred by being a candidate for transplant 'should not be allocated to the cost of the transplant, since they would be incurred, at any rate, to maintain the patient or keep the patient alive, regardless of whether the patient is waiting for a transplant or not' (from Hauboldt and Ortner 2002 in Eckstein et al 2007).

Examples of studies that articulated stages or categories for which costs were derived include:

- mobilisation and recovery of PBPC; post-mobilisation phase; conditioning and transplant; critical haematological reconstitution; non-critical haematological reconstitution; death (Barosi et al 99)
- pre-transplant, transplant, post-transplant follow-up (Mishra et al 2001)
- harvesting (including G-CSF assisted stem cell mobilisation, cryopreservation, pharmacy costs and nursing care) and high-dose chemotherapy phases for autologous transplantation (Mishra et al 2003 and 2005)
- induction chemotherapy, post-induction/post-remission chemotherapy, transplantation and complications arising (Redaelli et al 2004).

A5 Cost drivers

Many of the studies identified factors that have an important impact on costs. The cost drivers discovered depended partly on the type(s) of BMT services being studied, the aim of the study, the country in which the study was undertaken, data availability and the study methodology. While, some studies found that there was no association between patient baseline characteristics and costs (for example, Lee et al 2000), several studies highlighted the importance of post-transplant complications, including disease relapse as well as infections and, in the case of allogeneic transplants, graft-vs.-host disease (GVHD) in terms of predicting high-cost (for example, Griffiths 1993 in Westerman and Bennett 1996, Esperou et al 2004).

A number of studies noted the fundamental structural differences between the United States and Europe in terms of health service delivery, resulting in different cost drivers for BMT services depending on where studies are conducted.

One cost component that receives funding from the US Department of Health and Human Services is the National Bone Marrow Donor Registry ($US23m in 2005-06 budget, including $US10 for the

Cord Blood Stem Cell Bank) to assist the approximately 16,000 people under 55 diagnosed with leukaemia or another blood or genetic disorder who would need a blood stem cell transplant (FY 2005 Budget in Brief. USA). For patients with private health insurance, the costs of transplantation for certain types of cancer are covered by that insurance, while government financial assistance programs (through Medicaid and Medicare) are limited. In 2005, the cost of tissue typing (range $US65 to $US96 or $A 90.38-$A 133.48 (2007)) was also funded by the donor, either fully or in part with the remainder covered by the donor centre. Patient care costs for participants in clinical trials that are funded by the National Cancer Institute are often covered - either by patients' health insurers or by Medicare (National Cancer Institute, U.S. National Institutes of Health).

Gajewski et al (2004) discussed attempts during the past 20 years for the leading payers of US health care to control growth in health-care spending through managed care strategies. Providers of expensive services such as BMT are particularly scrutinized, with their clinical programs subject to new methods of pricing medical services and financial accountability. To protect themselves from excessive financial risk, providers have developed different payment rates for different types of transplant, eg, autologous versus HLA or genotypically matched related versus HLA mismatched transplants. Because at certain times in the HCT process risk is more unpredictable, HCT providers require different payment system strategies for the different time periods of care such as evaluation, pre-transplant disease management, harvesting, and cell processing, as well as short and long-term follow-up. These case rate agreements attempt to manage the unpredictable consequences of BMT such as regimen-related toxicities, infections and GVHD.

Thus, hospital inpatient, medical staff costs and overheads along with pharmacy costs are much higher in the United States than in Europe or countries with so-called 'socialised medicine'. US-based studies, therefore, tend to report significantly higher costs per patient than non-US based studies reflecting this difference in healthcare systems (Beard 2004). Redaelli's review of studies of AML (2004) found that, while hospital stays comprised 47-56% of total costs regardless of the country of study, the high overall cost found in US studies was due to higher hospital stay and pharmacy costs combined (34% and 31% respectively, from Du Foir 1992 and Bennett 1999 in Redaelli 2004). That study also found that pharmacy costs were a considerably smaller proportion of overall costs in Europe (11-16%), while laboratory costs (in particular, pathology tests) and blood products were reported as major cost drivers in Europe (Westerman and Bennett 1996).

For studies of autologous BMT, examples of cost drivers include:

- Number of hospital days and blood products (for the period from hospital admission to discharge only) – (Hartmann et al 1997)
- Stem cell mobilisation costs (harvest phase), nursing costs and pharmacy (Mishra et al 2003 and 2005)
- Room costs, laboratory, pharmacy, medical consultant fees; radiology and supportive care (Freeman et al 1999)
- Total body irradiation (TBI) and conditioning regimens, number of hospital days, blood products, antibiotic and supportive care (Vicent et al 2001)
- Induction chemotherapy (and within this, the number of cycles to achieve remission); post-induction: blood products, inpatient costs (medical staff and accommodation), lab/radiology and pharmacy (Redaelli et al 2004)
- Number of hospital days, number of stem cells collected, phase and type of disease, post-transplant GVHD prophylaxis; whether patient is a child or adult (Barosi et al 99).

For allogeneic transplants, examples of cost drivers include:

- Tissue typing and donor stem cell collection costs, medical and nursing staff costs, pharmacy, blood products and laboratory costs (Mishra et al 2001)
- Pharmacy, number of hospital days (Dooley et al 2007)
- Number of hospital days, medical and nursing staff costs (Van Agthoven et al 2002)
- Number of hospital days, post-transplant complications (Esperou et al 2004).

For studies involving both autologous and allogeneic BMT, cost drivers include:

- Whether donor stem cells are matched or mismatched, year of transplantation and complications (infections, veno-occlusive disease, GVHD, death) (Lee et al 2000)
- Pharmacy, blood bank and nursing costs (Yoder 98).

In terms of overall costs, systematic reviews by Moeremans and Annemans (2006), Simnett et al (2000) and Redaelli et al (2004) provided cost summaries, as follows.

Table 37: Overall costs from studies of autologous transplantation using peripheral blood stem cells for patients with multiple myeloma

	Mishra (2005)	Mishra (2003)	Kouroukis (2003)	Van Agthoven (2004)	Gulbrandsen (2001)
Country	Norway	Norway	Canada	Netherlands	Norway
Total cost	$US32160 (hospital perspective)	$US38186 (hospital perspective)	Can $ 32320 (payer perspective)	€ 67563 - 80630 (hospital + ambulatory drugs)	$US 34000 (societal costs)
$A (2007)	**$42,204**	**$58,896**	**$35,565**	**$114,167-$136,247**	**$52,440**
Time horizon	Peripheral stem cell transplantation	Peripheral stem cell transplantation	90 months	36 months	36 months

Source: Moeremans and Annemans 2006

Simnett et al (2000) reported five studies (one randomised and four non-randomised comparisons) that compared use of high-dose chemotherapy and autologous transplantation with conventional chemotherapy for patients with either non-Hodgkin's lymphoma, multiple myeloma, relapsed Hodgkin's lymphoma or breast cancer, as follows:

Table 38: Overall costs from studies of high-dose chemotherapy and autologous transplantation with NHL, MM, relapsed HL or breast cancer

	Uyl-de Groot et al (1995)	Zaidi et al 1996	Henon et al (1995)	Desch et al (1992)	Hillner et al (1992)
Indication	Non-Hodgkin's lymphoma	Non-Hodgkin's lymphoma	Myeloma – first line therapy	Hodgkin's disease – treatment of recurrent disease	Metastatic breast cancer
Total cost (US$1993)	$51,479 vs. $15,742	$25,473 vs. $5660	$56,700 vs. $46,555	$84,577 vs. $18,021	$99,171 vs. $39,911
$A (2007)	**$109,348 vs. $33,438**	**$54,108 vs. $12,022**	**$120,438 vs. $98,889**	**$179,653 vs. $38,279**	**$210,653 vs. $84,776**
Number of patients	42	11	22	-	-

For acute myeloid leukaemia, five studies published between 1989 and 1999 yielded proportions of cost drivers and total costs for BMT (for both autologous and allogeneic transplantation) as follows:

Table 39: Overall costs from studies of BMT for acute leukaemia

	Bennett et al (1999)	Dufoir et al (1992)	Viens-Bitker et al (1989)	Barr et al (1996)	Uyl-de Groot (1995)	Dufoir et al (1992)
Country	US	France	France	Canada	Netherlands	France
Time horizon	Transplant	5 years	12 months	18 months	2 years	5 years
Medical staff and accommodation	34%	24%	32%	51%	55%	23%
Drugs	31%	15%	17%	11%	14%	8%
Blood	11%	25%	16%	-	18%	45%
Labs/radiation oncology/diagnostic radiology	13%	30%	29%	38%	13%	19%
Other	11%	6%	5%	-	-	6%
Total cost (€2001)	$51,479 vs. $15,742	$25,473 vs. $5660	$56,700 vs. $46,555	$84,577 vs. $18,021	$99,171 vs. $39,911	$99,171 vs. $39,911
$A (2007)	**$89,208 vs. $27,279**	**$44,142 vs. $9,808**	**$98,256 vs. $80,675**	**$146,564 vs. $31,228**	**$171,854 vs. $69,162**	**$171,854 vs. $69,162**
BMT type	Allogeneic	Allogeneic	Allogeneic	Allogeneic	Autologous	Autologous

Source: Redaelli et al 2004

Beard et al (2004) reported total direct medical costs of high-dose chemotherapy with stem cell support (either autologous bone marrow transplantation or peripheral blood stem cell transplantation) for 15 studies of patients with either non-Hodgkin's lymphoma or other malignancies such as breast cancer and leukaemia. Some studies were retrospective (study periods range from 1989 to 1999) and each covered one or more stages including: induction (mobilisation and harvesting), treatment, post-transplant and post-discharge period. Comparisons were therefore difficult, with costs ranging from $US9,100 (or $A19,312 (2007)) for PBSCT with G-SCF for NHL (from Lee et al 1998) to $US74,000 (or $A157,049 (2007)) for PBSC for lymphoma (Bennett et al 1995).

A6 Detailed cost analyses, by stage of transplant.

A6.1 Cost analysis of HLA-identical sibling and voluntary unrelated allogeneic bone marrow and peripheral blood stem cell transplantation in adults with AML or ALL

In a cost analysis of HLA-identical sibling and voluntary unrelated allogeneic bone marrow and peripheral blood stem cell transplantation in adults with AML or ALL in four Dutch hospitals, van Agthoven et al (2002) retrospectively allocated direct medical costs for patients treated between 1994 and 1999, in two ways:

- by multiplying the medical consumption units used by patients by the unit cost of each item; and
- by identifying cost not tied to the patient's medical registration from hospitals' financial departments and by expert opinion

The analysis included costs for patients prepared for, but who did not undergo, transplantation, and covered all stages from pre-transplant tissue typing up to 24 months after transplantation. Costs were separately identified for three transplant types (bone marrow transplant, matched unrelated donor and peripheral blood stem cell transplant) according to the following categories:

- pre-transplant screening of patient using serological and molecular methods (average total cost 2.342 euros (2002) (or $A4,620 (2007))
- stem cell harvesting in one session (for BMT patients), or two sessions (for PBSCT patients);
- CD34 selection or T-cell depletion;
- donor lymphocyte infusion (if patients needed one or more additional infusions);
- total body irradiation and transplantation personnel.

Costs were further allocated either to the pre-transplant phase, transplantation phase, or to one of the three follow-up phases (that is, 1-6 months, 6-12 months and 12-24 months after transplantation).

For unrelated donors, the costs included 'donor costs' involving family HLA-typing and typing of the selected donor; the cost of requesting blood samples or donor grafts; sample typing (HLA-retyping of blood samples collected in each of the Dutch hospitals); and Europdonor intermediation). The calculation of average costs was based on unit costs of hospital days, day care treatments and outpatient visits (van Agthoven 2002 Table 1, p. 245), as well as personnel costs based on FTE requirements and employer costs per FTE (van Agthoven 2002 Table 3, p. 247). Table 40 shows average costs per patient for the transplant phase.

Table 40: Average costs per patient for transplantation stage components

Cost component	**BMT**	**MUD**	**PBSCT**
	Euro 2002	Euro 2002	Euro 2002
Pretransplantation screening	2342	2342	2342
Donor costs	10 843	47 063	11 137
Haematology 'isolation' hospital days	16 248	17 622	17 716
Consultations	98	113	120
Cytostatics	94	102	124
Antibiotics	2700	3394	2058
Hematopoietic growth factors	337	34	103
Immunosuppressants	510	638	720
ATG anti-thymocyte globulin	0	2723	0
Other medication	451	473	497
Blood components	1303	2405	2552
Parenteral nutrition	602	645	341
TBI (P&M-9)	1441	1441	1441
Laboratory diagnostics	2038	2763	2610
Microbiology diagnostics	1047	1452	1271
Pathology diagnostics	993	752	1306
Radiology diagnostics	396	509	817
Other imaging diagnostics	290	182	300
Other procedures	396	295	279
Total costs, excluding personnel costs	42 129	84 948	45 734
Total costs, excluding personnel costs $A (2007)	**83,820**	**16,9013**	**90,992**

Source: van Agthoven 2002, Table 4 p 248

Table 41 shows average costs per living patient for the three follow-up phases, and Table 42 shows average costs per transplanted patient. The analysis directly links allogeneic infrastructure requirements in the Netherlands to costs.

Table 41: Average costs per (living) patient in follow-up phases

Cost component	Follow-up phase 1			Follow-up phase 2			Follow-up phase 3		
	BMT	**MUD**	**PBSCT**	**BMT**	**MUD**	**PBSCT**	**BMT**	**MUD**	**PBSCT**
	Euro 2002	Euro 2002	Euro 2002	Euro 2002	Euro 2002	Euro 2002	Euro 2002	Euro 2002	Euro 2002
Haematology 'regular' hospital days	6066	8801	4121	3993	5866	3103	3912	5620	2129
Intensive Care hospital days	0	543	0	0	1143	0	0	0	0
Haematology outpatient visits	1436	1216	1253	805	678	593	654	1696	365
Other consultations	402	707	657	286	523	482	326	572	402
Antibiotics	11	1006	109	132	166	12	0	0	0
Hematopoietic growth factors	0	368	0	0	0	0	0	0	0
Other medication	7	116	88	9	35	4	0	6	0
Day care department	106	260	112	46	14	15	104	46	0
Radiotherapy	0	0	0	0	216	0	83	0	0
Blood components	1317	2740	1127	1006	1735	1027	599	1270	210
Laboratory diagnostics	2717	4796	2486	1800	3161	2769	1358	2256	1403
Microbiology diagnostics	732	1180	706	359	757	766	255	202	493
Pathology diagnostics	1692	2413	2201	811	1765	1159	411	509	706
Radiology diagnostics	525	1119	441	394	879	1133	163	714	293
Other imaging diagnostics	469	1060	567	340	904	1065	129	398	261
Other procedures	94	568	172	177	632	135	99	42	52
Donor lymphocytes infusion	1012	3402	1012	0	0	0	0	0	0
Total costs, excluding personnel costs	**16587**	**30292**	**15051**	**10157**	**18473**	**12265**	**8093**	**13331**	**6313**
Total costs, excl personnel costs ($A)*	28843	52675	26172	17662	32123	21328	14073	23181	10977
Total costs, excl personnel costs ($A) (2007)**	**33,001**	**60,269**	**29,945**	**20,208**	**36,754**	**24,402**	**16,101**	**26,523**	**12,560**

Follow-up phase 1 = from first discharge after transplantation up to 6 months after transplantation date. Follow-up phase 2 = 6–12 months after transplantation date. Follow-up phase 3 = 12–24 months after transplantation date.
Source: van Agthoven 2002, Table 6 p 249
* Not escalated ** Escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au

Table 42: Average costs per transplanted patient

	BMT			MUD			PBSCT		
Cost component	Ave costs per living patient	* % alive	=Ave costs per transplant patient	Ave costs per living patient	* % alive	=Ave costs per transplant patient	Ave costs per living patient	* % alive	=Ave costs per transplant patient
Personnel	26543		26543	26543		26543	26543		26543
Transplantation	42129	100	42129	84948	100	84948	45734	100	45734
FU1-phase	16587	98	16255	30292	90	27263	15051	92	13847
FU2-phase	10157	81	8227	18473	48	8867	12265	77	9444
FU3-phase	8093	64	5180	13331	31	4133	6313	54	3409
Total costs	103509		98334	173587		151754	105906		98977
Total costs ($A 2007)	**205,942**		**195,646**	**345,369**		**301,930**	**210,711**		**196,925**

Source: van Agthoven 2002, Table 7 p 249

A6.2 Study 2 – Evaluation of the use of cord blood as alternative stem cell source

The Technology Assessment Unit (TAU) of the McGill University Health Centre (MUHC) reported on an evaluation of the use of umbilical cord blood as an alternative source of donor stem cells for treatment of adults at that centre, for allogeneic transplantation from unrelated donors. Costs were calculated separately for: (i) the transplantation procedure up to the time of hospital discharge, and (ii) subsequent costs up to 10 years after transplantation. Costs were obtained from the Finance Department at MUHC and based on resource use by 15 patients who underwent allogeneic stem cell transplantation from related donors, and 2 patients who underwent cord blood transplantations from unrelated donors in 2004.

Table 43: Hospitalisation cost of an allogeneic stem cell transplantation at MUHC

	Cost estimate at the MUHC (CDN 2005) Allogeneic peripheral blood stem cell transplantation (N=15)	**Cost estimate at the MUHC (CDN 2005) Allogeneic cord blood stem cell transplantation (N=2)**
Mean length of stay (days)	38	45
Staff (Transplant coordinator, nursing*)	$15,646	$18,528
Supplies	$1,191	$1,410
Pharmacy	$18,324	$18,324
Imaging and diagnostic tests	$989	$989
Laboratory	$1,582	$1,582
HLA matching	$753	$753
Stem cells laboratory (virology and microbiology tests, staff and supplies)	$1,823	$1,823
Haematologist fees	$1,835 (38 x $48.30§)	$2,070 (40 x $48.30 + 5 x $27.5)
Infectologist consultation fees	$77 ($95.40 x 81%)¶	$77 ($95.40 x 81%)¶
Total cost of an allogeneic stem cell transplantation at the MUHC	$42,220	$45,556
Total cost of an allogeneic stem cell transplantation at the MUHC ($A 2007)	**$48,516**	**$52,349**

Note: Excludes overhead, bone marrow harvesting and donor costs.

The MUHC results were compared with the estimated direct hospitalisation costs obtained from five European economic analyses of stem cell transplantation (four of stem cell transplantation and one of allogeneic stem cell transplantation) of from $34,475 to $66,500 (CDN 2005) (or $A39,616 to $A52,349 (2007)).

MUHC also estimated the costs of complications that might occur during a 10 year follow-up period (see Table 44), while noting that only 'extremely meagre' data on which to base estimates existed. Based on possible relapses, infections and chronic GVHD, MUHC estimated that the total cost of an allogeneic stem cell transplantation including a 10-year follow-up (excluding the cost of procurement of stem cells) in an adult patient at the MUHC would be approximately CDN$57,000

and CDN$60,500 (or $A65,500 and $A69,522 (2007)) for bone marrow and cord blood respectively**.**

Table 44: Costs during the follow-up period

Treatment	Unit cost (CDN 2005)	Unit cost $A (2007)
Relapses	$4,169 Chemotherapy $2,165 – palliative care $95,500 – cord blood transplantation	$4,790 $2,487 $10,9742
Infection	$4,097	$4,988
Chronic GVHD	$3,228 (outpatient visit, nursing costs and physician fee – 3x per week, pathology, medication costs (cyclosporine, prednisolone)	$3,709
Follow-up visits	$60 (physician fee $20; nursing cost $11 for 15 mins; lab tests $29	$68

Note: Costs discounted 3%

A7 Casemix and transplantation

Two studies found that Diagnosis Related Group (DRG) based reimbursement underestimated the average total costs of BMT services. A study in Norway (based on a small sample of only 17 patients) collected costs prospectively for blood and bone marrow transplantation for patients diagnosed with leukaemia (both chronic myeloid and acute lymphatic leukaemia) and myelodysplastic syndrome. Costs for pre-transplant services, the transplant itself and 1 year post-transplant follow-up services were collected and compared with hospital reimbursement. The results indicated that DRG reimbursement costs for blood and bone marrow transplantation greatly underestimated the actual costs, with treatment being heavily subsidised by basic hospital grants (Mishra et al 2001).

A French 2004 study found a similar discrepancy between the DRG prospective payment system in that country and actual costs (Esperou et al 2004).

An Australian analysis found that some Australian DRG cost weights were too low, with consequent adverse impacts on the funding of State-wide referral services (Antioch and Walsh 2004). The study was targeted towards high-complexity DRGs relating to State-wide referral services, specifically, for respiratory, cardiology and stroke conditions. Given that the analysis was completed almost 5 years ago, and that the three Australian BMT DRGs encompass a wide range of increasingly complex and costly BMT service types, it is reasonable to apply the conclusion from that study to the current situation regarding BMT services.

A8 Previous cost estimates

State government officials from the relevant departments in Victoria, Queensland, South Australia and Western Australia were contacted regarding the existence of any documented costing studies in those states. Only two studies were discovered – a very small scale study undertaken in Queensland in 2004, and a study undertaken by the Royal Melbourne Hospital. Permission to include details of the latter study has not yet been granted and remains the subject of negotiation with Royal Melbourne Hospital.

A8.1 Queensland – 2004

A study of approximate costs of bone marrow transplants, by transplant type, undertaken at the Royal Brisbane and Women's Hospital dated 2004 yielded overall costs per patient type only. It should be noted that the study used a very small sample of only two patients in each costing type.

Costs included:

- direct inpatient ward costs
- indirect patient costs
- pharma/drug costs
- pathology costs
- medical imaging costs

- bone marrow transplant lab costs
- bone marrow transplant donor costs
- bone marrow transplant courier costs
- total body irradiation
- allied health professional costs
- day therapy unit/clinic costs.

Costs were estimated using either direct patient costs or estimated costs calculated on the basis of the number of separations/bed days per patient.

Table 45: Total costs by transplant type (2004)

Transplant Type	Unit Range ($A)	Unit Range ($A2007)
Allogeneic BMT – MUD (voluntary unrelated donor)	115,411-276,575	125,545- 300,861
Allogeneic BMT – sibling	85,106-180,392	92,579- 196,232
Non myelo-ablative (mini) Allogeneic BMT – MUD (voluntary unrelated donor)/sibling	14,552***-135,748	15,830- 147,668
Autologous BMT – Lymphoma	45,848**-47,207	49,874- 51,352
Autologous BMT – Myeloma	48,751-53,503	53,032- 58,201

Note: All patients survived after transplant with one exception - **deceased at 12 days post-transplant
***Excludes transition inpatient costs.

Based on these costs, senior bone marrow staff were consulted to determine mean approximate minimum costs for autologous and allogeneic transplants. Figures of $50,000 and $120,000 (or approx $54,500 and $130,5007) respectively were agreed.

A8.2 Newcastle Mater Misericordiae Hospital (NMMH)- 2004

In analysis undertaken for a (2004) Master of Medical Science thesis, Prajogo investigated the costs of high-dose chemotherapy and autologous bone marrow transplantation vs. standard chemotherapy in patients with relapsed non-Hodgkin's lymphoma.

Data was obtained for a small sample of eligible local patients with intermediate-high grade NHL treated at NMMH from January 1995 to June 2002. Out of a total of 69 patients with NHL, 23 patients were included in the study which examined direct medical costs drawn from medical records for the period from induction chemotherapy to conditioning and transplant only. The costs of each chemotherapy cycle were assumed to be constant. High-dose chemotherapy encompassed three doses of ESHAC (etoposide, solumedreol, Ara-C and carbolatin) followed by LACE (lomustine, Ara-C, cyclophosphamide and etoposide) and transplantation. Costs comprised pharmaceuticals (chemotherapy drugs, G-CSF, antibiotics, antivirals, antiemetics, other), laboratory, radiology, blood component therapy, special medical consultations, allied health services (dietician, physio, social worker, pastoral care), inpatient admissions and outpatient attendances.

Unit prices were used to calculate costs for hospital bed-days (NSW Health 2000 charges), medical procedures, pathology, radiology, blood bank services (Medicare Benefits Schedule 2001), transplant procedure charge (Medicare item 13700) and drugs (Pharmaceutical Benefits Schedule August 2001 or MIMS 2001).

A8.3 Induction Phase Costs

Each patient received three cycles of ESHAC delivered in the outpatient setting, as reflected in the higher outpatient attendance costs relative to inpatient admissions.

7 Escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au

Table 46: Pharmaceuticals - induction phase

Item	Mean cost per cycle ($A 2001)	Mean cost per cycle ($A 2007)*
Chemotherapy	1233	1453
G-CSF	1227	1446
Antibiotics, Antivirals	53	62
Antiemetics	81	95
other drugs	18	21
Total	**2,612**	**3,078**

(from Prajogo 2004, Table 4.24 p. 63)
* Escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au

Table 47: Non-pharmaceuticals - induction phase

Item	Mean cost per cycle ($A 2001)	Mean cost per cycle ($A 2007)*
Laboratory	287	338
Radiology	188	221
Blood component therapy	39	45
Medical consultation	103	121
Inpatient admissions	686	808
Outpatient attendances	1645	1938
Total	**2,948**	**3,516**

(from Prajogo 2004, Table 4.25 p. 64)
* Escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au

Table 46 shows that G-CSF alone comprised almost 50% of total pharmaceutical cost per cycle. When pharmaceutical and non-pharmaceutical costs were combined, the total mean cost per patient per cycle for the induction phase was $5560.

A8.4 Conditioning and BMT phase

Table 48: Pharmaceuticals - conditioning and BMT phase

	Mean cost per patient	% of total	Mean cost per patient*
	$ ($A 2001)		($A 2007)
Chemo (conditioning)	2402	33	2830
G-CSF	1867	25	2200
Antibiotics, Antivirals, antifungals	2049	28	2414
Antiemetics	658	9	775
other drugs	312	5	367
Total	**7,288**	**100**	**8,518**

(from Prajogo 2004, Table 4.27 p. 66)
* Escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au

Table 49: Non-pharmaceuticals per cycle - conditioning and BMT phase

	Mean cost per patient	% of total	Mean cost per patient*
	$ ($A 2001)		($A 2007)
Laboratory	2391	17	2817
Radiology	1377	10	1622
Blood component therapy	1045	6	1231
Medical consultation	1078	8	1270
Inpatient admissions	7000	49	8249
Outpatient attendances	1409	10	1660
Total	**14,300**	**100**	**16,852**

(from Prajogo 2004, Table 4.28 p. 67)
Note: Assumes cost of allied health services is included in inpatient admissions costs
* Escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au

Examination of Table 48 and Table 49 together show that the cost of inpatient admissions comprised almost 50% of the total non-pharmaceuticals cost for the conditioning and BMT phase, that is, about the same proportion of total cost as pharmaceuticals for this phase. Addition of costs for pharmaceuticals and non-pharmaceuticals shows that the mean total cost per patient for the conditioning and BMT phase was $21589 (or $25,370 (2007)).

Table 50 shows mean costs per patient for induction, conditioning and BMT combined. The total pharmaceuticals and non-pharmaceuticals cost per patient are shown, as well as the component costs within each of the two main groups.

Table 50: Total mean costs per patient - induction, conditioning and BMT

	Mean cost ($A 2001)	%	Mean cost ($A 2007)*
Pharmaceuticals	14757	**39**	17391
Non-pharmaceuticals	22733	61	26791
Total	**37,490**	100	**44,182**
Pharmaceuticals (total)			
Chemotherapy (conditioning)	5928	40	6986
G-CSF	5376	36	6335
Antibiotics, Antivirals, antifungals	2200	15	2592
Antiemetics	890	6	1048
Other drugs	363	3	427
Total	**14,757**	100	**17,391**
Non-pharmaceuticals			
Laboratory	3212	14	3785
Radiology	1915	8	2256
Blood component therapy	1157	5	1363
Medical consultation	1373	6	1618
Inpatient admissions	8962	40	10561
Outpatient attendances	6114	27	7205
Total	**22,733**	100	**26,791**

(from Prajogo 2004, Tables 4.30, 4.31 and 4.32 pp. 69-71)
* Escalated using Reserve Bank of Australia Inflation Calculator (RBA) www.rba.gov.au

A8.5 Cost drivers

This study found that non-pharmaceuticals comprised the largest overall cost (61%) of the induction, conditioning and BMT stages of treatment for NMMH patients with relapsed NHL using high-dose chemotherapy and autologous bone marrow transplantation between 1995 and 2002. This was due mainly to the cost of inpatient stay (40% of total non-pharmaceuticals cost). In terms of component costs of pharmaceuticals, the largest cost drivers were chemotherapy and G-CSF.

The estimated total mean cost per patient of $37,490 (2001) can be compared with costs reported in two Dutch studies of autologous transplantation (i) in patients with lymphoma and acute leukaemia, and (ii) in patients with NHL. Total costs were equivalent to $A70,769[8] and $A59,500[9] respectively (from Uyl-De Groot 1995a and 1995b, in Prajogo). The differences between these costs and those reported by Prajogo can be attributed, in part, to use of total body irradiation before transplantation in the Dutch studies, as well as lower utilisation rates (for example, medical consultations) in Australia, and differences in the costs of hospitalisation and blood products between the two countries. Also germane were: (i) the much lower proportion of total costs of pharmaceuticals in the second Dutch study (13% compared with 39% in Prajogo), consistent with the introduction of G-CSF and the greater role of the outpatient setting in the latter study; and (ii) the use of PBSCT rather than ABMT, leading to shorter hospital stays and reduced blood product support in the latter (Prajogo 2004).

Appendix 3 Cost by cost bucket allogeneic transplants

	St Vincent's		Royal North Shore		Westmead		Sydney Children's Hospital		Children's Hospital Westmead	
Cost Bucket	**Mean**	**% of Total**	**Mean**	**% of Total**	**Mean**	**% of Total**	**Mean**	**% of Total**	**Mean**	**% of Total**
Allied Health costs	$653	0.76%	$4,625	7.07%	$3,018	3.26%	$2,768	1.92%	$4,220	2%
Emergency Dept cost	$23	0.03%	$65	0.10%	$0	0.00%	$22	0.02%	$33	0%
ICU costs	$1,040	1.21%	$0	0.00%	$9,860	10.67%	$12,328	8.55%	$30,253	17%
Imaging costs	$759	0.88%	$969	1.48%	$484	0.52%	$1,649	1.14%	$2,041	1%
Medical cost	$8,940	10.41%		0.00%	$5,427	5.87%	$18,790	13.03%	$7,836	4%
Oncosts	$4,700	5.47%	$1,977	3.02%	$4,011	4.34%	$5,256	3.65%	$6,644	4%
Other costs	$1,902	2.21%	$1,703	2.60%	$3,238	3.50%	$7,180	4.98%	$7,898	4%
Pathology costs	$4,704	5.48%	$3,829	5.86%	$6,806	7.36%	$7,539	5.23%	$11,386	6%
Pharmacy cost	$30,561	35.60%	$27,013	41.32%	$27,183	29.41%	$33,388	23.16%	$46,850	26%
Ward costs	$32,571	37.94%	$25,189	38.53%	$32,412	35.06%	$55,264	38.33%	$59,795	34%
Total cost	**$85,853**	**100.00%**	**$65,368**	**100.00%**	**$92,440**	**100.00%**	**$144,184**	**100.00%**	**$176,955**	**100.00%**

Appendix 4 Cost by cost bucket autologous transplants

	St Vincent's		Royal North Shore		Westmead		Prince of Wales		St George		Nepean	
Cost Bucket	**Mean**	**% of Total**	**Mean**	**% of Total**	**Mean**	**% of Total**	**Mean**	**% of Total**	**Mean**	**% of Total**	**Mean**	**% of Total**
Allied Health costs	$411	0.86%	$2,797	5.72%	$715	1.95%	$264	0.50%	$825	2.49%	$904	2.63%
Emergency Dept cost		0.00%	$162	0.33%		0.00%		0.00%		0.00%		0.00%
ICU costs	$4,044	8.46%	$1,158	2.37%	$1,012	2.76%	$1,497	2.82%	$616	1.86%	$1,166	3.39%
Imaging costs	$504	1.05%	$1,097	2.24%	$237	0.65%	$441	0.83%	$561	1.69%	$1,354	3.93%
Medical cost	$3,800	7.95%		0.00%	$3,600	9.81%	$1,397	2.64%	$2,106	6.36%	$2,899	8.42%
Oncosts	$2,721	5.69%	$1,930	3.95%	$1,963	5.35%		0.00%	$1,300	3.92%	$1,538	4.47%
Other costs	$1,292	2.70%	$1,565	3.20%	$1,891	5.15%	$3,264	6.16%	$878	2.65%	$735	2.14%
Pathology costs	$2,776	5.80%	$2,904	5.94%	$3,392	9.24%	$2,029	3.83%	$2,239	6.76%	$729	2.12%
Pharmacy cost	$13,930	29.13%	$16,944	34.66%	$6,330	17.25%	$29,937	56.47%	$7,267	21.93%	$7,199	20.92%
Ward costs	$18,340	38.35%	$20,335	41.59%	$17,548	47.83%	$14,182	26.75%	$17,341	52.34%	$17,892	51.99%
Total cost	**$47,818**	**100.00%**	**$48,892**	**100.00%**	**$36,688**	**100.00%**	**$53,011**	**100.00%**	**$33,133**	**100.00%**	**$34,415**	**100.00%**

	Sydney Children's Hospital		Children's Hospital Westmead	
Cost Bucket	**Mean**	**% of Total**	**Mean**	**% of Total**
Allied Health costs	$714	2%	$1,192	3%
Emergency Dept cost	$0	0%	$576	2%
ICU costs	$4,197	11%	$1,937	5%
Imaging costs	$503	1%	$738	2%
Medical cost	$5,331	14%	$1,859	5%
Oncosts	$1,630	4%	$1,047	3%
Other costs	$2,802	8%	$1,745	5%
Pathology costs	$1,822	5%	$2,367	6%
Pharmacy cost	$7,925	22%	$8,204	22%
Ward costs	$11,918	32%	$18,451	48%
Total cost	**$36,841**	**100%**	**$38,117**	**100%**

Appendix 5 The NSW cost data collection

Table 51 below shows the results of the 2006/07 NSW Department of Health annual hospital cost data collection for the three BMT AR-DRGs.

Table 51: Average total BMT cost (NSW Health Cost Data Collection)

Hospital	A07Z	A08A	A08B
St Vincent's Hospital	$81,365	$63,883	$30,234
Westmead Hospital	$127,402	$38,508	$23,453
Royal North Shore Hospital	$67,180	$55,525	$28,518
Royal Prince Alfred Hospital	$100,196	$64,720	$36,798
Concord Hospital	$0	$43,891	$19,050
Gosford Hospital	$0	$54,786	$23,544
Liverpool Hospital	$0	$39,006	$19,810
John Hunter Hospital	$0	$104,129	$24,014
Nepean Hospital	$0	$130,240	$35,373
Newcastle Mater Hospital	$0	$37,697	$8,485
Prince of Wales Hospital	$0	$66,355	$33,546
St George Hospital	$0	$38,743	$23,063
Wollongong Hospital	$0	$44,102	$18,380
Sydney Children's Hospital	$163,867	$64,372	$8,789
Children's Hospital Westmead	$191,334	$56,522	$17,915

AR-DRG AO7Z = Allogeneic Bone Marrow Transplant
AR-DRG AO8A = Autologous Bone Marrow Transplant with catastrophic complications or comorbidities
AR-DRG AO8B = Autologous Bone Marrow Transplant without catastrophic complications or comorbidities

Appendix 6 The National Hospital Cost Data Collection

Table 52 below presents summary results for Round 11 (2006/07) of the National Hospital Cost Data Collection for the three BMT AR-DRGs.

Table 52 Average total BMT cost (National Hospital Cost Data Collection)

AR-DRG	AR-DRG Description	Average Cost per DRG ($)	Number of separations	Number of hospitals
	National			
A07Z	Allogeneic Bone Marrow Transplant	$95,303	343	19
A08A	Autologous Bone Marrow Transplnt+Ccc	$44,301	478	36
A08B	Autologous Bone Marrow Transplnt-Ccc	$15,127	394	35
	New South Wales - Estimated			
A07Z	Allogeneic Bone Marrow Transplant	$115,121	118	9
A08A	Autologous Bone Marrow Transplnt+Ccc	$56,555	137	15
A08B	Autologous Bone Marrow Transplnt-Ccc	$22,157	121	15
	Victoria - Estimated			
A07Z	Allogeneic Bone Marrow Transplant	$86,313	91	5
A08A	Autologous Bone Marrow Transplnt+Ccc	$38,086	164	8
A08B	Autologous Bone Marrow Transplnt-Ccc	$11,477	96	8
	Queensland - Estimated			
A07Z	Allogeneic Bone Marrow Transplant	$62,676	78	2
A08A	Autologous Bone Marrow Transplnt+Ccc	$42,757	90	5
A08B	Autologous Bone Marrow Transplnt-Ccc	$19,014	50	5
	South Australia - Estimated			
A07Z	Allogeneic Bone Marrow Transplant	$83,092	18	2
A08A	Autologous Bone Marrow Transplnt+Ccc	$30,793	35	3
A08B	Autologous Bone Marrow Transplnt-Ccc	$13,391	43	2
	Western Australia - Estimated			
A07Z	Allogeneic Bone Marrow Transplant	$128,873	37	3
A08A	Autologous Bone Marrow Transplnt+Ccc	$41,916	31	4
A08B	Autologous Bone Marrow Transplnt-Ccc	$4,453	55	4

Appendix 7 Related Inpatient Episodes – Cost by AR-DRG

DRG	DRG title	Number of Episodes	Total Cost	Per Diem Cost	Average Length of Stay
Q60A	Reticuloendothelial and Immunity Disorders W Catastrophic or Severe CC	45.3	$912,264	$1,415	14.22
R60A	Acute Leukaemia W Catastrophic CC	14.8	$741,796	$2,111	23.7
R60C	Acute Leukaemia W/O Catastrophic or Severe CC	181.8	$665,420	$1,644	2.2
R61B	Lymphoma and Non-Acute Leukaemia W/O Catastrophic CC	86.3	$594,017	$1,513	4.5
A06Z	Tracheostomy or Ventilation >95 hours	4.2	$362,841	$2,452	35.5
T60A	Septicaemia W Catastrophic or Severe CC	23.5	$326,041	$1,672	8.3
R61A	Lymphoma and Non-Acute Leukaemia W Catastrophic CC	11.3	$310,478	$1,568	17.5
R60B	Acute Leukaemia W Severe CC	19.8	$266,755	$1,524	8.8
T62A	Fever of Unknown Origin W CC	29.0	$244,690	$1,537	5.5
R03A	Lymphoma and Leukaemia with other OR procedures W catastrophic or severe CC	4.2	$181,917	$1,487	29.4
B66B	Nervous System Neoplasm W/O Catastrophic or Severe CC	31.0	$140,497	$1,489	3.0
B60B	Established Paraplegia/Quadriplegia W or W/O O.R. Procs W/O Catastrophic CC	1.0	$136,776	$1,169	117.0
B02A	Craniotomy W Catastrophic CC	1.0	$124,249	$2,845	43.7
B66A	Nervous System Neoplasm W Catastrophic or Severe CC	11.0	$119,202	$1,568	6.9
F75B	Other Circulatory System Diagnoses W Severe CC	9.3	$97,569	$1,517	6.9
E62B	Respiratory Infections/Inflammations W Severe or Moderate CC	6.5	$79,850	$1,369	9.0
Q60B	Reticuloendothelial and Immunity Disorders W/O Cat or Severe CC W Malignancy	9.0	$76,778	$1,525	5.6
R61C	Lymphoma and Non-Acute Leukaemia, Same Day	128.7	$71,729	$557	1.0
G02A	Major Small and Large Bowel Procedures W Catastrophic CC	1.0	$70,473	$1,499	47.0
L02A	Operative insertion of peritoneal catheter for dialysis W cat or Severe CC	1.0	$69,575	$1,449	48.0
Q61C	Red Blood Cell Disorders W/O Catastrophic or Severe CC	17.3	$69,574	$1,273	3.2
G60A	Digestive Malignancy W Catastrophic or Severe CC	8.7	$69,083	$1,524	5.2
X63A	Sequelae of Treatment W Catastrophic or Severe CC	2.5	$62,301	$1,016	24.5
T62B	Fever of Unknown Origin W/O CC	8.3	$58,855	$1,682	4.2
I65B	Connective Tissue Malignancy, including Pathological Fx W/O Cat or Sev CC	13.3	$58,710	$2,072	2.1
L09A	Other Procedures for Kidney and Urinary Tract Disorders W Cat CC	0.3	$54,474	$1,993	82.0
R64Z	Radiotherapy	19.3	$53,515	$2,768	1.0
T01A	O.R. Procedures for Infectious and Parasitic Diseases W Catastrophic CC	1.7	$53,493	$1,888	17.0
Q60C	Reticuloendothelial and Immunity Disorders W/O Cat or Sev CC W/O Malignancy	10.8	$51,956	$1,332	3.6
F67A	Hypertension W CC	1.7	$51,276	$1,690	18.2
R01A	Lymphoma and Leukaemia W Major O.R. Procedures W Catastrophic or Severe CC	1.7	$51,000	$477	64.2
T60B	Septicaemia W/O Catastrophic or Severe CC	4.8	$48,977	$1,477	6.9
F75A	Other Circulatory System Diagnoses W Catastrophic CC	2.0	$48,124	$1,641	14.7
G46A	Complex Gastroscopy W Catastrophic or	2.7	$46,786	$1,477	11.9

DRG	DRG title	Number of Episodes	Total Cost	Per Diem Cost	Average Length of Stay
	Severe CC				
G12A	Other Digestive System O.R. Procedures W Catastrophic or Severe CC	2.0	$46,601	$1,571	14.8
Q61B	Red Blood Cell Disorders W Severe CC	6.0	$45,538	$1,469	5.2
T63A	Viral Illness Age >59 or W CC	4.2	$45,360	$1,495	7.3
Q61A	Red Blood Cell Disorders W Catastrophic CC	2.0	$44,851	$1,583	14.2
A41A	Intubation Age<16 W CC	1.3	$35,983	$2,570	10.5
F04A	Cardiac Valve Proc W CPB Pump W/O Invasive Cardiac Inves W Cat CC	1.0	$35,500	$2,958	12.0
F75C	Other Circulatory System Diagnoses W/O Catastrophic or Severe CC	7.0	$35,421	$1,586	3.2
I04Z	Knee Replacement and Reattachment	0.3	$35,141	$1,506	70.0
D67A	Oral and Dental Disorders Except Extractions and Restorations	3.0	$33,743	$1,066	10.6
S65B	HIV-Related Diseases W Severe CC	2.0	$32,920	$1,606	10.3
L63A	Kidney and Urinary Tract Infections W Catastrophic CC	1.7	$32,358	$1,184	16.4
K64B	Endocrine Disorders W/O Catastrophic or Severe CC	8.3	$31,926	$1,520	2.5
E01A	Major Chest Procedures W Catastrophic CC	1.0	$31,843	$2,123	15.0
E01B	Major Chest Procedures W/O Catastrophic CC	2.3	$31,552	$2,868	4.7
R63Z	Chemotherapy	31.0	$29,750	$960	1.0
S65A	HIV-Related Diseases W Catastrophic CC	1.5	$29,531	$3,109	6.3
E62A	Respiratory Infectn/Inflamm+Cc	0.8	$29,253	$1,463	24.0
L60B	Renal Failure W Severe CC	1.3	$29,000	$1,338	16.3
I65A	Connective Tissue Malignancy, including Pathological Fx W Cat or Sev CC	3.0	$27,439	$1,914	4.8
G60B	Digestive Malignancy W/O Catastrophic or Severe CC	9.0	$26,842	$1,610	1.85
Z64B	Other Factors Influencing Health Status, Same Day Geriatric	26.3	$25,926	$985	1.0
T64A	Other Infectious and Parasitic Diseases W Catastrophic or Severe CC	2.3	$24,141	$1,766	5.9
G67A	Oesophagitis, Gastroent & Misc Digestive System Disorders Age >9 W Cat/Sev CC	4.2	$21,080	$1,318	3.8
R01B	Lymphoma and Leukaemia W Major O.R. Procedures W/O Catastrophic or Severe CC	2.0	$20,585	$1,287	8.0
K64A	Endocrine Disorders W Catastrophic or Severe CC	3.3	$20,428	$2,043	3.0
B07A	Peripheral and Cranial Nerve & Other Nervous System Procedures W CC	1.0	$19,647	$756	26.0
D63A	Otitis Media and URI W CC	3.7	$18,555	$1,295	3.9
S60Z	HIV, Same Day	26.5	$18,546	$700	1.0
K62B	Miscellaneous Metabolic Disorders Age >74 or W Severe CC	3.7	$16,394	$1,329	3.4
E71B	Respiratory Neoplasms W Severe or Moderate CC	4.3	$16,391	$1,891	2.0
G67B	Oesophagitis, Gastroent & Misc Digestive System Disorders Age >9 W/O Cat/Sev CC	3.8	$15,572	$857	4.7
G12B	Other Digestive System O.R. Procedures W/O Catastrophic or Severe CC	1.0	$15,335	$2,556	6.0
E75B	Other Respiratory System Diagnosis Age >64 or W CC	3.5	$15,198	$1,216	3.6
R03B	Lymphoma and Leukaemia W Other O.R. Procedures W/O Catastrophic or Severe CC	2.0	$15,116	$2,387	3.2
L63C	Kidney and Urinary Tract Infections Age <70 W/O Catastrophic or Severe CC	1.3	$14,615	$4,872	2.3
B02C	Craniotomy W/O CC	0.3	$14,331	$1,869	23.0
Q02A	Other O.R. Procedure of Blood & Blood Forming	0.8	$14,253	$586	29.2

DRG	DRG title	Number of Episodes	Total Cost	Per Diem Cost	Average Length of Stay
	Organs W Cat or Sev CC				
A41B	Intubation Age<16 W/O CC	0.3	$13,224	$2,204	18.0
F63A	Venous Thrombosis W Catastrophic or Severe CC	1.3	$12,673	$939	10.1
J68A	Major Skin Disorders	2.0	$12,516	$1,211	5.2
X63B	Sequelae of Treatment W/O Catastrophic or Severe CC	1.3	$12,383	$728	12.8
I66A	Inflammatory Musculoskeletal Disorders W Cat or Severe CC	1.0	$12,231	$1,595	7.7
I28A	Other connective tissue Procedures W CC	0.5	$11,771	$1,070	22.0
Z62Z	Follow Up W/O Endoscopy	18.0	$11,249	$625	1.0
F21A	Other Circulatory System O.R. procedure w Catastrophic CC	0.3	$11,117	$1,588	21.0
D40Z	Dental Extractions and Restorations	3.0	$11,113	$3,704	1.0
K62C	Miscellaneous Metabolic Disorders Age <75 W/O Catastrophic or Severe CC	2.0	$10,679	$2,464	2.2
G68A	Gastroenteritis Age <10 W CC	3.0	$9,909	$1,651	2.0
K61Z	Severe Nutritional Disturbance	0.5	$9,854	$1,159	17.0
L60C	Renal Failure W/O Catastrophic or Severe CC	2.3	$9,839	$1,181	3.6
E02A	Other Respiratory System O.R. Procedures W Catastrophic CC	0.3	$9,644	$1,447	20.0
L03B	Kidney, Ureter and Major Bladder Procedures for Neoplasm W/O Cat or Sev CC	0.7	$9,093	$2,728	5.0
B81A	Other Disorders of the Nervous System W Catastrophic or Severe CC	1.3	$8,894	$1,721	3.9
G69Z	Oesophagitis and Misc Digestive System Disorders Age<10	1.0	$8,891	$1,667	5.3
D64Z	Laryngotracheitis and Epiglottitis	0.3	$8,840	$1,894	14.0
K63Z	Inborn Errors of Metabolism	1.7	$8,511	$1,824	2.8
I12A	Infect/Inflam of Bone & Joint W Misc Musc Sys & Conn Tiss Procs W Cat CC	0.5	$8,497	$2,832	6.0
F71B	Non-Major Arrhythmia and Conduction Disorders W/O Catastrophic or Severe CC	1.8	$8,031	$1,662	2.6
G66A	Abdominal Pain or Mesenteric Adenitis W CC	1.3	$7,957	$1,591	3.8
K03Z	Adrenal Procedures	0.7	$7,934	$2,645	4.5
I68A	Non-surgical Spinal Disorders W CC	0.8	$7,902	$1,693	5.6
M62A	Inflammation of Male Reproductive System W CC	0.5	$7,579	$842	18.0
Q62Z	Coagulation Disorders	6.2	$7,498	$1,046	1.2
Q01Z	Splenectomy	0.3	$7,457	$1,721	13.0
T61A	Postoperative and Post-Traumatic Infections Age > 54 or W (Cat or Sev CC)	0.5	$7,102	$1,015	14.0
D06Z	Sinus, Mastoid and Complex Middle Ear Procedures	1.0	$7,017	$7,017	1.0
I71B	Other Musculotendinous Disorders Age >69 or W CC	1.3	$6,775	$1,452	3.5
T01B	O.R. Procedures for Infectious and Parasitic Diseases W Severe or Moderate CC	0.3	$6,742	$1,190	17.0
F71A	Non-Major Arrhythmia and Conduction Disorders W Catastrophic or Severe CC	0.8	$6,697	$913	8.8
L63B	Kidney and Urinary Tract Infections Age >69 or W Severe CC	1.0	$6,531	$1,399	4.7
L67B	Other Kidney and Urinary Tract Diagnoses W Severe CC	1.7	$6,280	$1,570	2.4
L62B	Kidney and Urinary Tract Neoplasms W/O Catastrophic or Severe CC	2.3	$6,053	$1,513	1.7
L65A	Kidney and Urinary Tract Signs and Symptoms W Catastrophic or Severe CC	0.8	$5,992	$1,160	6.2
G44A	Other ColonoscopyWCatastrophic or Severe cc	0.5	$5,969	$853	14.0

DRG	DRG title	Number of Episodes	Total Cost	Per Diem Cost	Average Length of Stay
G45A	Other Gastroscopy for Non-Major Digestive Disease	0.5	$5,137	$856	12.0
H64A	Disorders Of Biliary Tract +Cc	0.3	$5,124	$1,025	15.0
K60A	Diabetes W Catastrophic or Severe CC	0.3	$4,983	$2,492	6.0
G66B	Abdominal Pain or Mesenteric Adenitis W/O CC	0.7	$4,943	$2,471	3.0
L03A	Kidney, Ureter and Major Bladder Procedures for Neoplasm W Catastrophic CC	0.3	$4,729	$2,837	5.0
C63A	Other Disorders of the eye W CC	0.7	$4,609	$1,728	4.0
T61B	Postoperative & Post-traumatic Infections Age <55 W/O Cat or Sev CC	0.7	$4,278	$1,426	4.5
I66B	Inflammatory Musculoskeletal Disorders W/O Cat or Sev CC	2.5	$4,130	$1,652	1.0
I08B	Other Hip & Femur Pr -Cscc	0.3	$3,892	$1,061	11.0
Z64A	Other Factors Influencing Health Status	1.3	$3,777	$2,266	1.3
E71C	Respiratory Neoplasms W/O CC	1.0	$3,654	$2,741	1.3
G68B	Gastroenteritis Age <10 W/O CC	0.7	$3,466	$1,486	3.5
L62A	Kidney and Urinary Tract Neoplasms W Catastrophic or Severe CC	1.0	$3,455	$1,727	2.0
X62A	Poisoning/Toxic Effects of Drugs & Other Substances Age >59 or W CC	0.3	$3,121	$1,873	5.0
G46B	Complex Gastroscopy W/O Catastrophic or Severe CC	0.5	$3,063	$875	7.0
I12B	Infect/Inflam of Bone & Joint W Misc Musc Sys & Conn Tiss Procs W Sev CC	0.3	$3,015	$393	23.0
F73A	Syncope and Collapse W Catastrophic or Severe CC	1.5	$2,935	$839	2.3
B76A	Seizure W Catastrophic or Severe CC	0.7	$2,918	$2,189	2.0
J68B	Major Skin Disorders, Same Day	0.3	$2,886	$8,657	1.0
J67A	Minor Skin Disorders	0.3	$2,814	$1,055	8.0
S65C	HIV-Related Diseases W/O Catastrophic or Severe CC	0.5	$2,761	$5,522	1.0
M04A	Testes Procedures W CC	0.7	$2,757	$4,136	1.0
I76B	Other Musculoskeletal Disorders Age >69 or W CC	1.5	$2,716	$1,811	1.0
B70D	Stroke, Died or Transferred < 5 days	0.3	$2,620	$1,965	4.0
E02C	Other Respiratory System OR Procedures W/O CC	0.3	$2,496	$2,496	1.0
I25Z	Bone and Joint Diagnostic Procedures including Biopsy	0.3	$2,449	$1,837	4.0
D61Z	Dysequilibrium	0.3	$2,374	$1,780	4.0
E71A	Respiratory Neoplasms W Catastrophic CC	0.7	$2,028	$1,521	2.0
B67A	Degenerative Nervous System Disorders W Cat or Sev CC	0.3	$1,940	$1,940	3.0
Z60A	Rehabilitation + Cscc	0.3	$1,757	$479	11.0
B62Z	Admit for Apheresis	1.8	$1,666	$909	1.0
D13Z	Myringotomy W Tube Insertion	0.3	$1,616	$2,425	2.0
E67B	Respiratory Signs and Symptoms W/O Catastrophic or Severe CC	1.0	$1,533	$1,533	1.0
N09Z	Conisation, Vagina, Cervix and Vulva Procedures	1.0	$1,409	$1,409	1.0
M60A	Malignancy, Male Reproductive System W Catastrophic or Severe CC	0.3	$1,250	$1,874	2.0
U65Z	Anxiety Disorders	0.7	$1,241	$1,861	1.0
F42A	Circulatory Disorders W/O AMI W Invasive Cardiac Inves Proc W Complex DX/Pr	0.5	$1,199	$2,398	1.0
I61Z	Distal Femoral Fractures	0.3	$1,173	$1,760	2.0
960Z	Ungroupable	0.3	$1,101	$3,304	1.0
E67A	Respiratory Signs and Symptoms W	0.3	$930	$1,396	2.0

DRG	DRG title	Number of Episodes	Total Cost	Per Diem Cost	Average Length of Stay
	Catastrophic or Severe CC				
G03B	Stomach, Oesophageal and Duodenal Procedures W/O Malignancy W Cat or Sev CC	0.3	$908	$2,725	1.0
L65B	Kidney and Urinary Tract Signs and Symptoms W/O Catastrophic or Severe CC	1.3	$904	$452	1.5
E69B	Bronchitis and Asthma Age >49 or W CC	0.3	$863	$1,295	2.0
G44C	Other Colonoscopy, Same Day	1.0	$807	$807	1.0
G70A	Other Digestive System Diagnoses W CC	0.3	$804	$2,412	1.0
L41Z	Cystourethroscopy, Same Day	0.3	$769	$2,308	1.0
T64B	Other Infectious and Parasitic Diseases W/O Catastrophic or Severe CC	0.3	$731	$2,194	1.0
P67D	Neonate, AdmWt > 2499 g W/O Significant O.R. Procedure W/O Problem	0.3	$696	$1,044	2.0
Z01A	O.R. Procedures W Diagnoses of Other Contacts W Health Services W Cat/Sev CC	0.3	$620	$1,860	1.0
E74C	Interstitial Lung Disease W/O Catastrophic or Severe CC	0.3	$557	$1,670	1.0
E65B	Chronic Obstrct Airway Dis-Cscc	0.7	$549	$823	1.0
I68C	Non-surgical Spinal Disorders, Same Day	0.8	$509	$611	1.0
I64A	Osteomyelitis W CC	0.3	$493	$1,480	1.0
R62B	Other Neoplastic Disorders W/O CC	0.7	$411	$617	1.0
G45B	Other Gastroscopy for Non-Major Digestive Disease, Same Day	1.0	$409	$409	1.0
F74Z	Chest Pain	0.5	$356	$712	1.0
D66A	Other Ear, Nose, Mouth and Throat Diagnoses W CC	0.3	$343	$1,028	1.0
C60B	Ac & Mjr Eye Infectn A<55-Cscc	0.3	$332	$996	1.0
D63B	Otitis Media & Uri - Cc	1.3	$295	$221	1.0
L61Z	Admit for Renal Dialysis	0.3	$264	$791	1.0
D62Z	Epistaxis	0.3	$202	$607	1.0
J67B	Minor Skin Disorders, Same Day	0.3	$108	$325	1.0
M60B	Malignancy, Male Reproductive System W/O Catastrophic or Severe CC	0.3	$52	$157	1.0
All		**996.5**	**$7,828,507**	**$1,538**	**4.9**

** Includes only costs that occurred in year of separation for ending episodes

Note: Data adjusted for hospitals with data from different time periods & costs adjusted for inflation

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