Human Tissue Banking in Canada

Costing and Economic Analysis

Final Report

Human Tissue Banking in Canada

Costing and Economic Analysis

Final Report

Prepared for:
Canadian Council for Donation and Transplantation

Prepared by:
Goss Gilroy Inc.
Management Consultants
Suite 900, 150 Metcalfe Street
Ottawa, ON K2P 1P1
Tel: (613) 230-5577
Fax: (613) 235-9592
E-mail: ggi@ggi.ca

September 16, 2003

GOSS GILROY INC.
Management Consultants
Conseillers en gestion

Table of Contents

1.0 Introduction

The overall purpose of this study is to develop for the Canadian Council for Donation and Transplantation, a more comprehensive understanding of the costs and economics of operating tissue banks in Canada. To achieve this objective, it is necessary to convey an accurate picture of the types and magnitudes of all costs that Canadian tissue banks incur, as many costs are hidden in global hospital budgets, and many services are provided free of charge by the hospitals in which the tissue banks reside. It is also important to understand how Canadian tissue bank cost structures compare with those of American tissue banks, as many Canadian tissue banks and hospital operating rooms rely on purchasing imported tissue to meet demand. Fees for US tissue fees are often sharply higher than those paid to other Canadian tissue banks. Many tissue banks in Canada are only now beginning to develop fee structures.

US tissue banks are generally larger and produce more sophisticated tissue products. As the Canadian tissue banking community grows, evolves, produces ever more sophisticated tissue products, and relies less and less on US tissue imports, an understanding of these cost structures will prove invaluable in future budget planning and setting tissue fee levels.

Finally, it will prove very useful to the CCDT and tissue bank managers to know the true cost of providing tissues for transplantation. That is, the actual cost of retrieving, processing, storing, and distributing a tendon or an aortic valve for example. By developing unit costs for several types of tissue, managers of tissue banks will be given an opportunity to re-evaluate their current tissue fee structures in a meaningful context.

This study has undertaken 10 tasks that to develop a better understanding of the rationale for tissue fees in Canada:

1. Determine tissue prices from Canadian sources.
2. Determine tissue prices from foreign sources.
3. Sample American tissue bank cost structures
4. Sample Canadian tissue bank cost structures
5. Identify Canadian methodologies to determine “cost recovery” or “procurement reimbursement”.

6. Identify American methodologies to determine "cost recovery" or "procurement reimbursement".
7. Compare Canadian cost recovery to actual cost structure.
8. Compare tissue prices from Canadian to foreign sources.
9. Correlate Canadian tissue costs with varying levels of service.
10. Provide a Canadian cost per tissue donor for recovery, processing and storage procedures.

It is understood that the scope of the study includes human allograft tissues such as ocular tissues, amniotic membrane, skin, cardiovascular tissues and musculoskeletal tissues. Other tissues such as islets, bone marrow, stem cells and cord blood, autologous human tissue, reproductive tissues, non-human tissues and synthetic tissues are considered to be beyond the scope of this study.

1.1 Overview

This report presents our detailed approach to carrying out the tissue bank costing and economic analysis and includes the following sections:

- **Section 1** presents the purpose of the report, the objectives of the study, and provides an outline of the report content.
- **Section 2** describes the approach that this study has taken to achieve the above stated goals and objectives.
- **Section 3** provides an overview of the study's participants
- **Section 4** presents costs per donor for Canadian and American tissue banks that participated in the study.
- **Section 5** presents the costs per tissue for Canadian and American tissue banks that participated in the study.
- **Section 6** makes fee comparisons between Canadian and American participants
- **Section 7** presents the study's conclusions.

2.0 Methodology and Approach

2.1 The Approach

This study's approach consisted of three phases: *design, data collection*, and *analysis and reporting.*

Design

In the design phase, several instruments (interview guides, tissue bank process flow models, etc.) were designed with the assistance of members of the CCDT and tissue bank managers. Participation from a sample of tissue banks in Canada and the US was also secured. Copies of the interview guides used to collect information from tissue banks are provided in Appendix A and B.

Data Collection

The data collection phase consisted of interviewing tissue bank managers via telephone, visiting Canadian tissue banks, and surveying American tissue banks to collect cost and fee information.

Analysis and Reporting

The analysis and reporting phase consists of analysing data from tissue banks, converting it into a meaningful format, and creating the final report.

2.2 Types of Costs Captured

In order for tissue bank managers to be able to price their products and services in a manner that recovers costs, they must understand which costs vary with donor levels, which do not, and they must understand the costs associated with the major activities that are involved in producing final tissue products.

A tissue bank's total costs consist of two types of costs: variable and fixed costs.

Variable Costs

Variable costs or direct costs as they are often referred to, will generally vary with the number of donors that a tissue bank processes. Examples of variable costs include supplies directly attributable to processing and fees paid for services such as serological testing.

Fixed Costs

Fixed costs, also referred to as overhead costs generally do not vary with the number of donors a tissue bank processes. Examples include salaries for managerial and secretarial staff, capital costs, and utilities like heat and electricity.

A tissue bank's total costs can be expressed as:

Total Costs = Fixed Costs + Variable Costs

Stages of Production

During interviews with representatives at Canadian tissue banks, one of the primary objectives in understanding the variable component of tissue bank costs was to attempt, with the assistance of tissue bank personnel, to estimate the breakdown of variable costs across the principal stages in the overall process. With the assistance of CCDT representatives and tissue bank managers, it was agreed that the five principal stages to characterize the variable cost component of the tissue banking process would be:

- Donor screening and tissue recovery;
- Testing;
- Processing;
- Storage and distribution; and,
- Quality Assurance.

Note that fixed costs (i.e., capital, administrative salaries & wages, etc.) are generally

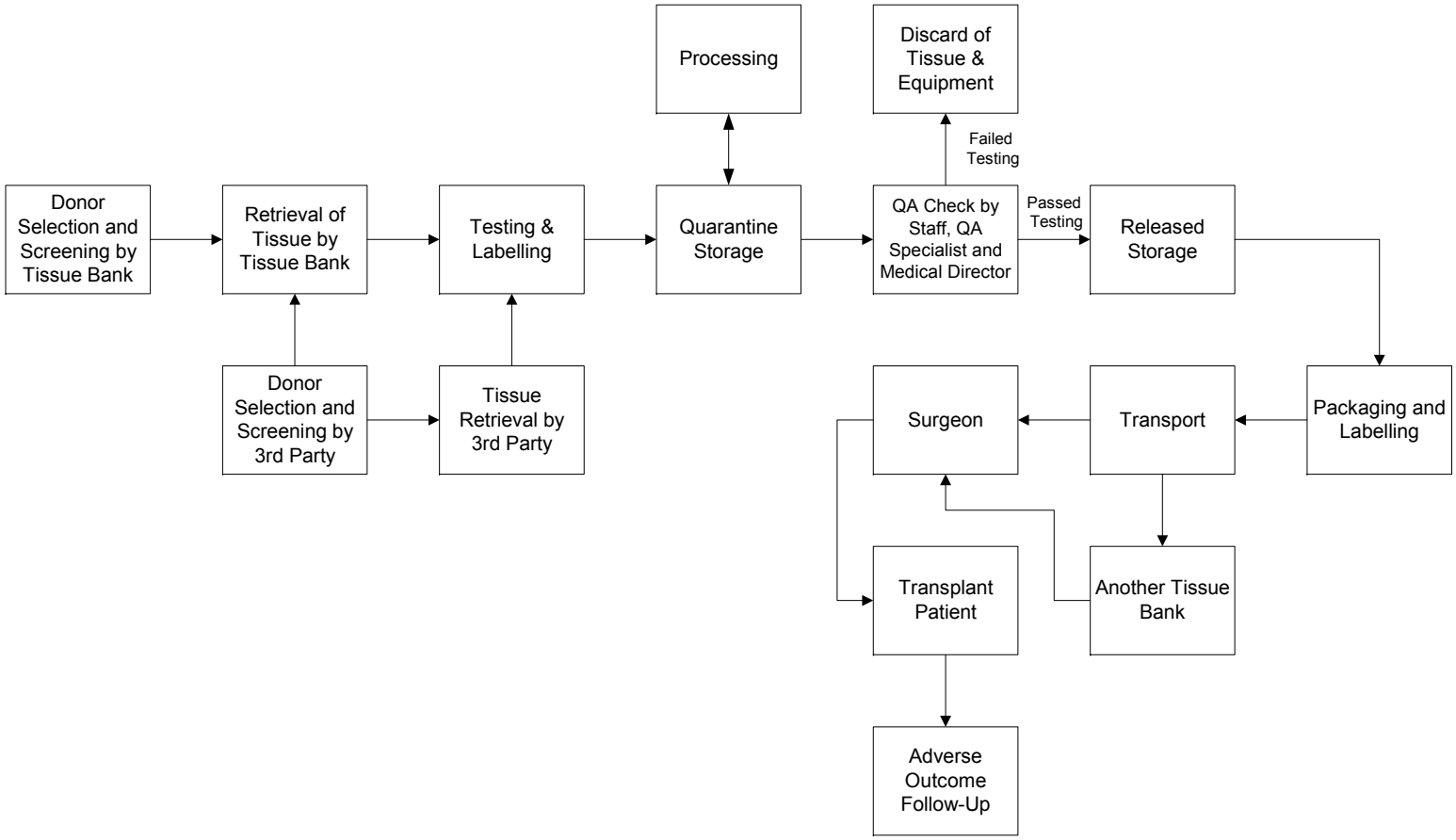
not specific to a production stage and cannot be meaningfully broken down in this manner. The types of variable costs associated with each of the five stages include salaries, wages, supplies, and expenses directly relating to the activities are described in the table below.

Table 2.1: Activities and Expenses Attributable to Stages of Production

Stage	Activities/Expenses
Screening & Recovery	Locating donors, obtaining consent, transporting retrieval teams and donors, screening medical and behavioural history, retrieval team wages, recovery supplies, and fees associated with purchasing tissue as opposed to retrieving it.
Testing	Charges for microbiological testing, serological testing, tissue-specific testing (i.e., slit lamp), autopsies, six-month follow-up testing of live donors, supplies associated with testing, and tissue bank staff wages and salaries attributable to time spent concerned with testing activities.
Processing	Salaries and wages attributable to time spent transforming raw tissue into a finished product (i.e. cutting, wrapping, labelling, etc.), tissue identification and coding, sterilizing, refrigerating, controlled-rate freezing, culturing, and supplies used in processing.
Storage and Distribution	Salaries and wages attributable to time spent concerned with storage, packaging tissue for transport, shipping tissue, and expenses for supplies (i.e. solutions, packaging, etc.)
Quality Assurance	Salaries, wages, and expenses associated with MD reviews, equipment calibration, preventative maintenance, monitoring, developing standards of practice, employee training and education, audits, and R & D.

In Figure 2.1 below, a conceptual diagram of the flow of tissue through a typical tissue bank is presented.

Figure 2.1: Process Flow – Tissue Banking



2.3 Definitions and Assumptions

The following definitions will prove useful in interpreting the results in the sections that follow:

Definitions:

- *Donor* – someone from whom tissue is recovered regardless of whether subsequent testing is passed. A single cadaver can be several types of donors (e.g., an eye donor, a bone donor, and a skin donor)
- *Variable Costs* – costs which vary with the number of donors
- *Fixed Costs* – costs which do not vary with the number of donors
- *Total costs* – the sum of variable costs and fixed costs
- *Total donors* – the sum of all donors (i.e., cardiovascular donors + eye donors, etc.). This sum includes donors whose processed tissue subsequently failed testing.
- *Capital costs* – the annualized cost of assets such as equipment and buildings that takes into account the replacement cost, borrowing rate, and economic lifespan of the asset.
- *Fixed salaries and wages* – labour costs that are administrative or clerical in nature and generally do not vary with the number of donors.
- *Variable salaries and wages* – labour costs attributable to technical tissue banking activities (i.e., testing, retrieving, processing, etc.) and generally vary with the number of donors.[1]
- *Other fixed expenses* – fixed expenses other than capital costs and administrative salaries and wages (i.e., AATB fees).
- *Supplies* – consists of items such as tissue media solutions, antibiotics, sterile clothes, recovery and packaging supplies, etc. These are costs that vary directly with the number of donors.
- *Other variable expenses* – consist of expenses such as shipping charges or testing fees that vary directly with the number of donors.

Assumptions:

- *Capital costs of buildings* – Except in the case where a tissue bank actually leases its premises, the annual capital cost of the premises is calculated

[1] Because some tissue banks do not operate near full capacity, an increase in donors may not require hiring more technical staff. For the purposes of this study however, labour devoted to technical activities is considered to be variable.

based on its square footage. The calculation assumes the premises have an economic lifespan of 40 years, and the cost per square foot for building a tissue bank is estimated at $200 CDN.[2]

- *Borrowing rate* – Used to calculate the annual capital cost associated with buildings and equipment. The rate of 5.85% used in all calculations is the average long-term yield on Canadian bonds from 1997-2002. This rate approximates the borrowing cost of hospitals.
- *Utility costs* – Except in cases where tissue banks could provide utility costs, they were assumed at $1.99CDN per square foot per year. This rate is the average of utility costs at three Canadian hospitals in recent years.[3]
- *Currency Exchange Rate* - American tissue bank costs have been converted into Canadian dollars at the rate of 1.5625 CDN/US, the average daily Bank of Canada US exchange rate at noon from Jan 1-Dec 31, 2002.[4]

2.4 Data Gathering Method

To collect cost and fee data from Canadian tissue banks, initial phone interviews were conducted with tissue bank managers. These interviews provided basic information on tissue banks such as the types and volumes of tissues processed. This information was then used to customize the interview guide for each tissue bank. Following the telephone interview, a visit was conducted at each tissue bank to gather cost and fee data. Tissue bank representatives that were present at the interviews typically included its manager and a technologist.

To collect cost and fee data from American tissue banks, initial phone interviews were also conducted to allow customization of the interview guide. American tissue bank representatives provided their information via a mail-back interview guide, and in some cases a short follow-up phone interview was required to verify or clarify information.

The following data was discussed and gathered from Canadian and American participants:

[2] Balys and Associates.
[3] Toronto East General and Orthopaedic Hospital – Energy Management Action Plan; Green Buildings BC- Retrofit Program – St. Paul's Hospital
[4] Bank of Canada Currency Converter - http://www.bankofcanada.ca/en/exchange-convert.htm

- Basic statistics (annual budget, number of full-time equivalent employees, etc.);
- Donor and tissue volumes (for each tissue);
- Donor and tissue rejection rates;
- Services performed (i.e., screening, testing, etc.);
- Size of tissue bank (in square feet);
- Major equipment owned (i.e., Biosafety cabinets, freezers, etc.);
- Expenses;
    - Leasing expenses;
    - Interest on debt (US tissue banks only);
    - Maintenance;
    - Computing and data storage costs;
    - Utilities;
    - Accreditation costs;
    - Insurance and legal services;
    - Donor and public education;
    - Quality assurance expenses (non-salary expenses only);
    - Supplies;
    - Transportation costs (shipping charges, retrieval team travel, and donor transportation);
    - Tissue costs (purchasing tissue from other tissue banks);
    - Salaries and wages;
    - Fees for service (i.e. testing);
    - Miscellaneous; and,
- Tissue Fees (prices).

2.4.1 Estimating Variable Costs

In order for meaningful analysis of the Canadian data to occur it was necessary to engage tissue bank technologists and managers in a discussion that uncovered the amount of labour and supplies that were necessary to produce a given category of tissues (in the case where a tissue bank produced more than once category of tissues).

Estimating Labour Costs

To estimate the labour time required, discussions took place regarding the type of activities that occurred at each stage of production, how many staff members were involved, and how long these activities required. A table similar to the example below was used:

Table 2.2: Labour Hours Required Per Donor Across Tissue Categories

	Labour Hours Required per Donor					
Tissue Category	**Screening & Recovery**	**Testing**	**Processing**	**Storage & Distribution**	**QA**	**Total**
Eyes						
Musculoskeletal						
Skin						
Cardiovascular Tissue						

By multiplying the number of donors for each tissue type by the total labour hours required per donor, a reasonable estimate of the labour required was developed. Labour hours were then converted into labour costs via one of two methods:

- Multiplying labour hours by the hourly wages of staff; or,
- Multiplying the percentage of total labour hours attributable to a tissue category for a given stage of production by total technical salaries and wages. For example, if it took 10 hours to screen and recover eyes from all eye donors, and total labour hours were 1000, then labour costs for screening and recovering eyes would be 10/1000 x the technical portion of staff salaries & wages. Note that if there is a portion of a technician's time spent doing administrative duties, this portion of their labour costs would be allocated to administrative salaries & wages, a fixed cost.

Next, the category of tissue (i.e., musculoskeletal) was broken down into specific tissue products, and labour time required per tissue was estimated. The example below breaks down musculoskeletal tissues into four tissues.

Table 2.3: Labour Hours Required Per Musculoskeletal Tissue

	Labour Hours Required per Tissue					
Tissue	Screening & Recovery	Testing	Processing	Storage & Distribution	QA	Total
Tendon						
Fascia						
Femoral Head						
Hemipelvis						

Estimating Supplies and Other Variable Expenses

Supplies like tissue media solutions used to process and store tissue and other variables expenses like shipping charges vary directly with the number of donors; more donors mean higher costs. To estimate these costs, discussions took place regarding the type and cost of supplies and other variable expenses incurred at each stage of production. Reasonable estimates for supplies and other variable expenses were derived for each tissue at every stage of production.

2.4.2 Estimating Fixed Costs

Fixed costs consist of three categories: capital (i.e., equipment), salaries and wages (administrative and clerical only), and other fixed expenses (i.e., accreditation fees). Certain fixed costs can be allocated solely to one type of tissue (e.g., the annualized capital cost associated with a slit lamp is allocated entirely to ocular tissues) and are considered tissue specific fixed costs.

Most fixed costs however, cannot be allocated to one specific category of tissue, and therefore must be shared across tissue categories. For fixed costs that were shared across tissues, the basis used for allocating fixed costs was donor volume. For example if 25% of all donors were musculoskeletal donors, then as a category, musculoskeletal tissues were allocated 25% of the fixed costs that were not tissue specific. Examining musculoskeletal tissues further, if 10% of musculoskeletal donors donated hemipelvis, then hemipelvis received 10% of shared fixed costs that were allocated to musculoskeletal tissues.

2.5 Presentation of Findings and Confidentiality

Results must be presented in a manner that is meaningful and useful to the CCDT and tissue bank managers. At the same time however, the nature of the data is sensitive and its presentation must safeguard the identity of participating tissue banks. Correspondingly, the names of participating tissue banks are not revealed in this study. Furthermore, because there are so few tissue banks in Canada, presenting a tissue bank's cost per donor may unintentionally reveal its identity. Average, minimum, and maximum costs of the participating tissue banks are therefore presented to avoid breaches of confidentiality.

Based on discussions with tissue bank managers in Canada and the United States, a study of this nature has likely never been undertaken before. Before drawing conclusions from the data, readers are reminded that although the sample of Canadian participants in the study represents more than 50% of the volume of skin, cadaveric musculoskeletal, and cardiovascular tissue processed in Canada in 2002, the size and practices of tissue banks can vary greatly. Costs do vary greatly across tissue banks, with the volume of donors processed and the types of tissues recovered, therefore *results may not be representative of costs at non-participating tissue banks.* This is particularly true of the results from US participants who represent a small fraction of tissue banking activity in their country. Instead of making authoritative statements as to what it costs to operate a tissue bank, the efforts of this study are a first step in understanding the operating and capital costs associated with tissue banking

2.6 Participants

Canadian Tissue Banks

After consultation with several stakeholders and in the interest of deriving the most valuable information for the study, it was decided that the most ideal sample of Canadian tissue banks would be a sample of tissue banks that hold AATB or EBAA certification and process at least one of the following tissues:

- Musculoskeletal tissues (cadaveric)
- Surgical bone;
- Skin;
- Ocular tissue; and,
- Cardiovascular tissue.

This sample of tissue banks allowed cost structures to be observed between tissue banks of varying sizes (i.e., donor volume, range of tissues processed). The inclusion of tissue banks that process and store several of the above tissues may offer evidence of economies of scale associated with comprehensive tissue services, improved resource utilization with regard to cadaver tissue harvesting, and if and how these economies of scale relate to the fee levels charged.

American Tissue Banks

In order to meet demand, Canadian tissue bank managers and hospital operating rooms need to import tissue from the US and have, over a period of years, developed relationships with tissue bank personnel in the US. These relationships resulted in the participation of four American tissue banks in this study. The US tissue banks participating in the study process the following tissues:

- Musculoskeletal tissues (cadaveric)
- Surgical bone;
- Skin;
- Ocular tissue; and,
- Cardiovascular tissue.

Because cost and fee data were collected via a mail out/mail back survey, the information received from American tissue banks was not nearly as detailed as it was for Canadian tissue banks. Resultantly, the cost analysis for American tissue banks is not nearly as comprehensive.

2.7 Examples of Cost Calculations

A demonstration of how tissue bank costs were calculated is provided in the simple example of a fictitious tissue bank, which follows. This tissue bank

retrieves and processes two types of tissue:

- Ocular tissue; and,
- Skin.

Total costs for the tissue bank are $250,000 and break down as follows:

Table 2.4: Sample Tissue Bank Cost Breakdown

Cost Item	Annual Cost
Fixed Costs	
Capital	$65,000
Administrative Salaries & Wages	$30,000
Other Fixed Expenses	$15,000
Total Fixed Costs	*$110,000*
Variable Costs	
Technical Salaries & Wages	$110,000
Supplies	$20,000
Other Variable Expenses	$10,000
Total Variable Costs	*$140,000*
Total Costs	***$250,000***

For the purposes of this study, a "donor" is someone from whom tissue has been recovered, regardless of whether subsequent testing is passed. Donor and tissue volumes for this sample bank are as follows:

Table 2.5: Sample Tissue Bank Donor and Tissue Volumes

Tissue Type	Number of Donors	Number of Donors or Tissue Rejected	Volume of Tissue Moved From Quarantine to Release Storage
Ocular Tissue	100	25	
Corneas		50	150
Sclera		15	65
Research globes		N/A	20
Skin	20	2	60 sq. ft.
Total	120	N/A	N/A

Cost per donor for this tissue bank is therefore: $250,000/120 donors = $2,083. Because the labour and expenses associated with processing donors whose tissue is subsequently discarded is comparable to that for donors whose tissue is suitable for transplantation, it is important to divide total costs by *all* donors. Dividing total costs solely by the donors whose tissue passes all testing would result in a higher cost per donor that would not reflect costs in an accurate manner.

2.7.1 Variable Cost Estimates

Using the methodology described in Section 2.3 above, the following variable labour estimates (in hours per donor) were developed:

Table 2.6 Sample Tissue Bank - Labour Hours per Donor

	Labour Hours Required per Donor					
Donor Type	**Screening & Recovery**	**Testing**	**Processing**	**Storage & Distribution**	**QA**	**Total**
Ocular	0.5	0.5	2.0	0.5	2.0	5.5
Skin	6.0	1.0	5.0	2.0	3.0	17.0
Total	6.5	1.5	7.0	2.5	5.0	22.5

The next step is to multiply the hours required per donor by the number of donors for each type of donor.

Table 2.7 Sample Tissue Bank - Labour Hours Adjusted for Donor Volume

		Labour Hours Adjusted for Donor Volume					
Donor Type	**Donors**	**Screening & Recovery**	**Testing**	**Processing**	**Storage & Distribution**	**QA**	**Total**
Ocular	100	50.0	50.0	200.0	50.0	200.0	550.0
Skin	20	120.0	20.0	100.0	40.0	60.0	340.0
Total	120	170.0	70.0	300.0	90.0	260.0	890.0

The final step in calculating variable labour costs is to multiply the percentage of total hours each donor type requires for each stage by the total technical salaries and wages ($110,000). For example to calculate the cost of screening and recovering tissue from ocular donors, the formula is 50.0 hours/890 hours x $110,000 = $6,180. Variable labour costs are presented in the next table.

Table 2.8 Sample Tissue Bank – Variable Labour Cost Estimates

	Variable Labour Cost Estimates					
Donor Type	**Screening & Recovery**	**Testing**	**Processing**	**Storage & Distribution**	**QA**	**Total**
Ocular	$6,180	$6,180	$24,719	$6,180	$24,719	$67,978
Skin	$14,831	$2,472	$12,360	$4,944	$7,416	$42,022
Total	$21,011	$8,652	$37,079	$11,124	$32,135	$110,000

Estimates of supplies (e.g., cryoprotectants) and other variables expenses (e.g., shipping charges) are then attributed to their appropriate tissue type and stage of production. The table below provides a detailed breakdown of these type of costs.

Table 2.9 Sample Tissue Bank – Supplies and Other Variable Expenses

Product	**Screening & Retrieval**	**Testing**	**Processing**	**Storage & Distribution**	**QA**	**Total**
Ocular Tissue						
Recovery supplies	$3,006					$3,006
Testing Fees		$601				$601
Tissue media solutions			$5,713			$5,713
Antibiotics			$1,500			$1,500

Product	Screening & Retrieval	Testing	Processing	Storage & Distribution	QA	Total
Storage solutions				$700		$700
Packaging				$250		$250
Shipping charges				$252		$252
Total Ocular	*$3,006*	*$601*	*$7,213*	*$1,202*	*$0*	*$12,022*
Skin						
Recovery supplies	$6,292					$6,292
Testing Fees		$899				$899
Cleaners			$489			$489
Tissue media solutions			$5,000			$5,000
Antibiotics			$2,000			$2,000
Cryoprotectant solutions			$1,500			$1,500
Packaging				$1,400		$1,400
Shipping charges				$398		$398
Total Skin	*$6,292*	*$899*	*$8,989*	*$1,798*	*$0*	*$17,978*
Total Ocular and Skin	**$9,298**	**$1,500**	**$16,202**	**$3,000**	**$0**	**$30,000**

By summing variable labour costs with supplies and other variable expenses, the result is total variable costs by stage of production.

Table 2.10: Sample Tissue Bank – Total Variable Costs

	Total Variable Costs					
Donor Type	Screening & Recovery	Testing	Processing	Storage & Distribution	QA	Total
Ocular	$9,185	$6,781	$31,933	$7,382	$24,719	$80,000
Skin	$21,124	$3,371	$21,348	$6,742	$7,416	$60,000
Total	$30,309	$10,152	$53,281	$14,124	$32,135	$140,000

Variable cost per donor results from dividing variable costs for ocular and skin tissue by their number of respective donors (100 and 20).

Table 2.11: Sample Tissue Bank – Total Variable Costs per Donor

	Total Variable Costs per Donor					
Donor Type	**Screening & Recovery**	**Testing**	**Processing**	**Storage & Distribution**	**QA**	**Total**
Ocular	$92	$68	$319	$74	$247	$800
Skin	$1,056	$169	$1,067	$337	$371	$3,000
Total	$253	$85	$444	$118	$268	$1,167

Variable costs per donor are therefore $800 per eye donor and $3000 per skin donor. Total variable costs per donor are $1,167. This figure is the variable costs of both tissues ($140,000) divided by the number of eye and skin donors (120). It can also be interpreted as the weighted average variable cost of skin and ocular donors.

2.7.2 Fixed Cost Estimates

To compute capital costs, the replacement cost of buildings and equipment is converted into an annualized capital cost by taking into account the economic lifespan of the equipment in years (specific to each tissue bank), and the borrowing rate of interest assumed. Using the methodology described in Section 2.4.2 above, capital cost estimates are derived by first allocating tissue specific assets (e.g., a specular microscope) to its appropriate tissue (ocular tissue). Assets that are used for both ocular and skin tissue (e.g., computers) are attributed based on percentage of donor volume. For example, for this sample tissue bank, computers have an annualized capital cost of $1,500. Because ocular donors represent 83.3% of donors (100 of 120), ocular tissues are attributed 83.3% of capital costs for computers. When these calculations are performed, the result is an annualized capital cost of $39,917 for ocular donors and $25,083 for skin donors, for a total of $40,000. Capital costs for ocular tissue and skin are presented in the table below; for simplicity and illustrative purposes, figures have been “rounded” and are not representative of any particular tissue bank.

Table 2.12: Sample Tissue Bank Capital Costs

Asset	Replacement Cost	Lifespan of Asset (in years)	Annualized Capital Cost		
			Ocular Tissue	Skin	Total Capital Costs
Tissue Specific Assets					
Enucleation Kits (8)	$15,000	7	$2,500		$2,500
Scleral Kits (3)	$4,500	7	$750		$750
Slit Lamps	$10,000	10	$1,500		$1,500
Specular Microscope	$40,000	10	$6,000		$6,000
Dermatome	$10,000	5		$3,000	$3,000
Skin surgical instrument set	$1,000	5		$250	$250
Liquid nitrogen freezer (3)	$45,000	10		$6,000	$6,000
Control-rate freezer (3)	$75,000	10		$9,000	$9,000
Cryoshippers (2)	$7,500	10		$1,000	$1,000
Shared Assets					
Building	$400,000	40	$20,833	$4,167	$25,000
Biosafety cabinet (2)	$26,000	10	$2,917	$583	$3,500
Refrigerator (2)	$16,000	15	$1,250	$250	$1,500
Software	$300	3	$83	$17	$100
Computers (3)	$6,000	3	$1,250	$250	$1,500
Office furniture	$5,000	20	$208	$42	$250
Vehicle	$25,000	10	$2,625	$525	$3,150
Total	**$686,300**		**$39,917**	**$25,083**	**$65,000**

The remaining two components of fixed costs, administrative salaries and wages and other fixed expenses (e.g., accreditation fees) are shared and therefore allocated to ocular tissues and skin according to percentages of donor volumes. The table below presents fixed costs across ocular and skin donors.

Table 2.13: Sample Tissue Bank Fixed Costs

Donor Type	Capital Costs	Admin Salaries and Wages	Other Fixed Expenses	Total Fixed Costs
Ocular Tissue	$39,917	$25,000	$12,500	$77,417
Skin	$25,083	$5,000	$2,500	$32,583
Total	$65,000	$30,000	$15,000	$110,000

By dividing fixed costs by the number of eye and skin donors, the fixed costs per donor are derived. Total fixed costs per donor are total costs for skin and ocular donors divided by the total number of skin and ocular donors (120).

Table 2.14: Sample Tissue Bank Fixed Costs per Donor

	Fixed Costs per Donor			
Donor Type	Capital Costs	Admin Salaries and Wages	Other Fixed Expenses	Total Fixed Costs
Ocular Tissue	$399	$250	$125	$774
Skin	$1,254	$250	$125	$1,629
Total	$542	$250	$125	$917

2.7.3 Total Cost Estimates

By summing variable and fixed costs, total costs for each donor type can be derived.

Table 2.15: Sample Tissue Bank Total Costs by Donor Type

Donor Type	Variable Costs	Fixed Costs	Total Costs
Ocular Tissue	$80,000	$77,417	$157,417
Skin	$60,000	$32,583	$92,583
Total	$140,000	$110,000	$250,000

By summing variable and fixed costs per donor for each donor type, total costs per donor are derived. The cost of $2,083 per donor is now divided into $1,574 per ocular donor and $4,629 per skin donor. The cost of $2,083 per donor represents an average cost of ocular and skin donors together.

Table 2.16: Sample Tissue Bank Total Costs per Donor

Donor Type	Variable Costs	Fixed Costs	Total Costs
Ocular Tissue	$800	$774	$1,574
Skin	$3,000	$1,629	$4,629
Total	$1,167	$917	$2,083

2.7.4 Estimating Costs per Tissue

Ocular tissue costs can be broken down into costs for corneas, sclera, and research globes using the same methodology that broke costs down between ocular and skin donors. The process begins with discussions with tissue bank managers that produce estimates of hours required to process given tissues (e.g., corneas). The following labour hours required per ocular were used to compute variable labour costs.

Table 2.17: Sample Tissue Bank Labour Hours Required Per Tissue

	Labour Hours Required Per Tissue					
Tissue	Screening & Recovery	Testing	Processing	Storage & Distribution	QA	Total
Corneas	0.23	0.23	0.93	0.23	0.93	2.57
Sclera	0.19	0.19	0.77	0.19	0.77	2.12
Research globes	0.13	0.13	0.50	0.13	0.50	1.38
Ocular Tissue Total	0.55	0.55	2.20	0.55	2.20	6.06

Labour hours per tissue are then converted into total labour hours by multiplying hours per tissue by tissue volumes. Table 2.18 below presents labour hours adjusted for tissue volume.

Table 2.18: Sample Tissue Bank Labour Hours Adjusted for Tissue Volume

		Total Labour Hours Adjusted for Tissue Volume					
Tissue	Volume of Tissue	Screening & Recovery	Testing	Processing	Storage & Distribution	QA	Total
Corneas	150	35.00	35.00	140.00	35.00	140.00	385.00
Sclera	65	12.50	12.50	50.00	12.50	50.00	137.50
Research globes	20	2.50	2.50	10.00	2.50	10.00	27.50
Ocular Tissue Total	N/A	50.00	50.00	200.00	50.00	200.00	550.00

For ocular tissues, labour costs for corneas, sclera, and research globe are derived by multiplying their respective portion of labour hours by labour costs for ocular tissues. For example, labour costs are $67,978 for ocular tissues (Table 2.8). Processing corneas required 140 hours of labour time out of a total of 550 hours for ocular tissue. Therefore labour time for processing corneas is 140/550 hours x $67,978 = $17,303 as presented in the table below.

Table 2.19: Sample Tissue Bank Labour Costs Breakdown by Tissue

	Labour Costs					
Tissue	Screening & Recovery	Testing	Processing	Storage & Distribution	QA	Total
Corneas	$4,326	$4,326	$17,303	$4,326	$17,303	$47,584
Sclera	$1,545	$1,545	$6,180	$1,545	$6,180	$16,994
Research globes	$309	$309	$1,236	$309	$1,236	$3,399
Ocular Tissue Total	$6,180	$6,180	$24,719	$6,180	$24,719	$67,978
Skin	$14,831	$2,472	$12,360	$4,944	$7,416	$42,022
Total	$21,011	$8,652	$37,079	$11,124	$32,135	$110,000

Supplies and other variable expenses are broken down across corneas, sclera, and research globes in the same manner that they were broken down between ocular tissues and skin. Where corneas, sclera, and research globes share supplies and other variable expenses, and tissue managers could not estimate a breakdown, a breakdown was made on a tissue volume basis. For example corneas represented 70% of ocular tissues (150/215); hence corneas would receive 70% of shipping charges. When supplies and other variable expense are added to labour costs, variable costs are derived.

Table 2.20 Sample Tissue Bank Total Variable Costs

	Total Variable Costs					
Tissue	**Screening & Recovery**	**Testing**	**Processing**	**Storage & Distribution**	**QA**	**Total**
Corneas	$7,000	$5,000	$23,000	$5,000	$16,000	$56,000
Sclera	$2,000	$1,500	$7,000	$1,800	$6,500	$18,800
Research globes	$185	$281	$1,933	$582	$2,219	$5,200
Ocular Tissue Total	$9,185	$6,781	$31,933	$7,382	$24,719	$80,000
Skin	$21,124	$3,371	$21,348	$6,742	$7,416	$60,000
Total	$30,309	$10,152	$53,281	$14,124	$32,135	$140,000

Fixed costs are broken down across corneas, sclera, and research globes in exactly the same manner used to break them down between ocular tissue and skin. When variable and fixed costs are summed, a breakdown of total costs for corneas, sclera, and research globes is possible, as presented in the table below.

Table 2.21: Sample Tissue Bank Cost Breakdown for Tissues

Tissue Type	**Variable Cost**	**Fixed Costs**	**Total Cost**
Corneas	$56,000	$53,936	$109,936
Sclera	$18,800	$18,372	$37,172
Research globes	$5,200	$5,108	$10,308
Ocular Tissue	$80,000	$77,417	$157,417
Skin	$60,000	$32,583	$92,583
Total	**$140,000**	**$110,000**	**$250,000**

By dividing the above costs by the total volume of tissue that was moved from quarantine to release storage, costs per tissue can be derived for corneas, sclera, research globes, and skin.

Table 2.22 Sample Tissue Bank Total Costs Per Tissue

Tissue Type	Volume of Tissue	Variable Cost	Fixed Cost	Total Cost	Basis
Corneas	150	$373	$360	$733	Per Cornea
Sclera	65	$289	$283	$572	Per Sclera
Research globes	20	$260	$255	$515	Per Globe
Skin	60 sq. ft.	$1,000	$543	$1,543	Per sq ft. Skin

3.0 The Participants

3.1 Overview

Due to the small number of tissue banks in Canada, data from participants have been aggregated or averaged to ensure that the identity of participants is not revealed. It is unlikely that presenting individual tissue bank data from American participants would reveal identities, however, for consistency, their data have been aggregated and averaged as well. All figures are based on the 2002 calendar year.

Six Canadian and four American tissue banks participated in this study. Two of ten participants were eye banks (1 Canadian and 1 American), while the remaining eight processed anywhere from two to four categories of tissues. These tissues included skin, musculoskeletal, cardiovascular, and ocular tissues.

3.2 Staffing Levels and Certification

As presented in the table below, the six participating Canadian tissue banks had 12.3 full time equivalent employees (FTEs), or approximately 2 per tissue bank. The four participating American tissue banks were considerably larger with 463.2 full-time employees or roughly 115 FTEs per tissue bank. Median staffing levels were 1.5 FTEs in Canada, and 29.4 FTEs at participating US tissue banks. There was considerably variability in the size of American participants however; one participant had just 4.5 FTEs while another had several hundred.

Three of six Canadian tissue banks are AATB certified, one is EBAA certified, and one holds both certifications. One Canadian participant does not hold certification by either association. Two American participants are AATB certified, one is EBAA certified, and again one holds both certifications.

Table 3.1 – Staff Levels and Certification of Participating Tissue Banks

	Canada	USA
Average FTEs/ tissue bank	2.1	115.8
Median FTEs/ tissue bank	1.5	29.4
Tissue banks AATB certified only	3	2
Tissue banks EBAA certified only	1	1
Tissue banks both AATB and EBAA certified	1	1
Tissue banks with no certification	1	0

3.3 Types of Tissues Handled

Participating tissue banks recovered, processed, and purchased a wide range of tissues. In the table below, the number of tissue banks that processed or purchased tissue is presented. The "Processed" column identifies tissue banks that recovered and fully processed tissue suitable for transplantation. The "Purchased" column identifies tissue banks that purchased pre-processed, finished tissue products from other tissue banks.

In Canada, four of six participating tissue banks processed surgical bone. This is not surprising as it is considered a safe and inexpensive source of allograft bone, and some Canadian tissue banks grew from surgical bone programs. Two tissue banks processed ocular tissue, as did two for skin, cadaveric musculoskeletal, and cardiovascular tissue. Two Canadian tissue banks purchased cadaveric musculoskeletal tissue and one purchased skin grafts.

Two participating American tissue banks processed ocular tissue, as did two for skin and cadaveric musculoskeletal tissues. One American tissue bank processed surgical bone and one processed cardiovascular tissue. None purchased any finished tissue.

Table 3.2 Types of Tissues Handled by Participating Tissue Banks

	Number of Participating Canadian Tissue Banks		Number of Participating American Tissue Banks	
Tissue Type	**Processed**	**Purchased**	**Processed**	**Purchased**
Ocular	2	0	2	0
Skin	2	1	2	0
Cadaveric Musculoskeletal	2	2	2	0
Surgical bone	4	0	1	0
Cardiovascular	2	0	1	0

3.4 Donor and Tissue Volumes

Participating Canadian tissue banks processed 1,318 donors in 2002, the majority of these being ocular and surgical bone donors (349 and 667 respectively). Cardiovascular donors totalled 169 and skin donors totalled 47. Tissues processed that reached released storage totalled 544 for ocular tissue, 206 square feet of skin, 1,641 cadaveric musculoskeletal tissues, 530 surgical bones (femoral heads), and 339 cardiovascular tissues. Tissue to donor ratios ranged from a low of 0.8 for surgical bone to a high of 19.1 for cadaveric musculoskeletal tissues. Typically, 4.4 square feet of skin from each donor was recovered and made available for transplant. Participating Canadian tissue banks also purchased 792 tissues (skin grafts and cadaveric bones), mostly from other Canadian tissue banks and occasionally from US tissue banks.

Participating American tissue banks processed tissue from 8,348 donors, again the majority were ocular and musculoskeletal donors. The tissue to donor ratio for cadaveric musculoskeletal tissues was remarkably similar across American and Canadian tissue banks (20.6 vs. 19.1). The lone American skin processor, for which figures were available, processed 1.2 square feet of skin per donor. This figure is considerably smaller than the average for Canadian skin processors in the study (4.4 sq. ft. of skin), however due to the small sample size, conclusions cannot be drawn.

Tissue rejection rates reflect the percentage of recovered tissue that failed subsequent testing. Ocular tissue rejection rates were 39.3% among Canadian participants and 25.0% among American participants. Cadaveric musculoskeletal

tissue rejection rates were higher among US participants, 32.6% vs. 18.6%. The rejection rate for skin was also higher: 15% among American tissue banks that participated vs. 2.9% among Canadian. Rejection rates for cardiovascular tissue and surgical bone were unavailable from American tissue banks.

Table 3.3 – Donor and Tissue Volumes of Participating Tissue Banks

Tissue Type	Donors	Tissues Processed	Tissue to Donor Ratio	Average Tissue Rejection Rate[2]
Canada				
Ocular	349	544	1.6	39.3%
Skin[1]	47	206	4.4	2.9%
Cadaveric MS	86	1,641	19.1	18.6%
Surgical Bone	667	530	0.8	15.7%
Cardiovascular	169	339	2.0	28.2%
Total	1,318	N/A	N/A	N/A
Purchased Tissue	N/A	792	N/A	N/A
USA				
Ocular	2,744	4,899	1.8	25.0%
Skin[1]	499	581	1.2	15.0%
Cadaveric MS	4,644	95,821	20.6	32.6%
Surgical Bone	N/P	N/P	N/P	N/P
Cardiovascular	461	N/P	N/P	N/P
Total	8,348	N/A	N/A	N/A
Purchased Tissue	792	N/A	N/A	N/A

[1] Skin tissue is presented in volume of square feet. NP = data not provided; N/A = Not applicable.

[2] The average tissue rejection rate is the number of tissues that failed testing divided by the number of total tissues recovered, averaged by tissue volume across tissue banks.

3.5 Sample Size

According to the Canadian Council for Donation and Transplantation, annual donor levels in Canada were roughly 2,000 living and 4,000 cadaveric donors at the time this report was written. Because a cadaver can donate more than one type of tissue, total donors in Canada are estimated to be approximately 6,550, with some 14,000 tissues recovered and processed. Please refer to the table below.

With the exception of ocular tissue and surgical bone, most types of tissue are only processed by perhaps 2-5 tissue banks across the Canada. The sample of Canadian tissue banks in the study processed 1,318 donors who resulted in 3,994 tissues in release storage. Canadian participants in the study accounted for approximately 8.7% of Canada's ocular donors, 62.7% of skin donors, 49.1% of cadaveric musculoskeletal donors, 33.4% of surgical bone donors, and 56.3% of cardiovascular donors. The percentage of tissue accounted for by Canadian participants was consistent with donor percentages.

Donor and tissue levels in the United States are however, much higher. In 2002, US eye banks supplied 46,625 corneal grafts from more than 42,000 donors and 13,881 corneas were exported to foreign countries.[5] More than 800,000 musculoskeletal allografts alone were distributed in 2002.[6] The sample of American tissue banks in this study is far too small to be considered in any way representative of tissue banking in the United States. Rather their inclusion in this study provides Canadian tissue bank managers and the CCDT with a first-time glimpse of donor volumes and cost structures at four American tissue banks and a starting point for understanding the differences between tissue bank operations in the two countries.

Table 3.4 – Participating Tissue Banks As A Percentage of Donor and Tissue Volume in Canada

	Tissue Banking Activity Across Canada		CDN Study Participants		CDN Participants as % of Activity in Canada	
Tissue	Donors	Tissues Processed	Donors	Tissues Processed	Donors	Tissues Processed
Ocular	4,000	7,600	349	544	8.7%	7.2%
Skin[1]	75	1,500	47	940	62.7%	62.7%
Cadaveric MS	175	3,000	86	1,641	49.1%	54.7%
Surgical Bone	2,000	1,589	667	530	33.4%	33.4%
Cardiovascular	300	600	169	339	56.3%	56.5%
Total	6,550	14,289	1,318	3,994	20.1%	28.0%

[1] It is assumed that 20 skin grafts are recovered from a typical skin donor.

[5] Eye Bank Association of America: http://www.restoresight.org/newsroom/newsroom.htm
[6] Musculoskeletal Allograft Tissue Safety, American Academy of Orthopaedic Surgeons, 2003

3.6 Capital and Operating Costs

Table 3.5 below illustrates the dramatic size difference between participating Canadian tissue banks and their American counterparts. Total costs in 2002 for the four American tissue banks totalled more than $149 million US, or $232 million Canadian dollars. One tissue bank was very large and accounted for more than three-quarters of this figure, however the remaining tissue banks still averaged more than $2.5 million US ($3.9 million CDN) in total annual costs.

Canadian tissue banks in contrast had much smaller operations with aggregate costs of $2.7 million CDN, or just $455,000 per tissue bank on average. Of particular interest is the breakdown between capital costs and operating costs. For Canadian tissue banks, capital costs represented more than 10% of total costs, while for American tissue banks, capital costs represented less than 1% of total costs.

Table 3.5 – Capital and Operating Costs of Participating Tissue Banks

	Canada	USA	USA (in CDN$ at $1.5625 CDN/US)
Capital Costs	$289,208	$727,822	$1,137,222
Operating Costs	$2,443,911	$148,361,501	$231,814,846
Total Costs	$2,733,119	$149,089,323	$232,952,067

Table 3.6 further illustrates this contrast. Canadian tissue banks spent $11.83 on capital costs for every $100 of operating expenses. The largest US tissue bank in the study spent just 31 cents for every $100 of operating expenses. The remaining three US tissue banks in the study still spent considerably less than Canadian participants - $3.99 per $100 of operating costs. Bearing in mind that the sample size of participants is low, this sharp difference would seem to suggest that larger tissue banking operations are relatively less capital intensive than smaller operations and may enjoy economies of scale. For example a tissue bank that doubles its donors over five years may not need to double its expenditures on equipment like freezers, refrigerators, or double its tissue bank's floor space during that period. Because the numbers appear to suggest that capital cost efficiencies can be achieved with higher donor volumes and larger operations,

incentives likely exist for Canadian operations to grow.

Table 3.6 Capital Expenditures per $100 of Operating Expenditures

	Capital Expenditures per $100 of Operating Expenditures
Canadian participants	$11.83
Largest US tissue bank	$0.31
3 Remaining US tissue banks	$3.99

3.7 Services

Tissue banks often use the services of other organizations to turn raw recovered tissue into tested, processed, ready-to-transplant human allografts. The table below presents the number of tissue banks performing stages of production either internally (i.e., performed by tissue bank staff), externally (i.e., performed by an external organization), or both (performed by tissue bank staff and an external organization).

Tissue bank staff perform most stages of production, however testing (i.e., serology, and to a lesser extent microbiology and tissue specific testing) is often performed by other organizations. Screening, tissue recovery, and quality assurance are also performed by external organizations but to a lesser extent. Processing and storage and distribution were only performed internally. One American tissue bank in the study did not provide data on whether services were performed internally or externally.

Table 3.7 Tissue Banking Production Stages Performed Internally vs. Externally

	Number of CDN Participants			Number of US Participants		
Stage	**Internal**	**External**	**Both**	**Internal**	**External**	**Both**
Screening	4	2		2		1
Recovery	5		1	2		1
Testing	2		4		1	2
Processing	6			2		1
Storage &	6			3		

	Number of CDN Participants			Number of US Participants		
Stage	**Internal**	**External**	**Both**	**Internal**	**External**	**Both**
Distribution						
QA	4		2	3		

4.0 Costs per Donor – Participating Tissue Banks

4.1 Introduction

In this section, costs per donor are presented for participating Canadian and American tissue banks. Before drawing conclusions from the data, readers are reminded that the sample of participants in the study is small, particularly the sample of US tissue banks. Furthermore, costs can vary greatly across tissue banks, with the volume of donors processed and the types of tissues recovered, therefore results may not be representative of costs at non-participating tissue banks. Instead the efforts of this study are a first step in understanding operating and capital costs associated with tissue banking.

Costs per donor are presented in three forms:

- Costs in an "accounting" format;
- Costs broken down between variable and fixed costs; and,
- Costs broken down across the five stages of production.

4.2 Costs per Donor – All Donor Types

Costs per donor for all tissue donors represent all tissue banking costs for all tissues divided by the total number of all types of donors. Cost per donor can be thought of as the weighted average cost per donor for each donor type (e.g., skin, ocular, etc.). In the case of Canadian tissue banks, the costs associated with purchasing already-processed tissue have been excluded, since the fees paid for these tissues actually represent the providing tissue banks' costs for recovering and processing tissues, not the purchasers'.

Table 4.1 illustrates that six participating Canadian tissue banks had average total costs per donor of $1,854. There is considerable variability across tissue banks due mostly to the types of tissues processed. The least costly Canadian tissue bank

(MIN), a surgical bone bank, had costs per donor of just $300. The most costly Canadian tissue bank (MAX), a tissue bank that recovered several tissue types for other tissue banks and fully processed one types of tissue, had costs of $3,725 per donor.

In the case of the minimum, maximum, and average costs per donor, the most costly item was salaries and wages, accounting for more than 50% of total costs. Supplies and capital costs also represented significant cost items. Miscellaneous costs, consisting of such costs as liquid nitrogen (a fixed cost if solely used to supply liquid nitrogen freezers) and serological testing fees, were also significant costs.

Table 4.1 Costs per Donor by Accounting Item – Canadian Tissue Banks

Category	MIN	MAX	CDN Avg
Capital	$18	$314	$188
Utilities	$1	$13	$10
Leasing	$0	$0	$1
Maintenance	$0	$82	$41
Computing/Data Storage	$0	$11	$3
Accreditation Expenses	$0	$27	$18
Insurance & Legal	$0	$114	$35
Donor & Public Education	$0	$9	$17
Quality Assurance (non-salary)	$0	$59	$30
Supplies	$19	$430	$234
Transportation	$1	$19	$34
Salaries & Wages	$260	$2,601	$996
Miscellaneous	$0	$44	$352
Total	**$300**	**$3,725**	**$1,854**

While a surgical bone bank's operations may be relatively inexpensive, there may be cost efficiencies from recovering and processing more than one type of tissue from cadavers. Although recovering and processing several types of tissue (e.g., ocular, cardiovascular, skin, and musculoskeletal) from a cadaver is more time consuming and costly than recovering just one type of tissue, cost efficiencies should be realized in areas such as recovery team costs. Correspondingly, while costs per cadaver will higher, costs per donor should be lower since a single cadaver can become several donors.

Four Canadian tissue banks recovered and fully processed just one type of tissue from cadavers. These tissue banks had average costs of $5,443 per donor. One Canadian tissue bank recovered and fully processed several types of tissues. Its cost per donor was lower: $3,125.

Table 4.2 Costs per Donor Tissue Banks Processing One Type of Cadaveric Tissue vs. Several Types

	Cost per Donor
Average cost per donor at four CDN tissue banks fully processing only one type of cadaveric tissue.	$5,443
Cost per donor at CDN tissue bank fully processing several types of cadaveric tissue.	$3,125

The amount of tissue recovered from cadavers and living donors and moved from quarantine to released storage varied widely across tissue banks. On average, 2.3 ocular grafts, 19.7 skin grafts, 18.5 cadaveric musculoskeletal grafts, and 2.1 cardiovascular grafts tissues were recovered and moved from quarantine to released storage per cadaver. From living donors, an average of 0.8 surgical bone grafts were recovered and moved from quarantine to releases storage. The average number of grafts from cadavers and living donors combined was 2.9. This number appears low because there were many more living donors processed at these tissue banks than cadavers. On average, 12.7 grafts were recovered and moved from quarantine to released storage per cadaver.

Table 4.3 Volume of Grafts Recovered and Moved to Released Storage Per Cadaver or Per Living Donor

Donor Type	MIN	MAX	CDN Avg
Ocular	1.5	3.1	2.3
Skin	19.5	20.0	19.7
Cadaveric Musculoskeletal	16.1	20.9	18.5
Surgical Bone	0.4	1.0	0.8
Cardiovascular	1.9	2.3	2.1
Graft to Cadavers and Living Donor Ratio	0.9	6.4	2.9
Graft to Cadaver Ratio	1.5	20.9	12.7

Examining the minimum, maximum, and average of the four participating American tissue banks in Table 4.4, costs per donor were much higher. Total costs per donor averaged $15,547, with the least costly tissue bank at $2,420 per donor, and the most costly at $43,679 per donor. These costs are presented in Canadian dollars, having been converted from US dollars at a rate of $1.5625 CAD/USD. The least costly tissue bank was an eye bank, and the most costly tissue bank processed several types of tissues. As in the Canadian case, salaries and wages, supplies, and miscellaneous items accounted for significant costs. Miscellaneous costs included fees paid to other organizations to process tissues, serology and microbiology testing, and research and development costs.

Costs for purchasing unprocessed tissue were also significant, yet unlike the Canadian tissue banks, capital costs are not. On a per donor basis, capital costs are similar for American and Canadian tissue banks ($261 and $189), but as a percentage of total costs, they are much smaller for the participating American tissue banks.

Table 4.4 Costs per Donor by Accounting Item – American Tissue Banks

	All Figures in CDN$		
Category	**MIN**	**MAX**	**US Avg**
Capital	$69	$134	$261
Utilities	$12	$344	$120
Leasing	$72	$442	$297
Maintenance	$0	$54	$20
Computing/Data Storage	$7	$679	$173
Accreditation Expenses	$15	$52	$23
Insurance & Legal	$312	$355	$402
Donor & Public Education	$106	$324	$260
Quality Assurance (non-salary)	$11	$271	$189
Supplies	$228	$2,590	$1,359
Transportation	$134	$1,390	$550
Purchased Tissue (unprocessed)	$36	$8,117	$2,038
Salaries & Wages	$1,214	$10,036	$4,688
Miscellaneous	$203	$18,890	$5,168
Total	$2,420	$43,679	$15,547

Examining costs in terms of fixed and variable components sheds light on whether tissue banking is a fixed or variable cost-intensive activity, which in turn can have

implications for pricing. For example, if a tissue bank's fixed costs exceed its variable costs, an increase in donors leaves variable costs per donor virtually unchanged, yet spreads fixed costs like equipment across more donors and reduces fixed costs per donor. Higher donor levels should therefore ultimately reduce total costs per donor for the tissue bank. On the other hand, when a tissue bank's fixed costs are relatively small compared to variable costs, the effect of increased donors on fixed costs is muted somewhat, and total costs per donor are not so greatly reduced.

For both Canadian and American tissue banks, more than 70% of costs were variable, indicating that tissue banking is relatively variable cost intensive. Please refer to Table 4.5 below. The proportion of fixed costs for Canadian tissue banks is higher than that for American (29.2% vs. 23.6%). These figures would suggest that the potential for cost efficiencies resulting from increased donor volumes is greater in Canada. If these cost efficiencies can be realized, it could also present an opportunity for lower tissue fees in Canada.

Table 4.5 Variable and Fixed Costs as a Proportion of Total Costs

	Variable Costs	Fixed Costs
CDN Average	70.8%	29.2%
US Average	76.4%	23.6%

Table 4.6 below breaks variable and fixed costs down further into their sub-components.

Table 4.6 Total Costs per Donor – Breakdown via Variable and Fixed Costs

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Donor
Participating Canadian Tissue Banks								
Minimum	$175	$20	$195	$18	$86	$1	$105	$300
Maximum	$2,125	$493	$2,618	$314	$476	$316	$1,107	$3,725
CDN Average	$799	$514	$1,313	$188	$196	$157	$541	$1,854
Participating American Tissue Banks								
Minimum	$971	$529	$1,500	$69	$243	$608	$920	$2,420
Maximum	$7,356	$29,603	$36,959	$134	$2,680	$3,906	$6,720	$43,679
US Average	$3,362	$8,509	$11,872	$261	$1,326	$2,089	$3,676	$15,547

In Table 4.7 below, variable costs have been broken down by stage of production. The US average in this table is based on three tissue banks, as one tissue bank was unable to provide a breakdown across stages of production. For this reason, the total cost per donor ($18,904) differs from that presented in the above tables ($15,547).

For both American and Canadian tissue banks, the most costly stage of production was screening donors and recovering tissue. This activity represented more than 50% of variable costs. For both, processing was the second most costly stage. With regard to fixed costs, other fixed expenses and administrative salaries and wages were much higher per donor at US tissue banks. Other fixed expenses include serology and microbiology testing, R & D, and fees paid to outside organizations to process tissues, significant costs for US tissue banks. These tissue banks also have higher overhead in the form of salaries for administrative staff, managers, and directors.

Table 4.7 Total Costs per Donor – With Variable Costs Broken Across Stages of Production

	Average CDN			Average USA		
Variable Costs*	**Variable Labour**	**Supplies & Other Variable Expenses**	**Total**	**Variable Labour**	**Supplies & Other Variable Expenses**	**Total**
Screening & Recovery	$389	$299	$688	$884	$6,604	$7,487
Testing	$54	$41	$95	$271	$488	$759
Processing	$156	$96	$253	$1,419	$3,004	$4,424
Storage & Distribution	$59	$77	$137	$685	$751	$1,436
Quality Assurance	$141	$0	$141	$527	$5	$532
Total Variable Costs	$799	$514	$1,313	$3,787	$10,851	$14,638
Fixed Costs						
Capital			$188			$239
Salaries & Wages			$196			$1,392
Quality Assurance**			$25			$185
Other Fixed Expenses			$132			$2,450
Total Fixed Costs			$542			$4,296
Total Costs			$1,854			$18,904

*Labour and expenses for each stage that generally vary with the number of donors

** Fixed expenses associated with quality assurance (e.g. equipment calibration, developing standards of practice, etc.)

Total costs across the five stages of production, as a proportion of total variable costs, are remarkably similar across countries as illustrated in Table 4.6 below. Screening and recovery was approximately 50%, testing between 5% and 7%, and storage and distribution, 10%. The differences were evident in the processing and quality assurance stages. Processing represented much more of total variable costs among US tissue banks, perhaps reflecting more time consuming and complex processing. Quality assurance accounts for more of total variable costs among Canadian tissue banks. The reason for this is unclear.

Table 4.8 Stages of Production as Percentage of Total Variable Costs

Stage	CDN Avg	US Avg
Screening & Recovery	52.4%	51.1%
Testing	7.2%	5.2%
Processing	19.2%	30.2%

Stage	CDN Avg	US Avg
Storage & Distribution	10.4%	9.8%
Quality Assurance	10.7%	3.6%
Total Variable Costs	100.0%	100.0%

4.3 Cost per Ocular Donor

One Canadian eye bank, one Canadian tissue bank, and one American eye bank in the study recovered and processed ocular tissue. The Canadian average below is a simple average of the eye and tissue bank, and the US figures are the costs of the American eye bank.

There was considerable variability between costs for the Canadian eye bank (CDN EB in the table below), and the Canadian tissue bank that processed eyes (CDN TB in the table below). Costs per eye donor were about 54% higher at the tissue bank ($1,830 vs. $1,192). This difference can be explained by the fact that the eye bank's donor volume exceeded that for the tissue bank by a factor of nearly five, hence its labour costs per donor were much lower.

The most striking observation is how similar average costs in Canada were to the US eye bank (in the absence of currency exchange rates). Canadian variable and fixed costs per eye donor were $940 and $571 CDN respectively. The US eye bank costs in US dollars were $960 and $580 respectively. Total costs per eye donor differed by less than $40 ($1,549 vs. $1,511).

When US dollars are converted into Canadian dollars, total costs for the US eye bank were $2,420 per eye donor.

Table 4.9 Fixed and Variable Costs per Ocular Donor

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Donor
CDN EB	$377	$248	$625	$189	$236	$141	$567	$1,192
CDN TB	$1,028	$227	$1,255	$341	$174	$59	$574	$1,830
CDN Average	$703	$238	$940	$265	$205	$100	$571	$1,511
US in $USD	$622	$338	$960	$44	$155	$389	$589	$1,549
US in $CAD	$971	$529	$1,500	$69	$243	$608	$920	$2,420

Fixed costs accounted for a greater percentage of total costs (37.8% in Canada, 38% in US) per eye donor compared to the average for all donor types (29.2% in Canada, 23.6% in US). Eye banking would appear to be less labour and supply intensive and more capital intensive than other forms of tissue banking. Given similar increases in donor volume occurred, total cost per eye donor would be more likely to decrease than total costs for most other donor types.

Table 4.10 Variable and Fixed Costs as a Proportion of Total Costs – Ocular Donors

	Variable Costs	Fixed Costs
CDN Average – Ocular Donors	62.2%	37.8%
CDN Average – All Donors	70.8%	29.2%
US Average – Ocular Donors	62.0%	38.0%
US Average – All Donors	76.4%	23.6%

In Table 4.11, costs per ocular donor are considerably lower than costs per donor for all donor types. This reflects the relatively simple nature of recovering and processing ocular tissue compared with other tissues like musculoskeletal and skin. Examining the table below, the proportion of variable costs across stages was similar however. Screening and tissue recovery was again the largest component of variable costs, with processing second most costly.

Table 4.11 Costs per Ocular Donor – With Variable Costs Broken Across Stages of Production

	Average CDN			US Eye Bank in $CAD		
Variable Costs	**Variable Labour**	**Supplies & Other Variable Expenses**	**Total**	**Variable Labour**	**Supplies & Other Variable Expenses**	**Total**
Screening & Recovery	$338	$55	$393	$486	$152	$638
Testing	$42	$46	$87	$0	$72	$72
Processing	$151	$57	$208	$194	$72	$267
Storage & Distribution	$38	$81	$118	$194	$218	$413
Quality Assurance	$134	$0	$134	$97	$14	$112
Total Variable Costs	$703	$238	$940	$971	$529	$1,500
Fixed Costs						
Capital			$265			$69
Salaries & Wages			$205			$243
Quality Assurance			$10			$8
Other Fixed Expenses			$90			$600
Total Fixed Costs			$571			$920
Total Costs			$1,511			$2,420

Table 4.12 below reveals that screening and recovery of eyes represented a smaller proportion of total variable costs than screening and recovery from the average of all donor types.

For the two Canadian tissue banks processing eye tissue, processing, storage and distribution, and quality assurance represented slightly higher percentages of variable costs than the average across all donor types. For the American eye bank, processing is a relatively smaller percentage of variable cost than the average of the four American tissue banks. The US eye bank's storage and distribution costs are relatively high, perhaps a reflection of more ocular tissue shipped compared with Canadian tissue banks.

Table 4.12 Stages of Production as Percentage of Total Variable Costs

	CDN Average		US Eye Bank	
Stage	**All Donors**	**Eye Donors**	**All Donors**	**Eye Donors**
Screening & Recovery	52.4%	41.8%	51.1%	42.5%
Testing	7.2%	9.3%	5.2%	4.8%
Processing	19.2%	22.1%	30.2%	17.8%
Storage & Distribution	10.4%	12.6%	9.8%	27.5%
Quality Assurance	10.7%	14.2%	3.6%	7.4%
Total Variable Costs	100.0%	100.0%	100.0%	100.0%

4.4 Cost per Cadaveric Musculoskeletal Donor

Two participating Canadian tissue banks recovered and processed cadaveric musculoskeletal tissues into finished allografts. Costs per cadaveric musculoskeletal donors were unavailable for participating US tissue banks.

Costs per cadaveric musculoskeletal donor averaged $8,346 among participating Canadian tissue banks, however there was considerable variability between the two. The Canadian tissue bank with costs of $3,441 per cadaveric musculoskeletal donor used technicians to recover and fully process a wide range of tissues and was able to spread costs across these tissues. The tissue bank with costs of $13,251 paid medical interns to recover tissue and thus has relatively higher recovery expenses. Furthermore, the remainder of costs were not spread across other tissues, but rather absorbed solely by musculoskeletal tissue.

Table 4.13 Fixed and Variable Costs per Cadaveric MS Donor

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Donor
CDN MIN	$2,570	$379	$2,949	$259	$174	$59	$492	$3,441
CDN MAX	$8,285	$1,990	$10,275	$918	$1,237	$822	$2,977	$13,251
CDN Average	**$5,428**	**$1,184**	**$6,612**	**$588**	**$706**	**$440**	**$1,734**	**$8,346**

Cadaveric musculoskeletal tissue banking is a more variable cost intensive process

than the average for all donor types. Variable costs represented 79.2% of cadaveric musculoskeletal costs, compared with 70.8% of the average of all tissue types. Correspondingly, cadaveric musculoskeletal programs at Canadian tissue banks would likely experience a less than average decrease in total costs per donor from increased donor volumes.

Table 4.14 Variable and Fixed Costs as a Proportion of Total Cadaveric Musculoskeletal Costs

	Variable Costs	Fixed Costs
CDN Average – Cadaveric MS	79.2%	20.8%
CDN Average – All Donors	70.8%	29.2%

Variable costs per donor are broken down across the five stages of production in the table below.

Table 4.15 Costs per Cadaveric MS Donor – With Variable Costs Broken Across Stages of Production

	CDN Average		
Variable Costs	**Labour**	**Supplies**	**Total**
Screening & Recovery	$3,762	$297	$4,059
Testing	$317	$328	$645
Processing	$669	$328	$997
Storage & Distribution	$353	$232	$585
Quality Assurance	$326	$0	$326
Total Variable Costs	$5,428	$1,184	$6,612
Fixed Costs			
Capital			$588
Salaries & Wages			$706
Quality Assurance			$36
Other Fixed Expenses			$405
Total Fixed Costs			$1,734
Total Costs			**$8,346**

Figures in Table 4.16 illustrate that screening and recovering tissue from cadaveric musculoskeletal donors accounted for a greater percentage of total variable costs than the average of all types of donors. Surprisingly, processing was a smaller

share of total variable costs than the average of all donors. This does not suggest that processing costs are lower per cadaveric musculoskeletal donor than for most other donors, merely that processing's share of total variable costs is somewhat lower than the average.

Table 4.16 Stages of Production as Percentage of Total Variable Cadaveric Musculoskeletal Costs

	CDN Average	
Stage	**All Tissues**	**Cadaveric MS**
Screening & Recovery	52.4%	61.4%
Testing	7.2%	9.8%
Processing	19.2%	15.1%
Storage & Distribution	10.4%	8.8%
Quality Assurance	10.7%	4.9%
Total Variable Costs	100.0%	100.0%

4.5 Cost per Living Musculoskeletal Donor

Four Canadian tissue banks in the study recovered surgical bone from living donors. The least and most costly tissue banks in terms of cost per surgical bone donor are identified in the table below as CDN MIN and CDN MAX respectively. Costs per surgical bone donor from US participants were unavailable.

Total costs per surgical bone averaged $599 across these four tissue banks, with the least costly at $304 and the most costly at $733. The lowest cost tissue bank is in fact a surgical bone bank only, while the highest cost tissue bank processes several types of tissues.

Table 4.17 Fixed and Variable Costs per Surgical Bone Donor

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Donor
CDN MIN	$175	$20	$195	$18	$86	$1	$105	$300
CDN MAX	$386	$36	$422	$79	$174	$59	$312	$733
CDN Average	$285	$26	$311	$86	$147	$54	$287	$598

In Table 4.18, variable costs represented just 52.0% of total costs per surgical bone donor, suggesting that recovering and processing surgical bone does not require a great deal of labour and supplies relative to other tissues. In fact, recovery is usually performed at no charge by orthopaedic surgeons conducting hip replacement surgery. Although fixed costs per donor were relatively low ($287 on average), they accounted for a relatively large share of total costs (48.0%). Surgical bone programs could potentially benefit from larger than average decreases in costs per donor if donor volumes were to increase.

Table 4.18 Variable and Fixed Costs as a Proportion of Total Costs

	Variable Costs	Fixed Costs
CDN Average – Surgical Bone	52.0%	48.0%
CDN Average – All Donors	70.8%	29.2%

Table 4.19 Costs per Surgical Bone Donor – With Variable Costs Broken Across Stages of Production

	CDN Average		
Variable Costs	**Labour**	**Supplies**	**Total**
Screening & Recovery	$70	$17	$87
Testing	$57	$2	$59
Processing	$7	$3	$10
Storage & Distribution	$50	$4	$54
Quality Assurance	$100	$0	$100
Total Variable Costs	$285	$26	$311

	CDN Average		
Variable Costs	**Labour**	**Supplies**	**Total**
Fixed Costs			
Capital			$86
Salaries & Wages			$147
Quality Assurance			$21
Other Fixed Expenses			$34
Total Fixed Costs			$287
Total Costs			**$598**

Table 4.20 below confirms that screening donors and recovering surgical bone are less costly than for other tissues (28.1% vs. 52.4% of variable costs). Testing, on the other hand, accounted for a higher percentage of total costs, perhaps due to the fact that testing occurs both immediately following the recovery of surgical bone and a six-month quarantine storage period. Storage and distribution and quality assurance accounted for a higher than average share of total variable costs but those stages' variable costs per donor of $54 and $100 respectively, were still less than the average cost of all donor types ($137 and $141 per donor) for these two stages.

Table 4.20 Stages of Production as Percentage of Total Variable Costs

	CDN Average	
Stage	**All Tissues**	**Surgical Bone**
Screening & Recovery	52.4%	28.1%
Testing	7.2%	19.0%
Processing	19.2%	3.4%
Storage & Distribution	10.4%	17.5%
Quality Assurance	10.7%	32.1%
Total Variable Costs	100.0%	100.0%

4.6 Costs per Skin Donor

Two Canadian tissue banks and two American tissue banks in the study recovered and processed skin. Costs per skin donor were available for one American tissue bank.

Total costs per skin donor among the Canadian participants averaged $6,922, with the lower cost processor at $4,124 and higher cost processor at $9,720 per skin donor. Variable costs per donor (in particular, labour) were comparable between these two tissue banks, however it is fixed costs per donor that were very different. This difference is likely the result of the lower cost tissue bank having processed many more skin donors, thus able to spread fixed costs like equipment across many donors.

Total costs per skin donor at the US tissue bank for which data was available were $3,506 USD or $5,478 CAD. Variable labour, and total variable costs were comparable with Canadian skin processors, however fixed costs per skin donor were lower than the Canadian average. The volume of skin donors processed at the US tissue bank far exceeded the combined volumes of both Canadian skin processors.

Table 4.21 Fixed and Variable Costs per Skin Donor

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Donor
CDN MIN	$2,185	$1,250	$3,434	$457	$174	$59	$690	$4,124
CDN MAX	$2,139	$2,425	$4,564	$1,604	$168	$3,384	$5,156	$9,720
CDN Average	$2,162	$1,837	$3,999	$1,030	$171	$1,721	$2,923	$6,922
US (in USD)	$1,337	$949	$2,286	$210	$720	$290	$1,220	$3,506
US (in CAD)	$2,089	$1,483	$3,572	$327	$1,125	$453	$1,906	$5,478

At first glance, Table 4.22 would appear to suggest that processing skin is less labour intensive than most tissues, but this would be misleading. Instead, fixed costs were relatively high for skin due to the costs associated with owning a dermatome. Furthermore, labour and supply costs are lower when donor volume is relatively low, which was the case at Canadian tissue banks processing skin. Increased skin donor volume would increase variable costs, but probably not increase fixed costs much. Correspondingly, increased skin donor volume would cause fixed costs to decrease as a percentage of total costs. An increase in donor volume of this nature would therefore result in more cost efficiencies than for some other tissues.

Table 4.22 Variable and Fixed Costs as a Proportion of Total Costs

	Variable Costs per	Fixed Costs
CDN Average – Skin	57.8%	42.2%
CDN Average – All Donors	70.8%	29.2%
USA Average - Skin	65.2%	34.8%
US Average – All Donors	76.4%	23.6%

Table 4.23 Costs per Skin Donor – With Variable Costs Broken Across Stages of Production

	CDN Average		
Variable Costs	**Labour**	**Supplies**	**Total**
Screening & Recovery	$661	$279	$940
Testing	$73	$68	$142
Processing	$752	$1,030	$1,782
Storage & Distribution	$155	$459	$614
Quality Assurance	$521	$0	$521
Total Variable Costs	$2,162	$1,837	$3,999
Fixed Costs			
Capital			$1,030
Salaries & Wages			$171
Quality Assurance			$12
Other Fixed Expenses			$1,710
Total Fixed Costs			$2,923
Total Costs			**$6,922**

Table 4.24 below illustrates that for skin, processing accounts for a much higher than average percentage of total variable costs. In fact, nearly half of variable costs associated with skin are accounted for by the processing stage.

Table 4.24 Stages of Production as Percentage of Total Variable Costs

	CDN Average	
Stage	**All Tissues**	**Skin**
Screening & Recovery	52.4%	23.5%
Testing	7.2%	3.5%
Processing	19.2%	44.6%
Storage & Distribution	10.4%	15.4%
Quality Assurance	10.7%	13.0%
Total Variable Costs	100.0%	100.0%

4.7 Costs per Cardiovascular Donor

Two participating Canadian tissue banks recovered and processed cardiovascular tissue. Figures from American tissue banks were unavailable. Due to the small number of tissue banks in Canada that process cardiovascular tissue, neither bank's costs can be revealed, merely the average of the two. Total costs per donor were very comparable, with just 15% separating the two participants.

Total costs averaged $3,500 per cardiovascular donor, with variable costs of $2,856 and fixed costs of $644 per donor.

Table 4.25 Fixed and Variable Costs per Cardiovascular Donor

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Donor
CDN Average	$1,323	$1,533	$2,856	$390	$106	$147	$644	$3,500

Processing cardiovascular donors was relatively more labour and supply intensive than fixed cost intensive. Variable costs accounted for 81.6% of total costs, which was considerably higher than the average for all tissues (70.8%). Higher volumes of cardiovascular donors would therefore not reduce total costs per cardiovascular donor to the same extent donor increases would reduce total costs per donor for other tissues.

Table 4.26 Variable and Fixed Costs as a Proportion of Total Costs

	Variable Costs per	Fixed Costs
CDN Average – Cardiovascular	81.6%	18.4%
CDN Average – All Donors	70.8%	29.2%

Table 4.27 Costs per Cardiovascular Donor – With Variable Costs Broken Across Stages of Production

	CDN Average		
Variable Costs*	**Labour**	**Supplies**	**Total**
Screening & Recovery	$263	$821	$1,084
Testing	$47	$62	$110
Processing	$567	$448	$1,015
Storage & Distribution	$70	$202	$272
Quality Assurance	$376	$0	$376
Total Variable Costs	$1,323	$1,533	$2,856
Fixed Costs			
Capital			$390
Salaries & Wages			$106
Quality Assurance**			$36
Other Fixed Expenses			$111
Total Fixed Costs			$644
Total Costs			**$3,500**

Table 4.28 below illustrates that for cardiovascular tissue, screening donors and recovering tissue accounted for a smaller than average share of total variable costs when compared with average for all donors (37.9% vs. 52.4%). This stage still accounted for a greater share of variable costs than any other stage however. Processing, on the other hand, accounted for a higher than average percentage of total variable costs.

Table 4.28 Stages of Production as Percentage of Total Variable Costs

	CDN Average	
Stage	**All Tissues**	**Cardiovascular Tissue**
Screening & Recovery	52.4%	37.9%
Testing	7.2%	3.8%
Processing	19.2%	35.5%
Storage & Distribution	10.4%	9.5%
Quality Assurance	10.7%	13.1%
Total Variable Costs	100.0%	100.0%

4.8 Summary of Costs per Donor

At participating Canadian tissue banks, average costs per donor were highest for cadaveric musculoskeletal donors ($8,346), with skin donors second most costly ($6,922). Costs per donor were lowest for surgical bone donors ($598). Total costs per donor (all types) averaged $1,854.

At participating US tissue banks, total costs per donor averaged $9,950 USD or $15,547 CAD. Ocular costs per donor were very comparable to Canadian costs. Costs per eye donor at the participating US eye bank were $1,549 USD or $2,420 CAD. Skin costs per donor were $3,506 USD or $5,478 CAD at the US skin bank in the study. ***These costs were lower than the Canadian average of $6,922 per skin donor, likely a result of significantly higher US donor volumes.***

Table 4.29 Total Costs per Donor – Canada and USA

	Total Costs per Donor		
Tissue Type	**Canada**	**USA in USD**	**USA in CAD**
Ocular	$1,511	$1,549	$2,420
Cadaveric Musculoskeletal	$8,346	N/A	N/A
Surgical Bone	$598	N/A	N/A
Skin	$6,922	$3,506	$5,478
Cardiovascular	$3,500	N/A	N/A
Average – All Tissues	**$1,854**	**$9,950**	**$15,547**

Table 4.30 illustrates a comparable balance between fixed and variable costs associated with eye banking in Canada and the United States. This balance is also somewhat comparable for skin banking.

Cardiovascular banking was the least fixed cost-intensive type of tissue banking among Canadian participants. Fixed costs represented just 18.4% of total costs. In contrast, surgical bone banking was the most fixed cost-intensive at 48.0% of total costs. ***Surgical bone programs could benefit from the largest percentage decreases in costs per donor if surgical bone donor volumes were to increase. Cardiovascular costs per donor, on the other hand, would likely experience the smallest percentage decrease from higher donor volume.***

Table 4.30 Variable and Fixed Costs as a Proportion of Total Costs

	Canada		USA	
Tissue Type	Variable Costs	Fixed Costs	Variable Costs	Fixed Costs
Ocular	62.2%	37.8%	62.0%	38.0%
Cadaveric Musculoskeletal	79.2%	20.8%	N/A	N/A
Surgical Bone	52.0%	48.0%	N/A	N/A
Skin	57.8%	42.2%	65.2%	34.8%
Cardiovascular	81.6%	18.4%	N/A	N/A
Average – All Tissues	70.8%	29.2%	76.4%	23.6%

From Table 4.31 below, ***screening donors and recovering tissue accounted for more than 50% of variable costs on average for both Canadian and American tissue banks.*** This stage of production represented the largest share of variable costs for cadaveric musculoskeletal tissues (61.4%), and the lowest share for skin (23.5%). Testing averaged 7.2% of variable costs in Canada, and was highest for surgical bone (19.0%) and lowest for skin (3.5%). Processing averaged 19.2% of variable costs at Canadian tissue banks, and was highest for skin (44.6%) and lowest for surgical bone (3.4%). ***Processing, on average represented a greater share of variable costs at American tissue banks (30.2% vs. 19.2% in Canada), perhaps reflecting greater complexity to their processing***. Storage and distribution and quality assurance both averaged roughly 10% of variable costs in Canada. Quality assurance costs represented a smaller percentage of overall costs; the reasons for this are unclear.

Table 4.31 Costs per Donor – With Variable Costs Broken Across Stages of Production

Stage	Ocular	Cadaveric MS	Surgical Bone	Skin	CV	Canada – All Donors	USA – All Donors
Screening & Recovery	41.8%	61.4%	28.1%	23.5%	37.9%	52.4%	51.1%
Testing	9.3%	9.8%	19.0%	3.5%	3.8%	7.2%	5.2%
Processing	22.1%	15.1%	3.4%	44.6%	35.5%	19.2%	30.2%
Storage & Distribution	12.6%	8.8%	17.5%	15.4%	9.5%	10.4%	9.8%
Quality Assurance	14.2%	4.9%	32.1%	13.0%	13.1%	10.7%	3.6%
Total Variable Costs	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

5.0 Costs per Tissue

Estimating costs per tissue is a particularly difficult, yet important task. For one, the process of estimating costs allows large blocks of costs such as musculoskeletal costs to be broken down into more useful pieces. For instance, the process of estimating costs per tissue can reveal high cost, low cost, variable cost-intensive, and fixed cost-intensive tissues. In the future, pricing will begin to play a more important role in day-to-day operations at Canadian tissue banks, if recovering costs becomes more common. Appropriate pricing will only be possible if tissue costs can be with reasonable accuracy.

5.1 Ocular Tissue Costs

5.1.1 Costs per Cornea

Two Canadian participants in the study processed ocular tissue. The tissue bank (CDN TB in the table below) that processed ocular tissue had costs of $744 per cornea; the eye bank in the study had costs of $837 per cornea (CDN EB in the table below). Average costs per cornea were $791. The US eye bank that participated in the study had costs of $905 USD or $1,415 CAD.

Variable costs in own-country currencies were approximately $500 per cornea across participants. Fixed costs varied more. The Canadian tissue bank had fixed costs of $203 per cornea versus $384 per cornea for the Canadian eye bank. Despite processing approximately half as many eye donors, the tissue bank's fixed costs were lower than both the US and Canadian eye banks because fixed costs like administrative salaries were spread across other tissues such as musculoskeletal and skin.

The US eye bank processed several times as many eye donors as the two Canadian ocular processors combined. Not surprisingly, its capital costs were the lowest per cornea. Other fixed expenses were relatively high for this eye bank ($340 CAD per cornea). These costs consisted of such high cost items as donor and public awareness, testing fees, and employee benefits.

Table 5.1 Fixed and Variable Costs per Cornea

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Cornea
CDN TB	$436	$105	$541	$121	$62	$21	$203	$744
CDN EB	$278	$176	$453	$128	$160	$96	$384	$837
CDN Average	$357	$140	$497	$124	$111	$58	$294	$791
US in $USD	$373	$203	$576	$25	$87	$217	$329	$905
US in $CAD	$583	$317	$901	$39	$136	$340	$514	$1,415

On average, 63% of corneal costs at Canadian tissue banks were variable and 37% were fixed. This balance between fixed and variable costs was nearly identical for the US eye bank. The lower share of total costs accounted for by fixed costs at the Canadian tissue bank compared with the Canadian eye bank was a result of administrative salaries and other fixed expenses being shared by other tissues.

Table 5.2 Variable and Fixed Costs as a Proportion of Total Corneal Costs

Corneas	Variable Costs	Fixed Costs
CDN TB	72.7%	27.3%
CDN EB	54.2%	45.8%
CDN Average	62.9%	37.1%
US Eye Bank	63.7%	36.3%

5.1.2 Scleral Tissue Costs

Costs per whole sclera averaged $610 at the participating Canadian banks. The tissue bank's costs were $471 per whole sclera and the eye bank's costs were $750 per whole sclera. There are several reasons for the higher scleral costs at the eye bank. For one, tissue rejection rates were much higher than those for the tissue bank (46.9% versus 16.4%). Furthermore, the eye bank did not process all sclera recovered because demand for sclera was relatively low. Finally, the eye bank had much higher fixed costs per sclera because its fixed costs were absorbed solely by ocular tissue, whereas the tissue bank was able to spread fixed costs across several tissue types.

Despite much higher donor volume, the US eye bank's costs of $770 USD per sclera ($1,204 CAD) were higher than the Canadian average. Again, relatively higher costs for donor and public awareness, testing fees, and employee benefits accounted for most of the difference.

Table 5.3 Fixed and Variable Costs per Whole Sclera

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Whole Sclera
CDN TB	$250	$48	$298	$103	$52	$18	$173	$471
CDN EB	$214	$152	$366	$128	$160	$96	$384	$750
CDN Average	$232	$100	$332	$116	$106	$57	$279	$610
US in $USD	$286	$156	$441	$25	$87	$217	$329	$770
US in $CAD	$446	$243	$689	$39	$136	$340	$514	$1,204

Fixed costs represented on average 45.6% of total costs across the Canadian eye bank and tissue bank, but were lower at the tissue bank than the eye bank. The US eye bank's balance between fixed and variable costs was similar to the Canadian average.

Fixed costs represented a greater share of total costs for sclera than for corneas. This would suggest that increased levels of ocular donors could cause a larger percentage decrease in costs per sclera than costs per cornea.

Table 5.4 Variable and Fixed Costs as a Proportion of Total Scleral Costs

Sclera	Variable Costs	Fixed Costs
CDN TB	63.2%	36.8%
CDN EB	48.8%	51.2%
CDN Average	54.4%	45.6%
US Eye Bank	57.3%	42.7%

5.1.3 Research Globes

Only one of two Canadian banks distributed research globes. Costs per research globe were $665. This cost is lower than the average corneal cost ($791), but higher than might be expected. Although fees charged for research globes are relatively low, the labour devoted to them is comparable with that for corneas.

Costs per research globe for the US eye bank before currency conversion were $593, a comparable cost to the Canadian bank.

Table 5.5 Fixed and Variable Costs per Research Globe

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Research Globe
CDN	$144	$137	$281	$128	$160	$96	$384	$665
US in $USD	$171	$93	$264	$25	$87	$217	$329	$593
US in $CAD	$267	$146	$413	$39	$136	$340	$514	$927

Fixed costs for research globes were actually greater than variable costs at both the US eye bank and the Canadian bank. Because research globes are more fixed cost-intensive than corneas and sclera, they could reap the greatest cost efficiencies if ocular donor volumes were to increase.

Table 5.6 Variable and Fixed Costs as a Proportion of Total Research Globe Costs

Research Globes	Variable Costs	Fixed Costs
CDN Bank	42.3%	57.7%
US Eye Bank	44.5%	55.5%

5.2 Costs per Cadaveric MS Tissues

Two Canadian tissue banks in the study recovered and processed cadaveric musculoskeletal tissues. Their costs are presented for whole bones, tendons, fascia, cancellous bone, structural grafts, fresh osteochondral allografts, and hemipelvis. American tissue banks were unable to provide data detailed enough to compute costs for cadaveric tissues.

5.2.1 Whole Bones

Whole bones are often processed into cancellous bone and structural grafts. Some whole bones, however, do not undergo further processing and are stored as is. One participating Canadian tissue recovered and stored whole bones as is. Its cost per whole bone is presented below. Total costs were $320 per whole bone, with variable costs of $274 and fixed costs of $46.

Table 5.7 Fixed and Variable Costs per Whole Bone

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Whole Bone
CDN TB	$240	$34	$274	$24	$16	$6	$46	$320

5.2.2 Tendons

Two Canadian participants recovered and processed tendons from a comparable number of donors. The lower cost tissue bank (CDN MIN in the table below) had costs of $174 per tendon; the higher cost tissue bank (CDN MAX) had costs of $1,634 per tendon. Due to the large cost difference between the two tissue banks, the average of $904 per tendon is not particularly representative of either tissue bank. This large difference in cost per tendon was the result of many factors:

- CDN MAX uses interns to recover tissue; CDN MIN uses relatively less expensive technicians to recover tissue;

- CDN MAX processes only musculoskeletal tissues; CDN MIN's processing costs are spread across several types of tissues;
- Because of the above two factors, CDN MAX's cadaveric musculoskeletal variable labour costs are more than five times that of CDN MIN;
- CDN MAX didn't recover tendons from all donors; CDN MIN did;
- CDN MIN's tendon rejection rate was half the rate for CDN MAX (see Table 5.9);
- On average 6.2 tendons per cadaver were moved to released storage at CDN MIN; on average 2.4 tendons per cadaver were moved to released storage at CDN MAX; and,
- Fixed costs per tendon were much lower at CDN MIN, the result of spreading fixed costs over several types of tissue (i.e., ocular, skin, etc.).

Table 5.8 Fixed and Variable Costs per Tendon

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Tendon
CDN MIN	$119	$23	$143	$17	$11	$4	$32	$174
CDN MAX	$1,141	$94	$1,235	$125	$165	$109	$399	$1,634
CDN Average	$630	$59	$689	$71	$88	$57	$215	$904

Table 5.9 Tissue Rejection Rates and Tissue to Donor Ratios

Tendons	Tissue Rejection Rate	Tendon to Donor Ratio
CDN MIN	20.2%	6.2
CDN MAX	40.0%	2.4

5.2.3 Fascia

The same Canadian participants that recovered and processed tendons also recovered and processed fascia. Cost differences were similar to those for

tendons. The lower cost tissue bank had costs of $154 per fascia; the higher cost tissue bank had costs of $2,147 per fascia. This large difference in cost per fascia was the result of the same factors presented for tendons with the following differences:

- CDN MIN's fascia rejection rate was 25.6% vs. 40.0% for CDN MAX; and,
- On average, 3.6 fascia were moved to released storage per cadaver at CDN MIN, compared with only 1.8 fascia at CDN MAX.

Table 5.10 Fixed and Variable Costs per Fascia

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Fascia
CDN MIN	$125	$15	$140	$7	$5	$2	$14	$154
CDN MAX	$1,522	$94	$1,616	$166	$219	$146	$531	$2,147
CDN Average	$823	$55	$878	$87	$112	$74	$273	$1,150

Table 5.11 Tissue Rejection Rates and Tissue to Donor Ratios

Fascia	Tissue Rejection Rate	Fascia Moved to Released Storage per Donor
CDN MIN	25.6%	3.6
CDN MAX	40.0%	1.8

5.2.4 Cancellous Bone

Cancellous bone was processed by the same two tissue banks that processed tendons and fascia. Costs per cancellous bone were $427 and $537 at the lower and higher cost tissue bank, respectively. The average of these two tissue banks was $482 per cancellous bone.

Despite the fact that labour, fixed costs, and tissue rejection rates at CDN MAX were considerably higher than those at CDN MIN, the difference in costs per cancellous bone was not as large as it was for tendons and fascia. This was because on average 7.5 cancellous bones per donor were moved to released storage at CDN MAX, and on average just one cancellous bone for every two cadavers were moved to released storage at CDN MIN.

Table 5.12 Fixed and Variable Costs per Cancellous Bone

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Cancellous Bone
CDN MIN	$387	$15	$401	$13	$9	$3	$25	$427
CDN MAX	$315	$94	$409	$40	$53	$35	$128	$537
CDN Average	$351	$55	$405	$27	$31	$19	$77	$482

Table 5.13 Tissue Rejection Rates and Tissue to Donor Ratios

Cancellous Bone	Tissue Rejection Rate	Cancellous Bone Moved to Released Storage per Donor
CDN MIN	0.0%	0.5
CDN MAX	11.3%	7.5

5.2.5 Structural Grafts

Costs per structural graft were $172 and $413 at the lower and higher cost tissue bank respectively. The average of these two tissue banks was $292 per structural graft.

Again, higher labour and fixed costs resulted in higher costs per structural graft for CDN MAX. This effect was muted somewhat by CDN MAX's relatively higher ratio of structural grafts to donors. On average 11.6 structural grafts per cadaver were moved to released storage at CDN MAX compared with 1.7 at CDN MIN. This difference may simply be that structural grafts at CDN MAX are cut into

smaller pieces, or it may simply have greater demand for these types of tissue.

Table 5.14 Fixed and Variable Costs per Structural Graft

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Structural Graft
CDN MIN	$128	$17	$146	$14	$9	$3	$26	$172
CDN MAX	$236	$94	$330	$26	$34	$23	$82	$413
CDN Average	$182	$56	$238	$20	$22	$13	$54	$292

Table 5.15 Tissue Rejection Rates and Tissue to Donor Ratios

Cancellous Bone	Tissue Rejection Rate	Structural Grafts Moved to Released Storage per Donor
CDN MIN	1.8%	1.7
CDN MAX	12.0%	11.6

5.2.6 Fresh Osteochondral Allografts and Hemipelvis

Only the relatively higher cost tissue bank processed fresh osteochondral allografts and hemipelvis. Costs were $1,553 per osteochondral allograft and $2,725 per hemipelvis.

Table 5.16 Fixed and Variable Costs per Tissue

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Tissue
Osteochondral Allograft	$1,043	$141	$1,184	$77	$176	$117	$369	$1,553
Hemipelvis	$2,153	$94	$2,247	$150	$197	$131	$478	$2,725

Table 5.17 Tissue Rejection Rates and Tissue to Donor Ratios

	Tissue Rejection Rate (after recovery)	Tissues Moved to Released Storage per Donor
Fresh Osteochondral Allografts	0.0%	2.3
Hemipelvis	0.0%	2.0

5.2.7 Summary of Cadaveric Musculoskeletal Tissue Costs

The tissue costs presented in Table 5.18 for CDN MIN and CDN MAX illustrate that tissue costs are greatly influenced by factors such as tissue recovery rates, tissue rejection rates, tissue recovery practices (tissue recovered by technicians vs. interns), donor volume, the number of different donor types processed, and capital costs.

Table 5.18 Total Costs per Cadaveric Musculoskeletal Tissue

	Total Cost per Tissue	
Cadaveric Musculoskeletal Tissue	**CDN MIN**	**CDN MAX**
Whole Bones	$320	N/A
Tendons	$174	$1,634
Fascia	$154	$2,147
Cancellous Bone	$427	$537
Structural Grafts	$172	$413
Fresh Osteochondral Allografts	N/A	$1,553
Hemipelvis	N/A	$2,725

From Table 5.19, the balance of variable and fixed costs at our two Canadian tissue banks would suggest that processing cadaveric musculoskeletal tissue into ready-for-transplant allografts is a variable cost-intensive process. At CDN MIN, variable costs as a share of total costs, range from 81.8% for tendons to 94.1% for cancellous bone. At CDN MAX, musculoskeletal tissues were also variable cost-intensive, but not quite so much. Fixed costs for these tissues at CDN MAX represented a larger share than for CDN MIN, because fixed costs such as equipment were absorbed solely by cadaveric musculoskeletal tissues, rather than

shared across other tissues, as was the case for CDN MIN.

Because musculoskeletal tissues are so variable cost-intensive, increases in donors would not likely have a particularly strong effect of reducing overall costs per tissue.

Table 5.19 Variable and Fixed Costs as a Percentage of Total Tissue Costs

	CDN MIN			CDN MAX		
Cadaveric Musculoskeletal Tissue	**Variable Costs**	**Fixed Costs**	**Total Costs**	**Variable Costs**	**Fixed Costs**	**Total Costs**
Whole Bones	85.6%	14.4%	100.0%	N/A	N/A	N/A
Tendons	81.8%	18.2%	100.0%	75.6%	24.4%	100.0%
Fascia	91.1%	8.9%	100.0%	75.3%	24.7%	100.0%
Cancellous Bone	94.1%	5.9%	100.0%	76.2%	23.8%	100.0%
Structural Grafts	85.0%	15.0%	100.0%	80.0%	20.0%	100.0%
Fresh Osteochondral Allografts	N/A	N/A	N/A	76.3%	23.7%	100.0%
Hemipelvis	N/A	N/A	N/A	82.5%	17.5%	N/A

5.3 Costs per Surgical Bone

Four participating Canadian tissue banks recovered surgical bone in the form of femoral heads. Due to the relatively large number of tissue banks across Canada that process surgical bones, costs for all four are presented, without concerns of breaches in confidentiality.

Total costs per femoral head averaged $885 across these four tissue banks. The lowest cost per femoral head was $352 (a surgical bone bank) and the highest cost was $1,642.

Table 5.20 Fixed and Variable Costs per Femoral Head

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Femoral Head
CDN 1	$205	$23	$229	$21	$101	$2	$124	$352
CDN 2	$342	$11	$353	$128	$168	$51	$347	$700
CDN 3	$443	$42	$485	$90	$200	$68	$358	$843
CDN 4	$592	$94	$686	$299	$395	$262	$956	$1,642
CDN Average	$396	$43	$438	$135	$216	$96	$446	$885

Aside from the surgical bone bank (CDN 1), higher rejections rates, and hence fewer femoral head moved to released storage per donor were associated with higher costs per femoral head.

Table 5.21 Tissue Rejection Rates and Tissue to Donor Ratios

Femoral Heads	Tissue Rejection Rate	Femoral Heads Moved to Released Storage per Donor
CDN 1	15.0%	0.85
CDN 2	0.0%	1.00
CDN 3	13.0%	0.87
CDN 4	59.8%	0.40

Variable and fixed costs accounted for an equal share of femoral head costs on average across the four tissue banks. The tissue bank with the lowest cost per femoral head (CDN 1) also had the lowest fixed costs as a percentage of total costs. Conversely, the tissue bank with the highest costs per femoral head also had the highest fixed costs as a percentage of total costs.

Because fixed costs represented a relatively high share of total surgical bone costs, Canadian surgical bone processors could experience a larger percentage decrease in costs per femoral head from increased levels of surgical bone donors compared with higher donor volumes for most other tissues. If the costs from these four participants are representative of surgical bone processing across Canada, increased donor levels would likely do more to reduce costs per femoral head at

tissue banks than at surgical bone banks, where capital and overhead is minimal.

Table 5.22 Variable and Fixed Costs as a Proportion of Total Femoral Head Costs

Skin	Variable Costs	Fixed Costs
CDN 1	64.9%	35.1%
CDN 2	50.4%	49.6%
CDN 3	57.5%	42.5%
CDN 4	41.8%	58.2%
CDN Average	49.5%	50.5%

5.4 Costs per Square Foot of Skin

Tissue banks process skin into grafts of varying size. To make meaningful comparisons, figures for grafts were converted into square feet of skin.

The two participating Canadian skin processors averaged $1,933 per square foot of skin. The lower cost Canadian tissue bank had costs of $1,358 per square foot, and the higher cost tissue bank had costs of $2,508 per square foot. Variable costs were nearly identical for these two tissue banks ($1,131 and $1,178 per square foot), however fixed costs varied considerably. This difference can be attributed to donor volume. The lower cost tissue bank processed considerably more skin donors, thus fixed costs like equipment were spread over many donors, and hence more square feet of skin.

The participating US skin bank's costs per square foot of skin were comparable to the larger Canadian skin processor (CDN MIN) when US dollars are expressed in Canadian currency. Its costs were $1,490 CAD per square foot of skin compared to $1,358 per square foot of skin for the Canadian tissue bank.

Table 5.23 Fixed and Variable Costs per Square Foot of Skin

	Variable Labour	Supplies & Other Variable Expenses	Total Variable Costs	Capital Costs	Fixed Salaries & Wages	Other Fixed Expenses	Total Fixed Costs	Total Costs per Sq. Ft.
CDN MIN	$720	$412	$1,131	$150	$57	$19	$227	$1,358
CDN MAX	$552	$626	$1,178	$414	$43	$873	$1,331	$2,508
CDN Average	$636	$519	$1,155	$282	$50	$446	$779	$1,933
US in $USD	$364	$258	$622	$57	$196	$79	$332	$953
US in $CAD	$568	$403	$972	$89	$306	$123	$518	$1,490

Variable costs as a share of total skin costs averaged 59.7% in Canada and 65.2% for the American skin bank. Because fixed costs represented a relatively higher share of total skin costs in Canada, Canadian skin processor's costs per square foot of skin would likely decrease more than American counterparts from similar skin donor volume increases. This effect would be particularly strong for the higher cost Canadian skin processor, with currently small donor volume.

Table 5.24 Variable and Fixed Costs as a Proportion of Total Skin Costs

Skin	Variable Costs	Fixed Costs
CDN MIN	83.3%	16.7%
CDN MAX	47.0%	53.0%
CDN Average	59.7%	40.3%
US Average	65.2%	34.8%

5.5 Cardiovascular Tissue Costs

Due to the competitive nature of this cardiovascular tissue and the small number of tissue banks in Canada that process this type of tissue, costs per tissue are not presented for participating tissue banks in this study to ensure the identities of participants were not inadvertently revealed.

6.0 Tissue Fees

The fees presented in this section as the "Canadian average" are the average of participating Canadian tissue banks and fees gathered from publicly available price lists of non-participating Canadian tissue banks. Where possible, separate averages are provided for the four participating US tissue banks and three non-participating US tissue banks for which fees were available.

Three of the six participating Canadian tissue banks (2 tissue banks and 1 eye bank) did not charge fees for tissue. For the remaining tissue banks that did charge fees, discussions with tissue bank managers revealed that market prices and recovering costs were taken into account when setting fees. Market prices are the generally accepted fees charged for tissue that have been established over time. For cardiovascular tissue where the market is very competitive, market prices were the dominant factor in setting prices. For skin and musculoskeletal tissues, where the market is less competitive, both factors were considered.

All four US tissue banks charge fees for tissue. For musculoskeletal tissues and skin, managers expressed that they used established market prices as the basis for setting fees. These fees are often influenced by the prices set by a few very large tissue banks. The participating US eye bank's manager indicated that cost recovery was the basis their fees for ocular tissue.

6.1 Ocular Tissue

Fees are not charged for ocular tissue in Canada, however, on occasion, fees will be charged to ship sclera tissue out of Canada. Canadian fees for sclera were $425, $250, and $138 for whole, half, and one-quarter pieces of sclera. These fees are presented in Table 6.1 below.

Fees for corneas averaged $2,891 at participating US tissue banks; corneal costs averaged $1,415. Whole sclera fees averaged $820 while costs averaged $1,204. Fees for half and one-quarter pieces of sclera averaged $508 and $352.

Fees for research globes averaged $156 at US participants; costs for research

globes averaged $927.

Table 6.1 Ocular Tissue Fees and Costs

	CDN Average		Average of US Participants in $CAD	
Ocular Tissue	**Fees**	**Costs**	**Fees**	**Costs**
Corneas	$0	$791	$2,891	$1,415
Sclera (whole)	$425	$610	$820	$1,204
Sclera (half)	$250	N/A	$508	N/A
Sclera (quarter)	$138	N/A	$352	N/A
Research globes	N/A	$665	$156	$927

6.2 Musculoskeletal Tissue Fees

Fees for a wide array of musculoskeletal tissues are presented in Table 6.2.

Table 6.2 Fees for Musculoskeletal Tissues

Musculoskeletal Tissues	**CDN Avg**	**Avg of US Participants in $CAD**	**Average of US Non-Participants in $CAD**
Ground Bone			
Cancellous chips 7.5cc			$225
Cancellous chips 15cc			$419
Cancellous chips 30cc	$400	$569	$503
Cancellous chips 40cc			$791
Cancellous chips 60cc	$650		$1,010
Cancellous chips 90cc			$1,409
Cancellous cubes 15cc			$361
Cancellous cubes 30cc			$520
Demineralized bone powder .25cc		$41	
Cancellous Bone			
Femoral Condyle - Hemi	$750		$1,124
Femoral Condyle – Whole	$1,050		$1,898

Musculoskeletal Tissues	**CDN Avg**	**Avg of US Participants in $CAD**	**Average of US Non-Participants in $CAD**
Femoral Head	$917	$1,517	$1,216
Humerus Head	$875		$852
Soft Tissue			
Fascia lata small	$130		$477
Fascia lata medium	$250		$568
Fascia lata large	$475		$748
Pericardium – Half	$195		
Pericardium - Whole	$700		
Tendons			
Achilles tendon	$823		$1,030
Bone-tendon-bone (i.e. patellar tendon)	$713	$2,492	$2,425
Gracilis tendon			$1,030
Semitendinosis tendon			$1,063
Tibialis tendon			$1,078
Whole Bones			
Hemi-pelvis	$3,352		$6,438
Femur with head	$3,338		$4,973
Whole fibula	$400		$1,290
Whole tibia	$2,550		$4,169
Whole humerus	$650		$3,541
Whole radius			$2,013
Structural Grafts			
Acetabulum	$2,000		$1,631
Whole ilium			$4,184
Tri-cortical wedge - 12mm	$600		$564
Tri-cortical wedge - 14mm	$800		$604
Tri-cortical wedge - 15mm			$679
Iliac crest wedge - 8-12mm		$997	
Ilium bicortical block small			$725
Ilium bicortical block medium			$764
Ilium bicortical block large			$845
Ilium tricortical block small			$1,272
Ilium tricortical block medium			$1,344
Ilium tricortical block large			$1,441

Musculoskeletal Tissues	CDN Avg	Avg of US Participants in $CAD	Average of US Non-Participants in $CAD
Femur head with trochantor			$1,931
Proximal femur & head	$1,850		$3,098
Proximal femur w/o head	$1,050		$2,182
Distal femur & shaft			$3,541
Distal femur with condyle	$2,550		$2,716
Distal femur		$5,230	$3,219
Distal femur with flair	$1,330		
Bi-cortical dowel 12mm	$400		$436
Bi-cortical dowel 14mm	$400	$730	$436
Femoral strut	$550		$641
Femur shaft 50mm			$771
Femur shaft 100mm			$833
Femur shaft 150mm	$838		$963
Femur shaft 200mm	$838		$1,016
Cortical strut <200mm			$580
Cortical strut >200mm			$925
Proximal fibula			$1,288
Fibula shaft 50mm		$753	$531
Fibula shaft 100mm			$748
Fibula shaft 150mm			$933
Fibula shaft 200mm			$1,094
Fibula shaft 250mm			$1,303
Proximal tibia & shaft			$3,219
Proximal tibia	$1,835		$2,443
Distal tibia & shaft			$1,175
Distal tibia	$638		$1,194
Tibia shaft	$900		$848
Tibia strut	$300		$490
Humerus head	$1,250		$963
Proximal humerus & rotator cuff	$750		$2,435
Proximal humerus			$1,645

Fees for tissue processed by US tissue banks, when converted into Canadian dollars were generally higher than fees charged by Canadian tissue banks. The following table presents musculoskeletal tissue with average US fees (in $CAD)

that were at least 50% higher than the Canadian average. Where applicable, fees of participating US tissue banks have been averaged with non-participating US tissue banks to arrive at an overall US average.

Table 6.3 Musculoskeletal Tissue For Which Average US Fees Were At Least 50% Higher than Average Canadian Fees

Musculoskeletal Tissues	CDN Avg Fees	US Avg Fees	% Difference
Cancellous chips 60cc	$650	$1,010	55.4%
Fascia lata large	$475	$748	57.5%
Tibia strut	$300	$490	63.3%
Whole tibia	$2,550	$4,169	63.5%
Proximal femur & head	$1,850	$3,098	67.5%
Femoral Condyle – Whole	$1,050	$1,898	80.8%
Distal tibia	$638	$1,194	87.1%
Hemi-pelvis	$3,352	$6,438	92.1%
Proximal femur w/o head	$1,050	$2,182	107.8%
Fascia lata medium	$250	$568	127.2%
Whole fibula	$400	$1,290	222.5%
Proximal humerus & rotator cuff	$750	$2,435	224.7%
Bone-tendon-bone (i.e. patellar tendon)	$713	$2,459	244.8%
Fascia lata small	$130	$477	266.9%
Whole humerus	$650	$3,541	444.8%

For the following musculoskeletal tissues, average US fees were between 25% and 50% higher than average Canadian fees.

Table 6.4 Musculoskeletal Tissues For Which Average US Fees Were Between 25% and 50% Higher than Average Canadian Fees

Musculoskeletal Tissues	CDN Avg Fees	US Avg Fees	% Difference
Achilles tendon	$823	$1,030	25.2%
Proximal tibia	$1,835	$2,443	33.1%
Cancellous chips 30cc	$400	$536	34.0%
Bi-cortical dowel 14mm	$400	$583	45.8%
Femur with head	$3,338	$4,973	49.0%
Femoral Head	$917	$1,367	49.0%

Musculoskeletal Tissues	CDN Avg Fees	US Avg Fees	% Difference
Femoral Condyle - Hemi	$750	$1,124	49.9%

For the following musculoskeletal tissues, average US fees exceeded Canadian fees, but by less than 25%.

Table 6.5 Musculoskeletal Tissues For Which Average US Fees Were Higher Than Average Canadian Fees By No More than 25%

Musculoskeletal Tissues	CDN Avg Fees	US Avg Fees	% Difference
Distal femur with condyle	$2,550	$2,716	6.5%
Bi-cortical dowel 12mm	$400	$436	9.0%
Femoral strut	$550	$641	16.5%
Femur shaft 150mm	$838	$963	14.9%
Femur shaft 200mm	$838	$1,016	21.2%

Fees charged for the following musculoskeletal tissues were actually higher in Canada than in the US after currency exchange.

Table 6.6 Musculoskeletal Tissues For Which Average Canadian Fees Were Higher Than Average US Fees

Musculoskeletal Tissues	CDN Avg Fees	US Avg Fees	% Difference
Humerus Head	$875	$852	-2.6%
Tibia shaft	$900	$848	-5.8%
Tri-cortical wedge - 12mm	$600	$564	-6.0%
Acetabulum	$2,000	$1,631	-18.5%
Humerus head	$1,250	$963	-23.0%
Tri-cortical wedge - 14mm	$800	$604	-24.5%

In Tables 6.7 and 6.8 below, costs that could be derived for musculoskeletal tissues at Canadian tissue banks are compared with fees. In Table 6.7 musculoskeletal tissues are presented for which fees exceed costs in Canada. Costs for whole bone (femur) were $320 in Canada, while fees charged were $3,338. Costs for cancellous bone ($482) were considerably less than the range of fees charged for different sizes ($750-$1,050). Fees for cancellous bone were

even higher at US tissue banks ($1,124-$1,898). Fees charged for femoral heads in Canada were very comparable with their cost ($917 vs. $885). Fees for structural grafts ranged from $400 for bi-cortical dowels to $2,550 for distal femur with condyle. Costs for structural grafts averaged $292. Fees for hemipelvis exceeded costs by $627 ($3,352 vs. $2,725).

Table 6.7 Musculoskeletal Tissues For Which Fees Exceed Costs

	CDN Avg		US Avg in $CAD
Musculoskeletal Tissue	**Fees**	**Costs**	**Fees**
Whole Bone (femur)	$3,338	$320	$4,973
Cancellous Bone (size dependent)	$750-$1,050	$482	$1,124-$1,898
Femoral Head	$917	$885	$1,216-$1,517
Structural Graft	$400-$2,550	$292	$436-$4,184
Hemipelvis	$3,352	$2,725	$6,438

In Table 6.8 below, musculoskeletal tissues are presented for which costs exceed fees. Fees for fascia depending on size averaged $130 to $475. Costs for fascia in contrast, averaged $1,150 at Canadian tissue banks. Fees for tendons averaged $713 to $823 depending on the type of tendon. This fee was comparable but less than the average tendon cost in Canada of $904.

Table 6.8 Musculoskeletal Tissues For Which Costs Exceed Fees

	CDN Avg		US Avg in $CAD
Musculoskeletal Tissue	**Fees**	**Costs**	**Fees**
Fascia (size dependent)	$130-$475	$1,150	$477-$748
Tendons (various types)	$713-$823	$904	$1,030-$2,425

6.3 Skin

Skin fees per square foot were higher at US tissue banks than in Canada after currency conversion. Fees for skin in Canada averaged $852 while costs averaged $1,933. Even the lowest cost Canadian participant had skin costs that exceeded fees: $1,358 per square foot.

Fees averaged $1,250 CAD at participating US tissue banks and $1,286 per square foot at non-participating US tissue banks. The costs per square foot of skin at the participating US tissue bank were $1,490 CAD.

Table 6.9 Skin Fees and Costs

	CDN Average		Average of US Participants in $CAD		Average of US Non-Participants in $CAD	
Skin	**Fees**	**Costs**	**Fees**	**Costs**	**Fees**	**Costs**
Per square foot	$852	$1,933	$1,250	$1,490	$1,286	N/A

6.4 Cardiovascular Tissue

Fees for aortic and pulmonic valves averaged $4,625 across Canadian tissue banks. Fees for conduits averaged $1,584 and fees for patches averaged $791. Because cardiovascular tissue is very competitive and processed by only a few tissue banks in Canada, the difference between the average fees below in Table 6.10 and fees charged at any one of these tissue banks is small. Fees from US tissue banks were not available, however the average fee for a heart is estimated to be $7,300 USD[7].

Costs from US participants were unavailable from US tissue banks. Costs at Canadian tissue banks could not be presented due to confidentiality concerns.

Table 6.10 Cardiovascular Fees

	CDN Average		Average of US Participants in $CAD	
Cardiovascular Tissue	**Fees**	**Costs**	**Fees**	**Costs**
Aortic valve	$4,625	N/A	N/A	N/A
Pulmonic valve	$4,625	N/A	N/A	N/A
Conduit	$1,584	N/A	N/A	N/A
Patch	$791	N/A	N/A	N/A
Pericardium (whole)	$700	N/A	N/A	N/A

[7] CryoLife Inc. Annual Report, 2002.

7.0 Conclusions

Donor Volume Translates into Cost Efficiencies

Higher levels of donor volume usually translate into cost efficiencies for tissue banks. High donor volume allows costs associated with equipment, administrative salaries, and other fixed expenses like accreditation fees to be spread over more donors translating into lower costs per donor.

Although not true for every tissue bank in the study, in general, costs per donor were lower when donor volume was higher, as illustrated by Table 7.1. In the greyed areas of the table, costs per donor rankings are provided for the tissue banks with the highest number of donors for each donor type (i.e. ocular, skin, etc.). A ranking of 1 indicates that the tissue bank had the lowest cost of all tissue banks processing that type of donor. So, the tissue bank with the highest number of ocular donors had the lowest costs (ranking of 1), and its costs per eye donor were 21.1% lower than the average costs per eye donor of all participating tissue banks.

For three donor types, ocular, skin, and cardiovascular tissues, the tissue bank with the highest number of donors also had the lowest costs per donor. In contrast, the tissue banks with the lowest donor volume had the lowest costs per donor for just one donor type, cadaveric musculoskeletal. For all other donor types, their costs per donor were higher than average.

Table 7.1 Donor Volume and Costs per Donor

	Highest Donor Volume		Lowest Donor Volume	
Donor Type	Cost per Donor Ranking	% Above or (Below) Average Cost per Donor	Cost per Donor Ranking	% Above or (Below) Average Cost per Donor
Ocular	1	-21.1%	2	21.1%
Cadaveric MS	2	58.8%	1	-58.8%
Surgical Bone	4	22.6%	3	17.0%
Skin	1	-40.4%	2	40.4%

	Highest Donor Volume		Lowest Donor Volume	
Donor Type	Cost per Donor Ranking	% Above or (Below) Average Cost per Donor	Cost per Donor Ranking	% Above or (Below) Average Cost per Donor
CV	1	-7.3%	2	7.3%

Processing Multiple Donor Types Translates into Cost Efficiencies

When a tissue bank processes several types of donors, cost efficiencies are bound to occur. This is particularly true for the relatively costly tissue recovery stage (accounting for more than 50% of variable costs), when additional tissues like eyes can be recovered at a fairly small incremental cost.

In much the same way as increasing donor volumes, processing several types of donors and tissues spreads costs across equipment and administrative salaries and decreases costs per donor. This was particularly true for participating processors of cadaveric musculoskeletal tissues. The tissue bank that processed several types of donors had much lower tissue recovery and fixed costs per cadaveric MS donor than the tissue bank that solely processed musculoskeletal donors.

Four Canadian tissue banks recovered and fully processed just one type of tissue from cadavers. These tissue banks had average costs of $5,443 per donor. One Canadian tissue bank recovered and fully processed several types of tissues. Its cost per donor was lower: $3,125.

Table 7.2 Costs per Donor For Tissue Banks Processing One Type of Cadaveric Tissue vs. Several Types

	Cost per Donor
Average cost per donor at four CDN tissue banks fully processing only one type of cadaveric tissue.	$5,443
Cost per donor at CDN tissue bank fully processing several types of cadaveric tissue.	$3,125

Tissue Banking is a Variable Cost-Intensive Activity

On average variable costs accounted for 70.8% of costs at participating Canadian tissue banks, and 76.4% of US tissue banks. Cardiovascular banking was the most variable cost-intensive type of tissue banking among Canadian participants. In contrast, surgical bone banking was the least variable cost-intensive. Surgical bone programs could benefit from the largest percentage decreases in costs per donor if surgical bone donor volumes were to increase. Cardiovascular costs per donor, on the other hand, would likely experience the smallest percentage decrease from higher donor volume.

Table 7.3 Variable and Fixed Costs as a Proportion of Total Costs

	Canada		USA	
Tissue Type	Variable Costs	Fixed Costs	Variable Costs	Fixed Costs
Ocular	62.2%	37.8%	62.0%	38.0%
Cadaveric Musculoskeletal	79.2%	20.8%	N/A	N/A
Surgical Bone	52.0%	48.0%	N/A	N/A
Skin	57.8%	42.2%	65.2%	34.8%
Cardiovascular	81.6%	18.4%	N/A	N/A
Average – All Tissues	70.8%	29.2%	76.4%	23.6%

Tissue Recovery Practices Present Significant Opportunities for Cost Efficiencies

Screening donors and recovering tissue accounted for more than 50% of variable costs on average for both Canadian and American tissue banks. For every tissue, except skin, this stage was the most costly. Because tissue recovery accounts for such a large percentage of costs, cost efficiencies in this stage can have a significant impact on lowering total costs. A tissue bank that recovers musculoskeletal tissues, eyes, skin, and cardiovascular tissues will almost certainly have lower recovery costs per donor than four tissue banks that recover just one of each of those types of tissue. Additionally, using trained technicians rather than medical interns can reduce recovery costs significantly.

Table 7.4 Costs per Donor – With Variable Costs Broken Across Stages of Production

Stage	Ocular	Cadaveric MS	Surgical Bone	Skin	CV	Canada – All Donors	USA – All Donors
Screening & Recovery	41.8%	61.4%	28.1%	23.5%	37.9%	52.4%	51.1%
Testing	9.3%	9.8%	19.0%	3.5%	3.8%	7.2%	5.2%
Processing	22.1%	15.1%	3.4%	44.6%	35.5%	19.2%	30.2%
Storage & Distribution	12.6%	8.8%	17.5%	15.4%	9.5%	10.4%	9.8%
Quality Assurance	14.2%	4.9%	32.1%	13.0%	13.1%	10.7%	3.6%
Total Variable Costs	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

US Tissue Banks Enjoy Greater Economies of Scale

Canadian tissue banks averaged total costs of $455,000 per tissue bank. American tissue banks are generally much larger. Even when the largest American tissue bank was excluded from the analysis, the remaining three US tissue banks averaged more than $2.5 million US ($3.9 million CDN) in total annual costs.

For Canadian tissue banks, capital costs represented more than 10% of total costs, while for American tissue banks, capital costs represented less than 1% of total costs. Canadian tissue banks spent $11.83 on capital costs for every $100 of operating expenses. The largest US tissue bank in the study spent just 31 cents for every $100 of operating expenses. The remaining three US tissue banks in the study still spent considerably less than Canadian participants - $3.99 per $100 of operating costs. Because the numbers appear to suggest that capital cost efficiencies can be achieved with higher donor volumes and larger operations, financial incentives likely exist for Canadian operations to grow.

Table 7.5 Capital Expenditures per $100 of Operating Expenditures

	Capital Expenditures per $100 of Operating Expenditures
Canadian participants	$11.83
Largest US tissue bank	$0.31
3 Remaining US tissue banks	$3.99

Fees Charged by US Tissue Banks for Corneal Tissue Were Inconsistent With Costs

Fees for corneas charged by the participating US eye bank and tissue bank averaged $2,891 CAD. Costs per cornea, which were estimated for the US eye bank were $1,415 CAD. Average fees per whole sclera however, were significantly less than this eye bank's cost to ($820 versus $1,204).

Fees Differed From Costs for Most Cadaveric Musculoskeletal Tissues at Canadian Tissue Banks

Costs and fee comparisons were made for five major categories of cadaveric musculoskeletal tissues processed at participating Canadian tissue banks. For whole bones and cancellous bones, fees were considerably higher than costs. For hemipelvis, fees were higher than costs, but the percentage difference was much smaller than for whole bones and cancellous bones.

Table 7.6 Musculoskeletal Tissues For Which Fees Exceeded Costs

	CDN Avg	
Musculoskeletal Tissue	**Fees**	**Costs**
Whole Bone (femur)	$3,338	$320
Cancellous Bone (size dependent)	$750-$1,050	$482
Structural Graft	$400-$2,550	$292
Hemipelvis	$3,352	$2,725

In contrast, Canadian tissue banks do not appear to be charging high enough fees to recover costs associated with recovering and processing fascia and tendons.

Table 7.7 Musculoskeletal Tissues For Which Costs Exceeded Fees

	CDN Avg	
Musculoskeletal Tissue	**Fees**	**Costs**
Fascia (size dependent)	$130-$475	$1,150
Tendons (various types)	$713-$823	$904

Fees and Costs for Femoral Heads in Canada Were Comparable

Costs to produce femoral heads across four participating Canadian tissue banks

averaged $885. Fees charged averaged $917. Fees for femoral heads at participating and non-participating US tissue banks averaged $1,517 and $1,216 CAD respectively.

Surgical bone donor femoral heads are also a source of cancellous bone. Costs for cancellous bone averaged $482 at Canadian tissue banks, nearly half the cost of femoral heads. Fees for cancellous bone ranged from a low of $750 for femoral condyle-hemi to a high of $1,050 for femoral condyle-whole

Skin Fees Charged in Canada and the US Were Not High Enough To Recover Costs

Costs per square foot of skin at two participating Canadian tissue banks averaged $1,933. The lowest cost processor had costs of $1,358 per square foot. Fees charged in Canada averaged just $852 per square foot. The US skin bank that participated in the study charged $1,250 per square foot; its costs were $1,490 per square foot. Across the three non-participating tissue banks for which data was available, fees averaged $1,286 per square foot.

Table 7.8 Skin Fees and Costs in Canada and the US

	CDN Average		Average of US Participants in $CAD		Average of US Non-Participants in $CAD	
Skin	**Fees**	**Costs**	**Fees**	**Costs**	**Fees**	**Costs**
Per square foot	$852	$1,933	$1,250	$1,490	$1,286	N/A

Summary

This study found tissue fees were generally higher in the US than Canada. Average fees for surgical bone and skin were higher at US participating tissue banks. Of 33 types of musculoskeletal tissues, the average US fee charged was higher for 27 of them. Participating US tissue banks did not provide cardiovascular tissue fees, however, Canadian tissue bank managers believe US fees for cardiovascular tissue are higher. Canadian tissue banks generally do not charge fees for ocular tissue.

Fees and costs for tissue were often quite different at tissue banks. US fees for corneal tissue exceeded costs, however fees for sclera and research globes did not recover their costs. Costs exceeded fees for skin in both Canada and the US. For most musculoskeletal tissues, costs and fees varied considerably. In the case of surgical bone, fees and costs were comparable.

Although there appear to be considerable differences between fees and costs for many tissues, tissue fees are sometimes determined by market prices and somewhat out of the control of tissue bank managers. Furthermore, fees need not match costs for every tissue a tissue bank processes, providing that total revenues are comparable to total costs for the entire operation.

APPENDIX A

Canadian Tissue Bank Interview Guide

Contact Information:

Name of Tissue Bank: _____

Location: _____

Contact Person(s) Details: _____

Basic Statistics:

Year Opened: _____

Number of full-time employees (FTEs): _____

Annual Budget: $ _____ Salaries & Wages _____
Capital _____
Supplies & Other Expenses _____

Funding Source: θ Government θ Non-Profit/Charity θ Both

Products Handled (2002):

Product	**# of Donors**	**Volume Handled**	**% or # Rejected After Tissue Recovered**
θ Eyes			
θ Corneas			
θ Sclera			
θ Other			
θ Skin			

Product	# of Donors	Volume Handled	% or # Rejected After Tissue Recovered
θ Musculoskeletal			
θ Whole Bones			
θ Tendons			
θ Fascia			
θ Cancellous bone			
θ Surgical bone			
θ Large structural grafts			
θ Small structural grafts			
θ Autologous cranial flaps			
θ Other			
θ Cardiovascular			
θ Aortic valved conduits			
θ Pulmonary valved conduits			
θ Non-valved conduits			
θ Pericardium			
θ Descending aorta			
Other			

Services Performed:

	Internal	Contracted Out	Not Applicable

	Internal	Contracted Out	Not Applicable
Donor Awareness Activities	θ	θ	θ
Donor Selection	θ	θ	θ
Donor Screening	θ	θ	θ
Tissue Retrieval	θ	θ	θ
Advanced Serology Testing	θ	θ	θ
Microbiology Testing	θ	θ	θ
Labelling	θ	θ	θ
Processing	θ	θ	θ
Quarantine Storage	θ	θ	θ
MD Reviews	θ	θ	θ
Autopsy Reports	θ	θ	θ
Tissue Discard	θ	θ	θ
Released Storage	θ	θ	θ
Packing & Shipping	θ	θ	θ
Adverse Event Follow-Up	θ	θ	θ
Quality Assurance	θ	θ	θ
Six month follow-up serological tests (live donors)	θ	θ	θ

How many square feet of space does your tissue bank occupy? _____

Capital Costs: (Please indicate the equipment you have and its approximate replacement cost)

	Replacement Cost	Lifespan (Years)
Major Equipment		
• Bone Saws		
• Dermatome		
• Cardiovascular surgical instrument set		
• Bone surgical instrument set		
• Skin surgical instrument set		
• Ocular surgical instrument sets (enucleation and excision)		

	Replacement Cost	Lifespan (Years)
• Slit lamp (eye banks only)		
• Specular Microscope (eye banks only)		
• Biosafety Cabinet		
• Class 100 Clean Room		
• 4ºC Refrigerator		
• Mechanical Freezer (-70ºC)		
• Liquid Nitrogen Freezer (-150ºC)		
• Liquid nitrogen tanks		
• Control Rate Freezer		
• Heat sealer (for packaging)		
• 36ºC Incubator		
• Freeze Drying Machine		
• Autoclave (to sterilize instruments)		
• Bar Coding Device (for packaging & labelling)		
• X-ray machine		
• Operating Theatre (to recover tissues)		
• Operating Theatre equipment (such as bed, • tables, trays, lights)		
• Vehicle (non-leased)		
• Other tissue recovery and/or processing • equipment		
o Software applications		
o Furniture		
o Other		

Leasing Costs:

	Monthly Cost	Annual Cost
Office Space		
Equipment (e.g. computers, other office equipment, vehicles, liquid nitrogen tanks)		

Annual Maintenance:

	Monthly Cost	Annual Cost
Building		
Equipment		

Computing/Data Storage Costs:

	Monthly Cost	Annual Cost
Tech/Fix-it		
Software license renewals		
Data storage		

Accreditation Costs (AATB, EBAA or other):

	Annual Cost
Accreditation fees	
Inspection fees	
Independent Audits	
ISO certification fees	

Insurance & Legal Services

	Annual Cost
Property Insurance	
Liability Insurance	
Employee Benefit Plan	
Legal fees	

Other	

Donor and Public Education

	Annual Cost
Donor education & public awareness	
Promotion (web site, etc.)	

Quality Assurance

(Please provide non-salary costs only)

	Annual Cost
Equipment calibration	
Preventative maintenance	
Developing Standards of Practice	
Training & competency testing	
Internal & external audits	
Research & development	

Supplies

	Annual Cost	Which stage(s) are supplies used for?
Liquid nitrogen		
Cleaners		
Tissue media solutions		
Antibiotics		
Cryoprotectant solutions		
Sterile packaging materials		
Recovery supplies (for each tissue)		
Processing supplies (for each tissue)		
Sterile clothes (i.e. gloves, gowns, caps, etc)		

Transportation Costs

	Annual Cost
Packaging costs	
Shipping charges	
Non-salary costs related to transporting donors to a centre and/or returning donors to funeral homes (if not contracted out)	
Non-salary costs related to transporting retrieval teams to donor centres (if not contracted out)	
Other	

Tissue Costs

	Annual Cost
Fees paid for tissues ordered from other tissue banks in Canada	
Fees paid for tissues ordered from tissue banks outside Canada	
Other	

Miscellaneous

	Annual Cost
Property taxes	
Other	

Salaries and Wages:

(Please do not attempt to complete the remaining pages prior to our meeting)

Total Annual Cost: _____

Estimate the % of salaries and wages to tissue banking activities vs. administration and overhead:

	%
Operational Staff (screening, testing, storage, etc.)	
Medical Director	
Admin & Overhead (management, clerical, etc.)	
Total	100%

Activity Breakdown

In estimating the % of salaries and wages attributable to each of the five principal activities (recovery, testing, processing, storage & transport, and quality assurance), the following must be considered:

- How long does the activity take?
- How many staff are involved in the activity?
- How expensive are the wages and salaries of those involved relative to others?

Activity	How many person hours are required per donor?	What is the approximate hourly cost of staff doing this work?	What % of supply cost is used in each stage?
Screening & Recovery			
Testing			
Processing			
Storage & Distribution			
Quality Assurance			

What percentage of the medical director's time is spent in the above activities? _____

What percentage of the admin people's time is spent in the above activities? _____

Contracted Services

If any of the five principal activities is contracted out rather than performed by your staff, please indicate the annual expenses associated with these activities**.**

	Annual Cost of Contracted Activity
Screening & Recovery	
Testing	
Processing	
Storage & Distribution	
Quality Assurance	
Total:	**$**

Product Breakdown

	Labour Hours Required Per Product (or donor if preferred)					
Product	Volume Processed	Recovery	Testing	Processing	Storage & Distribution	Quality Assurance

	Percentage of Supply Cost Attributable				
Product	Screening & Recovery	Testing	Processing	Storage & Distribution	Quality Assurance
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**

Questions:

1. Can you please provide a comprehensive price list for your tissues?

2. How do you determine your fees? Cost recovery? Market based?

3. Comments?

APPENDIX B

US Tissue Bank Interview Guides

Human Tissue Banking: Costing and Economic Analysis

The Canadian Council for Donation and Transplantation (CCDT) is an advisory body working to ensure that all Canadians have the opportunity to participate in an integrated Canadian organ and tissue donation and transplantation system. The mission of the CCDT is to provide the Canadian Conference of Deputy Ministers of Health with the best evidence-based advice on achieving a coordinated, equitable and sustained strategy for organ and tissue donation and transplantation.

The CCDT has retained the consulting services of Goss Gilroy Inc to better understand the true costs of providing tissue-banking services in Canada and how tissue fees are established. Furthermore, Goss Gilroy Inc will be gathering similar, but less detailed cost data from American tissue banks by way of a mail out survey to allow useful comparisons to be made between tissue banks on either side of the border.

The following assurances will be made to all participating tissue banks:

- The names and locations of participating tissue banks will remain confidential (tissue bank names and locations will not be revealed in the report)
- To further assure participant confidentiality, all costs in the report will be presented in terms of unit costs (i.e., costs per donor) rather than absolute costs
- Participants will be mailed a copy of the final report
- The time commitment of participants should be approximately 1 hour to complete and mail back a cost survey of their establishment.

The project authority for this study is:

Kim Liss
Senior Program Analyst
Canadian Council for Donation and Transplantation
Edmonton, Alberta, Canada
(780) 482-6975
Email: kimkel@telusplanet.net.

Thank you again for your participation.

Yours truly,

Chris Ritchie
Senior Consultant
Goss Gilroy Inc.
900-150 Metcalfe St.
Ottawa, ON, Canada
Tel: 613-230-5577
Fax: 613-235-9592
Email: critchie@ggi.ca

Contact Information:

Name of Tissue Bank: _____

Address: _____

Contact Person(s) Name: _____ Position: _____

Phone: _____ Email: _____

Basic Statistics:

Please provide the following basic information regarding your tissue bank:

Year opened: _____

Number of full time employees (FTEs): _____

Annual budget: $ _____

Products Handled:

Please describe the types of tissue you handle, the volumes, and the percentage or number of tissues that fail testing.

Product Type	# of Donors	% or # of Tissues Rejected After Recovery	Volume Processed (# of tendons etc.)
Musculoskeletal:			
θ Whole Bones			
θTendons			

Product Type	# of Donors	% or # of Tissues Rejected After Recovery	Volume Processed (# of tendons etc.)
θ Fascia			
θ Cancellous bone			
θSurgical bone			
θLarge structural grafts			
θ Small structural grafts			
θ Hemipelvis			
θ Osteochondral allografts			
θ Other			
Skin			
Cardiovascular			
θ Aortic valved conduits			
θ Pulmonary valved conduits			
θ Non-valved conduits			
θ Pericardium			
θ Descending aorta			
θ Saphenous veins			
θ Other			

Services Performed:

Please check off the services your tissue bank provides, indicating whether you perform them internally, if you contract the service out to a third party, or if the service is not applicable to your operation.

	Internal	Contracted Out	Not Applicable
Donor Awareness Education	θ	θ	θ
Donor Selection	θ	θ	θ
Donor Screening	θ	θ	θ
Tissue Retrieval	θ	θ	θ
Advanced serology testing	θ	θ	θ
Microbiology Testing	θ	θ	θ
Labelling	θ	θ	θ
Processing	θ	θ	θ
Quarantine Storage	θ	θ	θ
MD Reviews	θ	θ	θ
Autopsy Reports	θ	θ	θ
Six month follow-up serological tests (live donors)	θ	θ	θ
Tissue Discard	θ	θ	θ
Released Storage	θ	θ	θ
Packing and shipping	θ	θ	θ
Adverse Event Follow-Up	θ	θ	θ

Buildings:

Approximately how many square feet do your facilities occupy?

_____ sq. ft.

Is your tissue bank part of a hospital, or a stand-alone institution? _____

Equipment:

Please provide details on the equipment your facility ***owns:***

Major Equipment	**What is the approximate replacement cost of the equipment?**	**How many years does the equipment usually last?**
• Bone Saws		
• Dermatome		
• Cardiovascular surgical instrument set (if applicable)		
• Bone surgical instrument set		
• Skin surgical instrument set		
• Biosafety Cabinet		
• Class 100 Clean Room		
• 4ºC Refrigerator		
• Mechanical Freezer (-70ºC)		
• Liquid Nitrogen Freezer (-150ºC)		
• Liquid nitrogen tanks		
• Control Rate Freezer		
• Heat sealer (for packaging)		
• 36ºC Incubator		
• Freeze Drying Machine		
• Autoclave (to sterilize instruments)		
• Bar Coding Device (for packaging & labelling)		
• X-ray machine		
• Operating Theatre (to recover tissues)		
• Operating Theatre equipment (such as bed, • tables, trays, lights)		
• Vehicle (non-leased)		
• Other tissue recovery and/or processing equipment		
○ Software applications		
○ Office Furniture		
○ Other		
○		

Leasing Costs:

Does your tissue bank lease any equipment or office space? If so please provide details:

Leasing costs:	**Monthly Cost**
Office Space	
Equipment	

Interest on Debt:

Does your tissue bank have any loans? If so, please provide details as best you can:

	Purpose of Loan	**Present Balance**	**Interest Rate**	**Amort. (Yrs.)**	**Remain. Yrs.**	**Monthly Pmt**
Loan 1						
Loan 2						
Loan 3						

Annual Maintenance:

Please estimate the typical cost of annual maintenance performed at your tissue bank (e.g., repairs to the building inside and out, repairing heating and air conditioning, maintaining equipment, etc.)

Maintenance	**Annual Cost**
Building	
Equipment	

Computing/Data Storage Costs:

Please estimate your typical annual computing costs**:**

Computing/data storage costs:	**Annual Cost**
Tech/Fix-it	
Software license renewals	
Data storage	

Utilities:

Please estimate your heat and electricity costs if possible:

Utility costs:	**Annual Cost**
Heat	
Electricity	
Water charges	

Accreditation Costs (AATB, EBAA or other):

Please provide your accreditation costs (if any):

Accreditation costs:	Annual Cost
Accreditation fees (divide fees by number of years they cover)	
Inspection fees	
Audits	
ISO certification fees	
Other	

Insurance & Legal Services

If possible, please estimate your insurance and legal costs:

Insurance & legal services	Annual Cost
Property Insurance	
Liability Insurance	
Legal fees	
Other	

Donor/Public Education

Please estimate your annual costs for employee and public education:

Employee and public education	Annual Cost
Donor education & public awareness	
Promotion (web site, etc.)	
Other	

Quality Assurance

Please estimate your annual costs for quality assurance. Please do not include staff wages in this section.

Quality Assurance	Annual Cost
Equipment calibration	
Preventative maintenance	
Developing Standards of Practice	
Training & competency testing	
Internal & external audits	

Supplies

Please provide your costs for supplies

Supplies	Annual Cost
Liquid nitrogen	
Cleaners	
Other	
Tissue media solutions	
Antibiotics	
Cryoprotectant solutions	
Sterile packaging materials	
Recovery supplies (for each tissue)	
Processing supplies (for each tissue)	
Sterile clothes (i.e. gloves, gowns, caps, etc)	
Other	
TOTAL	$

Transportation Costs

Please provide your costs for retrieving and shipping tissue

Transportation Costs	Annual Cost
Packaging costs	
Shipping charges	
Costs related to transporting donors to a centre and/or returning donors to funeral homes (if not contracted out)	
Costs related to transporting retrieval teams to donor centres (if not contracted out)	
Other	

Tissue Costs

Tissue Costs	Annual Cost
Standard acquisition charges for tissue recovery (all sites combined)	
Fees paid for tissues ordered from other tissue banks	
Other	

Miscellaneous

Miscellaneous	Annual Cost
Research & Development	
Allowance for bad debt	
Other	

Salaries and Wages:

1. Please enter your tissue bank's total annual expenses for salaries and wages:

2. Total annual cost of salaries and wages:_____

3. Please estimate the percentage of salaries and wages attributable directly to the tissue banking process (retrieval, testing, storage, shipping, etc.) vs. administration (e.g. 90% activities; 10% administration):

	%
Operational Staff (screening, testing, storage, etc.)	
Medical Director	
Managerial & Secretarial	
Total	**100%**

4. Please estimate the percentage breakdown of wages and salaries across the five principal tissue-banking activities: *tissue screening and recovery, testing, processing, storage and distribution*, and *quality assurance.*

In estimating the percentage of salaries and wages attributable to each activity, it may be helpful to think of the following:

- How much time does the activity require relative to other activities?
- How many staff are involved in the activity?
- How expensive are the wages and salaries of those involved relative to the salaries of those in other activities?

Activity	% of Salaries & Wages
Tissue Screening and Recovery	%
Testing	%
Processing	%
Storage & Distribution	%
Quality Assurance	%
Total:	**100%**

5. If any of the above five principal activities is contracted out rather than performed by your staff, please indicate the annual expenses associated with these activities**.**

	Annual Cost of Contracted Activity
Tissue Screening and Recovery	
Testing	
Processing	
Storage & Distribution	
Quality Assurance	
Total:	**$**

6. Please estimate the percentage of wages and salaries that go into producing your product lines.

In estimating the percentage of labour costs attributable to each line of products, it may be helpful to think of the following:

- How much time is required to produce the product (from retrieval right through to when it is ready for shipping) relative to other products?
- How many staff are involved in the product relative to other products?
- How expensive are the wages and salaries of those involved with the particular

product relative to the wages and salaries of those in other products?

- How much volume of each product did you produce?

Product Line	% of Labour Costs Dedicated to Product
	%
	%
	%
Total:	**100%**

Fees:

1. Please indicate the fees that you charge for your various tissue or eye products, or if more convenient, attach a price list:

Product	Fees Charged (i.e. per tendon, etc.)

2. How do you set your tissue fees? To recover your costs? Based on the going

market price? Other rationale?