The Use of the Transition Cost Accounting System to Compare Costs of Treatment Between Canada and the United States: Methodological Issues Based on the Case of Acute Myocardial Infarction

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ABSTRACT

The Transition cost accounting system integrates clinical, resource utilization, and financial information and is currently being used by several hospitals in Canada and the United States (U.S.) to calculate the costs of patient care. The potential use of the Transition system for estimating in-hospital costs in health services research, however, depends on the accuracy of the system's measurements. Thus, the objectives of this thesis were 1) to assess the use of hospital-based cost accounting systems to measure costs of treatment, 2) to identify potential sources of measurement error inherent to the Transition system methodology, 3) to collect audit documentation in order to evaluate the accuracy of the Transition system's information, and to collect cost of treatment data from Canadian and U.S. hospitals in order to illustrate the system's use in health services research, and 4) to discuss the potential use of the Transition system in health services research in Canada and the U.S.

To do so, 1) the Transition cost accounting methodology was first reviewed, 2) audit documentation was obtained from a single hospital in order to examine the reliability of the data that are transferred into the Transition system data warehouse, 3) a survey was carried out in order to examine cost accounting differences among hospitals using the Transition system, and 4) a case study was undertaken in order to use the Transition system to examine differences in costs of treatment of acute myocardial infarction (AMI) in Canada and the U.S.

The results of the study suggest that the Transition system methodology entails a certain amount of complexity, and several sources of measurement error may compromise the accuracy of its measurements. Although accuracy is not likely to be compromised when information is transferred from one system to another, inter-hospital variations in cost accounting practices may affect the accuracy of estimates comparing costs of treatment between hospitals. The case study results suggest that costs of treating patients with AMI in the Canadian hospitals is less than half the costs in the U.S. hospitals.

The findings of this thesis suggest that the Transition cost accounting information system may be a useful tool for studies estimating in-hospital costs of treatment in Canada and the U.S., provided that sources of measurement error are considered in the analysis and that the system's information is regularly audited by the hospital.

RÉSUMÉ

Le système de comptabilité analytique Transition intègre de l'information clinique, d'utilisation de ressources et de coûts de revient pour chacun des patients qui est admis à l'hôpital. De plus, ce système est présentement employé par plusieurs hôpitaux au Canada et aux États-Unis et peut donc être un outil utile pour la recherche en services de santé. Cependant, l'utilisation potentielle de ce système dépend de l'exactitude et de la précision de ses estimés de coûts. Ainsi, les objectifs de cette thèse sont: 1) d'évaluer l'utilisation des systèmes de comptabilité analytique pour mesurer les coûts de traitement à l'hôpital, 2) d'identifier les sources d'erreur potentielles inhérentes à l'utilisation du système Transition, 3) de rassembler des données du système Transition afin d'évaluer l'exactitude de ses mesures et de démontrer l'utilisation de ce système et 4) de discuter l'utilisation potentielle du système Transition dans la recherche en services de santé au Canada et aux États-Unis.

Pour ce faire, 1) la méthodologie du système Transition a été passée en revue, 2) la documentation de vérification comptable d'un hôpital utilisant le système Transition a été examinée, 3) une étude a été effectuée afin d'examiner les différences de comptabilité parmi les hôpitaux utilisant le système Transition et une étude de cas a été complétée afin d'employer le système Transition pour examiner les différences de coûts de traitement d'un infarctus aigu du myocarde au Canada et aux États-Unis.

Les résultats de cette étude suggèrent que la méthodologie employée par le système Transition nécessite une certaine quantité de complexité et plusieurs sources d'erreur peuvent compromettre l'exactitude et la précision de ses mesures. Bien que l'exactitude des données comptables et cliniques ne soit pas susceptible d'être compromise quand l'information est transférée d'un système informatique à la base de données principale du système Transition, les différences relatives aux choix comptables entre les hôpitaux peuvent compromettre l'exactitude des résultats. L'étude de cas indique que les coûts de traitement d'un infarctus aigu du myocarde aux États-Unis sont deux fois plus élevés qu'au Canada. Les résultats de cette thèse suggèrent que le système Transition peut être un outil valable pour estimer les coûts de traitement dans les hôpitaux Canadiens et Américains tant que les sources potentielles d'erreurs sont prises en considération et que les hôpitaux vérifient régulièrement l'exactitude des données qui sont transférées à la base de données principale du système Transition.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Canada and the United States (U.S.) have conducted a large-scale social experiment: alternative ways of funding expenditures for health care (1). Canada has a predominantly publicly financed, privately delivered health care system, while health care in the U.S. consists of privately and publicly financed health insurance. Because of this difference, numerous studies have compared health care expenditures in Canada and the U.S. (1-7). National-level data indicate that between 1960 and 1997 the proportion of gross domestic product spent on health care increased from 5.5% to 9.3% in Canada and from 5.3% to 14.0% in the U.S. (8-9).

The marked escalation of health care expenditures over the years has resulted in tighter budget constraints in both the public and private Canadian and U.S. health care sectors. In addition, recent technological innovations in health care delivery in the two countries have emphasized the need for a cost-effective approach to the care of patients admitted to health care institutions (10). Canadian and U.S. policy makers, hospital administrators, and physicians are increasingly pressured to examine treatment patterns that are generating excessive costs. Scrutiny as to what drives costs can help in the development of critical pathways that maintain quality of care while minimizing costs of treatment (11). Such studies are typically considered part of the field of health services research, a multidisciplinary field of inquiry that examines patient management techniques, clinical outcomes, and costs of treatment.

Studies comparing health care spending between Canada and the U.S. have historically relied on public-use databases and nationwide statistics on health care expenditures. To date, very few studies examined differences in the costs of treating specific diseases or providing specific services in Canadian and U.S. hospitals. This may be due, in part, to the lack of large, standardized data sets designed for this purpose and to the complexity in measuring medical resource utilization and costs in health care organizations. Compared to measuring the costs of manufactured goods, for example, the measurement of the costs of in-hospital patient care is a particularly challenging task.

This is because all patients admitted into a hospital are not identical, and the treatment of each generally requires the use of a different combination of resources. Even patients treated for the same disease may receive different treatments because of their preferences, differences in demographic and clinical characteristics, and the occurrence of medical complications.

Over the past years, technology has supported the trend toward patient-level cost management, and hospital administrators are beginning to take more and more interest in implementing cost accounting information systems, or software systems for cost accounting. The Transition system, for example, is a commercially available hospital cost accounting system (Eclipsys Solutions Corporation, Boston, MA) that integrates large volumes of patient-level clinical and financial information into a single database (12). The Transition system is unique, however, in that it is currently being used by several hospitals in Canada and many hospitals the U.S.

Although the primary use of hospital cost accounting systems is for internal management purposes, it may be possible to use the Transition system to examine the costs of health care services in Canadian and U.S. hospitals. The system's use for this purpose, however, depends primarily on the accuracy of its measurements. The Transition system methodology entails a certain amount of complexity, and several sources of measurement error may compromise the accuracy of its measurements. In addition, inter-hospital variations in cost accounting practices may affect the accuracy of cost estimates when using the Transition system to compare costs between hospitals. In the short term, a primary investigation should highlight the major pitfalls and key issues in using the Transition system to examine the costs of health care services in Canadian and U.S. hospitals.

1.2 Aims of Thesis

The aims of this thesis are:

1. To assess the use of hospital-based cost accounting systems to measure costs of treatment.

2. To identify potential sources of measurement error inherent to the Transition system methodology.
3. To collect hospital audit documentation in order to evaluate the accuracy of the Transition system's information, and to collect cost of treatment data from Canadian and U.S. hospitals in order to illustrate the system's use in health services research.
4. To discuss the potential use of the Transition system in health services research in Canada and the U.S.

CHAPTER 2: BACKGROUND

2.1 Introduction

Over the past years, public interest in health care has been increasingly focused on the effects of social factors, financing systems, organizational structures, health technologies, personal behaviors, and costs on the provision of health care services. Generally speaking, the cost of treating patients is defined as the value of the products and services used in patient care. Because patient care usually requires a substantial number and variety of medical resources, the total cost of treating a patient is estimated by the aggregate of the value of all resources used. Costs related to patient care typically include physicians' costs, drug costs, hospitalization costs, institutional costs (e.g., nursing home costs), and additional costs incurred by patients and their families. The focus of this chapter is on in-hospital costs of treatment, i.e. the costs incurred by the hospital providing medical care to patients.

2.2 Traditional Methods for Estimating In-Hospital Costs of Treatment

Traditionally, sources of information for estimating costs of treatment in Canadian and U.S. hospitals included generic per diem costs, specialty per diem costs, and costs per weighted case (13). *Generic per diem costs* are daily dollar rates that represent the average cost of one hospitalization day irrespective of the patient's medical condition. *Specialty per diem costs* are daily dollar rates established for specific hospital departments and represent the average cost of hospitalization in specific departments. *Costs per weighted case* capture the cost of hospitalization of a patient in a specific condition and are usually classified according to clinical diagnoses.

In spite of the availability of such estimates in many Canadian and U.S. hospitals, these rates represent measurements that may be inaccurate for research purposes. For instance, not all estimates account for patient-level differences in resource utilization and, consequently, cannot be readily used in studies comparing differences in costs between different patient management techniques. In addition, per diem costs and costs per

weighted case may not regularly updated by the hospital and therefore overestimate or underestimate true costs because treatment patterns and costs of resources tend to vary over time.

A more precise method for the costing of health care services is that of "top-down" costing. This method is largely used by U.S. hospitals and involves breaking down department expenditures to obtain procedure-level costs (14). The most prevalent top-down costing approach is called the ratio of cost to charge (RCC) method. This method estimates procedure-level costs by computing an overall ratio of departmental aggregate costs to charges and applying this ratio for individual procedures and services. However, several limitations arise when using the RCC method. First, costs derived through this method are based on aggregate information and may not accurately reflect the actual costs of a particular procedure provided within the department (14). Second, charges are set on the basis of a variety of internal and external factors and do not necessarily maintain a constant relationship with costs (e.g., discounts) (14). Another limitation is that the ratio of cost to charge method is not applicable to Canadian hospitals. In Canada, hospitals do not charge third-party payers for the treatment of individual patients, and charge data are therefore not available in Canada.

A more accurate method for estimating costs of treatment in Canadian and U.S. hospitals is that of micro costing (13). *Micro costing* involves identifying all of the resources used in patient care, assigning costs to each resource used, and multiplying the resources used by the estimated unit costs to obtain a measure of total cost of treating a patient (13). Although this method provides accurate cost estimates, the time and costs involved in identifying resource utilization for every patient are excessive. Micro costing studies may be feasible when estimating the costs of treating a single patient, but they are impractical for studies involving large numbers of patients.

A practical and potentially accurate method that Canadian and U.S. hospitals are increasingly adopting to estimate costs is the use of hospital cost accounting systems. Hospital cost accounting systems are software systems that integrate resource utilization and financial data already recorded in other hospital information system databases. For the most part, data are extracted from the hospital Billing System, Payroll System,

General Ledger System, and from individual departments' resource utilization databases (15).

The use of hospital-based cost accounting systems is similar to micro costing in that both methods collect data on a patient-level basis. This is important because few statistical analyses may be completed with aggregate data or generic estimates. The primary difference between the two methods, however, is that data collection using cost accounting systems is automated. Patient-level data may therefore be easily extracted for a large number of patients and over a long period of time. The monetary and human resources required for data collection are therefore less important than in studies in which data are collected by reviewing medical charts or by following patients during their hospitalization.

2.3 Use of Hospital Cost Accounting Systems for Internal Decision Making

The cost accounting system represents the hospital's major financial information system for management analysis and decision-making. The system identifies statistical and financial aspects of the day-to-day activities and records them in a suitable manner to provide data that will help management in better controlling and planning for the hospital's operations (16). Specifically, hospital cost accounting systems provide internal reports to department managers for planning and controlling routine operations. In addition, such systems are used to provide internal reports to administrators for use in formulating major policies and strategic plans for future activities.

Cost accounting systems provide information that is crucial for operating a hospital more efficiently in today's competitive health care environment (17). In the face of rising costs, growing external regulatory requirements, and rapidly changing healthcare technology, hospitals are under increasing pressure to improve financial controls and operational efficiency (15). An adequate cost accounting system will enable hospital administrators to conduct their institution efficiently so as to render the best possible service to their community at the lowest possible cost. Several cost accounting software packages such as CostFlex, Kreg, Trego, and Transition are commonly used by North American health care organizations. To my knowledge, however, the Transition

cost accounting system is unique in that it is currently being used by several hospitals in Canada and the U.S. It is therefore possible use the Transition system to compare procedure-level costs and patient-level costs in several Canadian and U.S. hospitals.

2.4 The Transition Cost Accounting System Framework

The Transition system framework views the hospital activity as a three-stage production process (12). In the first stage, procedures and services provided in the patient care process are converted into distinct products. In the second stage, products are grouped to produce end products, or individual patient cases. In the third stage, patient cases are grouped to form product lines, or any group of patients with a common characteristic such as a similar clinical diagnosis.

Using the Transition system software, detailed patient-level demographic, clinical, resource utilization, and cost data are integrated into a single database. For each patient, demographic and clinical data are extracted from the hospital Medical Records system and transferred into the Transition system data warehouse. These data include information from the patient's discharge summary such as the length of hospital stay, primary and secondary clinical diagnoses, and principal and secondary procedures. Similarly, patient-level resource utilization data are recorded at patient care departments, i.e. department providing direct medical services patients, and transferred into the Transition system data warehouse. Unit costs are then associated with individual products and services used in the treatment of a patient, and the aggregate of these costs represents the patient's total costs of treatment within the hospital.

2.5 Use of the Transition Cost Accounting System in Health Services Research

For several reasons, the Transition cost accounting system may be an important tool for health services research in Canada and the U.S. First, patient-level resource utilization information can be used to examine and compare patient management techniques between different physicians, between different hospitals, and between Canada and the U.S.

Second, unit costs of products and services estimated by the Transition software can be used in the economic evaluation of hospital-based health care interventions. This information may be especially useful for cost of illness studies and for the evaluation of alternative treatment programs through the undertaking of cost-effectiveness, cost benefit, and cost utility analyses (18).

Third, the availability of detailed demographic and clinical information in the Transition system data warehouse can be used to identify patient characteristics that are associated with increased costs of treatment. Importantly, detailed demographic and clinical information is crucial in order to account for differences in patient characteristics, so as to avoid bias, when comparing costs of treatment between two or more patient populations.

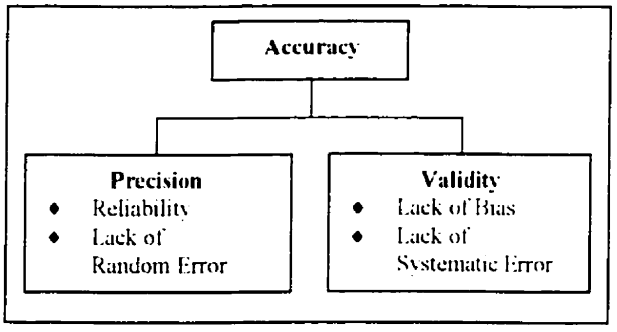
The potential use of the Transition system in health services research, however, largely depends on the accuracy of the cost estimates provided by the software. Because of the possibility for error in measuring costs, it is crucial to understand the Transition system methodology for estimating unit costs of products and services. In addition, the measurement and interpretation of financial information may vary among hospitals using the Transition system. Consequently, it is also important to identify potential sources of bias when comparing costs of treatment between different hospitals using the Transition software.

CHAPTER 3: METHODS

3.1 Accuracy of Cost Measurements in Health Services Research

Health services research is a multidisciplinary field of inquiry that examines the access, quality, and costs of health care services. A common goal to all studies in health services research, however, is the estimation of one or more parameters that are the object of measurement with the highest level of accuracy, or with little error. The focus of this section is on the accuracy of cost measurements in health services research. The *accuracy* of a cost measurement refers to the degree of conformity of the cost estimate to the true parameter value. In general, the assessment of a measurement's accuracy encompasses the appraisal of both its precision and validity (Figure 3.1a).

Figure 3.1a
Accuracy of Cost Measurements



The *precision* of a cost measurement refers to the degree of spread of the observations used to obtain the estimated cost and corresponds to the measurement's reliability, or lack of random error. *Random error* is the divergence of the cost measurement from the true value because of sampling variability, i.e. because of chance alone (19, 20).

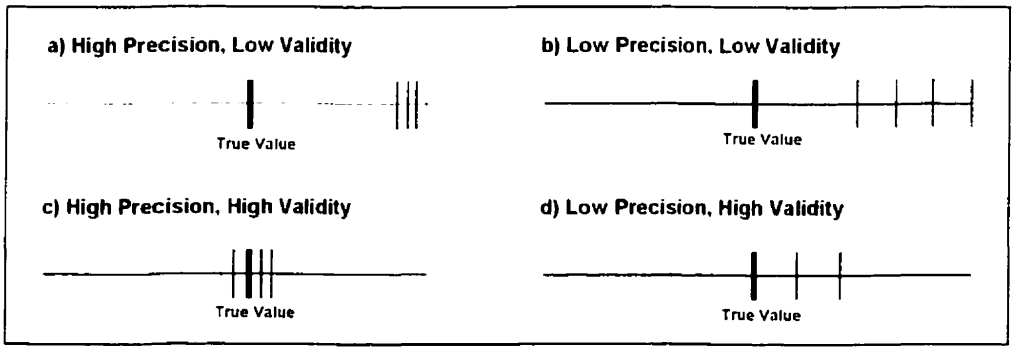
The magnitude of the precision of a cost measurement can be generally measured using statistical methods (19). The precision of a measurement can be primarily increased by increasing the size of the study, or the sample size. The bigger the sample

size, the higher the precision of the cost measurement. Because the overall costs of a treatment episode tend to be more variable than biological data, it is difficult to show a difference in costs between two groups of subjects using the same level of precision designed to show a difference in biological outcomes (18). For instance, a study designed to detect a moderate difference in blood pressure reduction between two drug therapies may not be appropriate for detecting a moderate difference in costs between the two treatments. Studies examining costs therefore require large sample sizes before moderate differences can be estimated (21).

The *validity* of a cost measurement refers to the tendency to arrive at the true or correct value and corresponds to the measurement's lack of bias, or lack of systematic error. *Bias* refers to the difference between the mean measured value and the mean of the true parameter value (22). *Systematic error* occurs when there is a tendency to produce results that differ in a systematic manner from the true value due to all causes other than sampling variability (19).

High precision of a cost measurement does not guarantee high validity and, conversely, increasing the validity of the measurement does not ensure increased precision. Accurate cost measurements are both precise and unbiased, and inaccurate cost measurements may be either imprecise, biased, or both. A cost measurement with low precision and high validity, for instance, will have the measured values spread out and a mean cost estimate close to the true parameter value (Figure 3.1b). Compared to precision, the validity of a cost measurement is more important, more insidious, and generally more difficult to measure (19).

Figure 3.1b
Illustration of the Precision and Validity of Cost Measurements

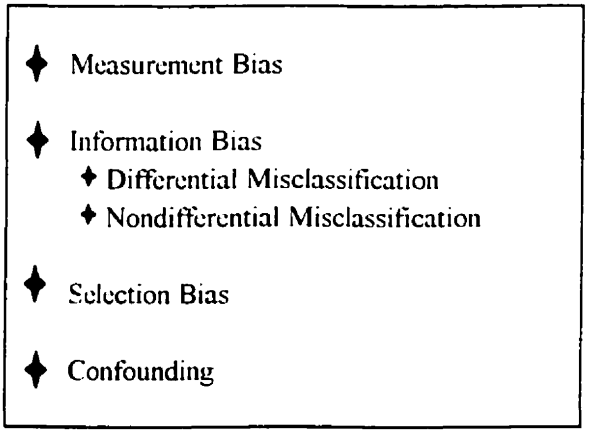


3.2 Assessing the Validity of Cost Measurements

The validity of a cost measurement is comprised of two components: external validity and internal validity (23). The *external validity*, or generalizability, of a cost measurement is the extent to which the estimated cost applies to subjects not participating in the study. In more general terms, external validity refers to the extent to which the results of a study can be extrapolated to the population of reference (20). The *internal validity* of a cost measurement, on the other hand, refers to the degree to which the measured costs are correct for the particular set of observations being examined (94). Internal validity is a prerequisite for external validity, and for a study to be of any use it must first be internally valid (20).

Various sources of bias can threaten the internal validity of cost measurements, but four types of bias can generally be identified when estimating the costs of health care services: measurement bias, information bias, selection bias, and confounding (24) (Figure 3.2). The focus here will be on the potential sources of bias relating 1) to measurements estimating the costs of health care services (e.g., the cost of a surgical intervention) and 2) to measurements estimating the association between a cost outcome (e.g., cost of illness) and the exposure of interest (e.g., type of surgical intervention).

Figure 3.2
Types of Bias Compromising the Internal Validity of Cost Measurements

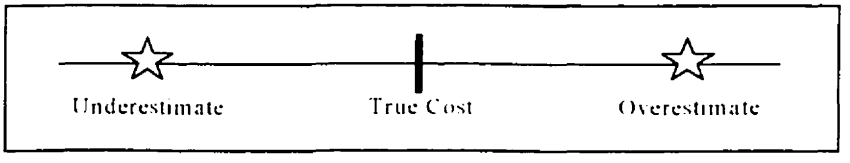


3.2.1 *Measurement Bias*

Measurement bias occurs when the cost measurement does not represent what it is supposed to measure (20). Because medical treatment usually requires a substantial number of medical resources, there are many potential sources of measurement bias when estimating the costs of health care services. Depending on the circumstances, measurement bias may result in an overestimate or an underestimate of the true cost parameter under investigation (Figure 3.2.1).

Consider a study examining the costs of treating a disease within a hospital. During a patient's hospital stay, personnel will allocate their time to caring for the patient, and physicians may order the administration of drugs and the use of expensive equipment for treatment. An accurate measurement of the in-hospital costs of treating the disease should include the costs associated with all of these inputs. Failing to measure the costs of the time spent by orderlies, for example, will underestimate the costs related to the treatment of the disease.

Figure 3.2.1
Effects of Measurement Bias on Cost Estimates



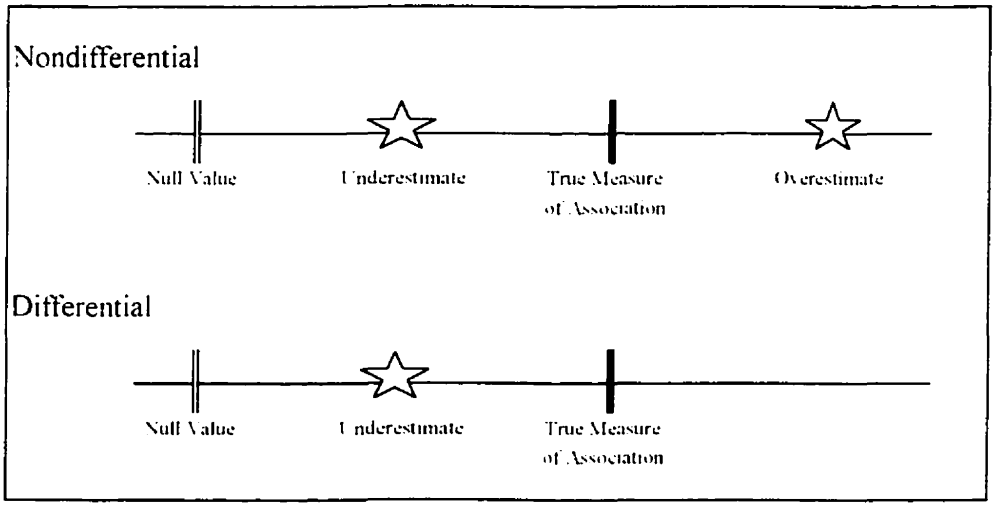
3.2.2 *Information Bias*

Information bias occurs when the measured costs are more accurate or more complete for one group of observations than for another. While measurement bias occurs when measuring a particular cost outcome, information bias occurs when estimating the association between a cost outcome and a particular exposure (e.g., cost of illness vs type of treatment).

The consequences of information bias are different depending on whether or not the measurement error on one axis (outcome) depends on the other measurement axis (exposure) (23). The existence of measurement error on one axis that is *independent* on the other axis is referred to as *nondifferential misclassification*. The existence of measurement error on one axis that is *dependent* on the other axis is referred to as *differential misclassification*.

Depending on the circumstances, the effect of differential misclassification may be to overestimate or underestimate the true measure of association between the cost outcome and the exposure (Figure 3.2.2). On the other hand, the effect of nondifferential misclassification is always to attenuate the measure of association toward the null value.

Figure 3.2.2
Effects of Information Bias on Measures of Association

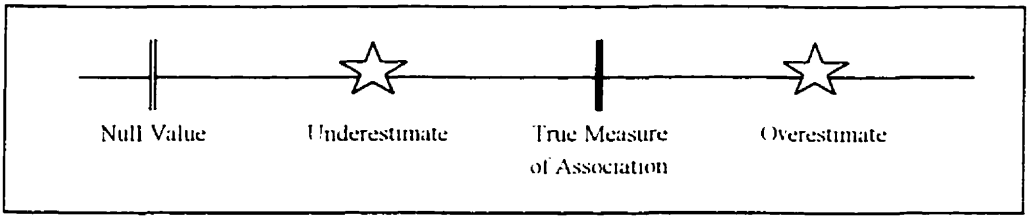


3.2.3 Selection Bias

Selection bias typically refers to distortions in measurements that result from procedures used to select subjects and from factors that influence study participation (23). Although many varieties of selection bias exist, the common element of such biases is that the relation between the exposure and outcome is different for those who participate

in the study and those who would be theoretically eligible for the study but do not participate. Depending on the circumstances, selection bias may overestimate or underestimate the true measure of association between a cost outcome and the exposure of interest (Figure 3.2.3).

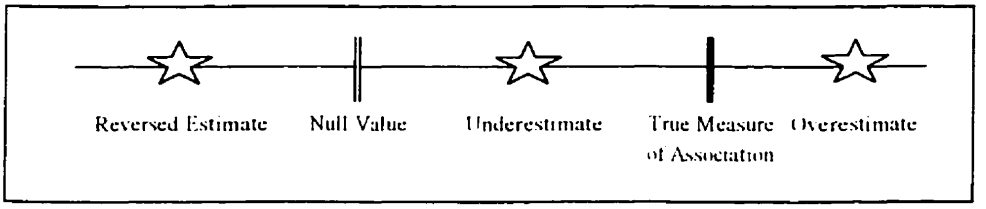
Figure 3.2.3
Effect of Selection Bias on Measures of Association



3.2.4 Confounding

Confounding occurs when the apparent association between a cost outcome and the exposure of interest is distorted because the effect of an extraneous factor, the confounding variable (23). In general, a *confounding variable* is associated with both the exposure and outcome under study. An example of confounding in studies examining the costs of health care services is when the method used to estimate costs did not take into account the severity of the patient's condition, the confounding variable (13). In this case, severity of illness is generally associated with higher health care costs (the outcome) and the exposure of interest (type of medical intervention). Depending on the circumstances, confounding may totally or partially account for the measure of association under investigation (Figure 3.2.4). Confounding may even mask an underlying true association between exposure and outcome, or even reverse it.

Figure 3.2.4
Effects of Confounding on Measures of Association



3.3 Understanding the Transition Cost Accounting System Methodology

The Transition system is a computer software for hospital cost accounting that is typically used to calculate the total costs associated with the treatment of patients admitted into the hospital. Data on medical resource utilization are collected at each patient care department and subsequently transferred into the Transition system data warehouse. The aggregate of the costs of all products and services used in the treatment of a patient represents the hospital's total cost of treating that patient. Importantly, the Transition data warehouse includes patient-level demographic and clinical information in addition to detailed resource utilization and cost information.

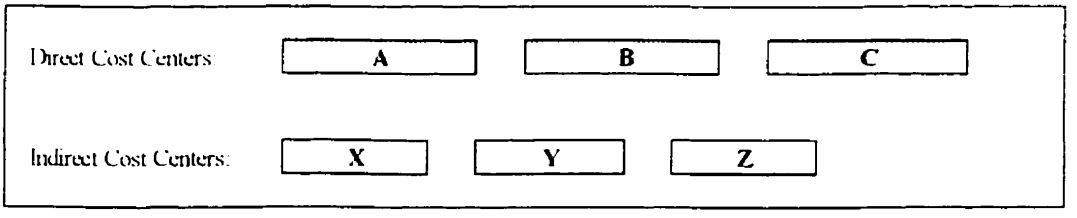
The use of the Transition cost accounting system to examine the costs of health care services warrants a clear understanding of the tool's methodology for measuring costs. Once this process is clearly understood, it will be possible to assess the accuracy of the cost estimates provided by the system and, subsequently, to use the system to undertake cost studies in health services research. The following is a detailed description of the 6-step Transition system methodology used to estimate total unit costs of products and services used in in-hospital patient care.

3.3.1 Classification of Departments as Direct or Indirect Cost Centers

In the first step of the Transition system methodology, hospital departments are classified as direct cost centers or indirect cost centers (Figure 3.3.1). The system's methodology views hospital departments as direct or indirect cost centers as each department incurs costs that are directly or indirectly related to the provision of medical

services. *Direct cost centers* are patient care departments (e.g., radiology, operating room) that directly provide services to patients, and the costs incurred by these departments are called *direct costs*. *Indirect cost centers* are hospital overhead departments (e.g., administration, housekeeping), and the costs incurred by these departments are called *indirect costs*.

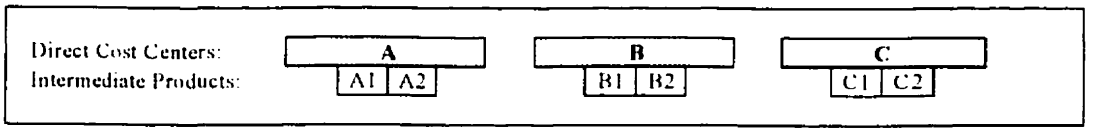
Figure 3.3.1
Step 1: Classification of Departments as Direct or Indirect Cost Centers



3.3.2 Identification of Department Level Intermediate Products

In the second step, procedures and services provided in patient care departments are selected and grouped into discrete intermediate products (Figure 3.3.2). *Intermediate products* are department specific and may represent either a product or a service or a combination of products and services used in patient care. Examples of intermediate products that are products include the drugs provided by the pharmacy or a gown from central supply. Examples of intermediate products that are services include a cardiopulmonary resuscitation in the emergency department or nursing care in the intensive care unit. Examples of intermediate products that combine products and services include a coronary angioplasty in the cardiac catheterization laboratory or a chest x-ray in the department of radiology.

Figure 3.3.2
Step 2: Identification of Department Level Intermediate Products

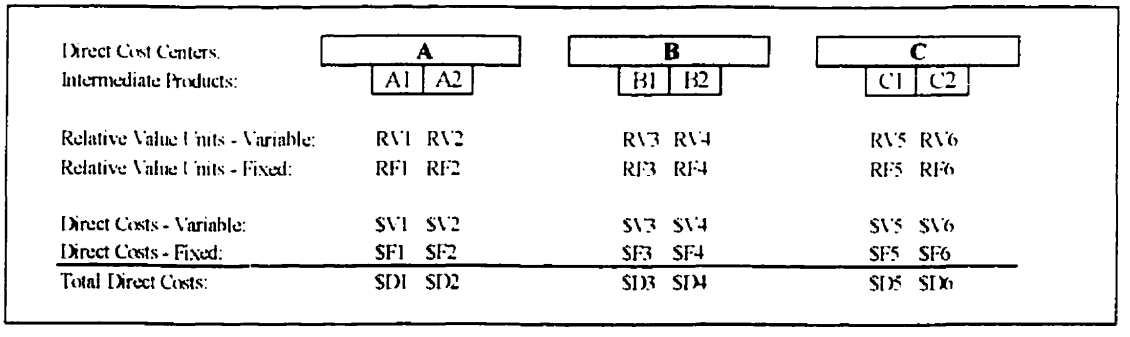


3.3.3 *Estimation of the Direct Costs of Intermediate Products*

In the third step, the relative direct costs of each department's intermediate products are estimated (Figure 3.3.3). Direct costs include direct labor costs and direct materials costs. *Direct labor costs* are costs related to the actual labor of individual employees within the department (e.g., salaries and fringe benefits of nurses and technicians). *Direct materials costs* are all department-level non-labor costs that become part of the patient care process (e.g., pharmaceutical products, supplies). Direct labor and materials costs may be classified as fixed or variable costs depending on their responsiveness to fluctuations in volume. Costs that remain unchanged despite fluctuations in activity are called *fixed costs*. Costs that change directly in proportion to changes in activity are called *variable costs*.

In order to estimate an intermediate product's direct costs, the weighted procedure method is used. Using this method, each intermediate product is assigned a number of relative value units (RVUs) which represents the product's estimated consumption of supplies, equipment, and personnel time. In other words, RVUs are an expression of the relative direct costs of one intermediate product to another within a given patient care department (25). Once RVUs have been assigned to all intermediate products within a department, the fixed and variable direct costs of a single RVU can be calculated by dividing the department's total fixed and variable costs, respectively, by the department's total number of RVUs used throughout a period. The variable and fixed direct cost of each intermediate product can subsequently be estimated by multiplying the intermediate product's assigned variable and fixed RVUs by the cost of a single RVU.

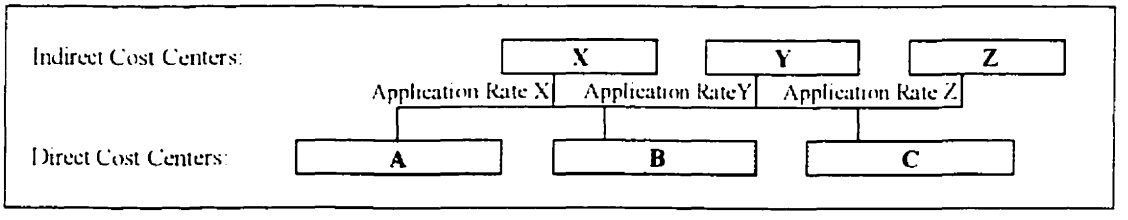
Figure 3.3.3
Step 3: Estimation of Direct Costs of Intermediate Products



3.3.4 Identification of Application Rates for Allocating Indirect Costs

In the fourth step of the Transition methodology, application rates are identified in order to allocate indirect costs to direct cost centers (Figure 3.3.4). For each type of indirect cost, or cost pool, a base for allocation must first be determined. A *cost pool* is any grouping of costs to be allocated, and a *base*, or cost driver, is a criterion upon which the allocation is to be made (14). Using the cost pool and base, an *application rate* is determined to allocate the total costs of an indirect cost center to a number of direct cost centers. The total costs of a hospital's housekeeping services, for instance, are typically allocated based on square footage. An application rate would then be determined by dividing total hospital housekeeping costs by total hospital square footage. A rate of $0.50/square foot, for example, indicates that each department will be allocated $0.50 per square foot for housekeeping services provided. While for some indirect cost pools, such as housekeeping, a fairly accurate and plausible allocation basis can be found (e.g., square footage), many other indirect costs are much more difficult to allocate in a plausible way. The costs of central administration are one example of indirect costs that are difficult to distribute.

Figure 3.3.4
Step 4: Identification of Application Rates for Allocating Indirect Costs

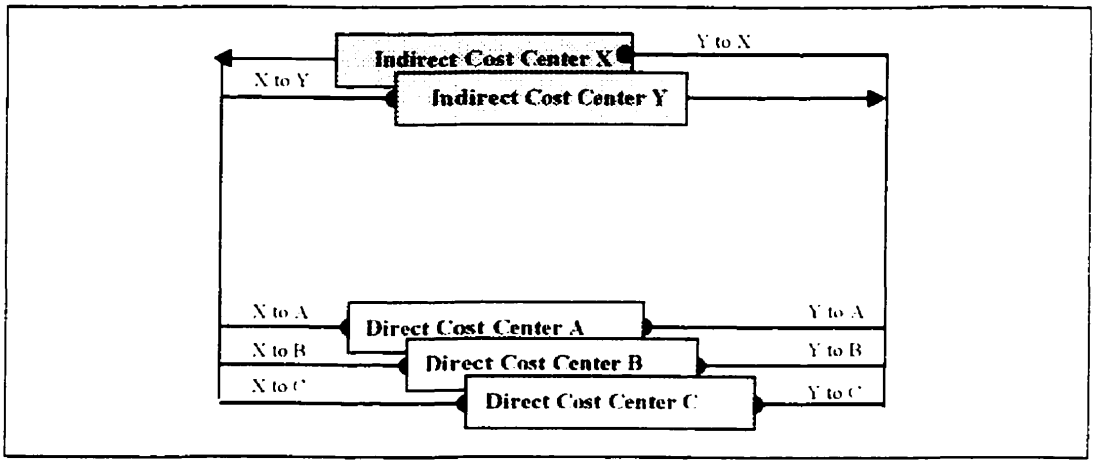


3.3.5 Allocation of Indirect Costs to Direct Cost Centers

In the fifth step, an allocation algorithm is used in order to allocate indirect costs to direct and indirect cost centers (Figure 3.3.5). A common method for allocating indirect costs is the step-down method. Under this method, indirect cost centers are

ranked in terms of decreasing amounts of service offered to other centers, and their costs are allocated one at a time in descending order. In essence, the step-down method is a one way or one-direction allocation method. Once the costs of an indirect cost center have been allocated, it is deemed "closed", no other cost center can assign costs to it, and there remains one center fewer in the analysis (25). The assumption of a one-way service between departments works well enough for financial reporting and in some cases represents the flow of the use of services quite well (26). However, the step-down method may become less accurate as the interactions among service departments become more important. Consequently, the user may choose to use another allocation algorithm such as the reciprocal allocation method. This method is conceptually appealing because it recognizes the simultaneous interaction of service departments rather than the somewhat arbitrary, one directional relationship the step-down method assumes (26).

Figure 3.3.5
Step 5: Allocation of Indirect Costs to Direct Cost Centers

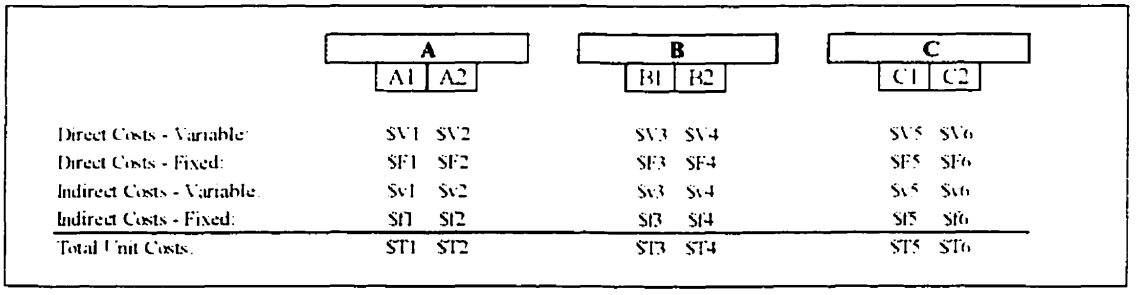


3.3.6 Estimation of Indirect Costs and Total Costs of Intermediate Products

In the sixth and last step, the indirect costs that were allocated to patient care departments are assigned to intermediate products within each department (Figure 3.3.6). This is done using the RVUs previously assigned to each intermediate product. First, the indirect cost of a single RVU is estimated by dividing the total indirect costs assigned to

the department by the department's total number of RVUs. The indirect cost of each intermediate product is then estimated by multiplying the intermediate product's assigned number of RVUs by the indirect cost of a single RVU. Once indirect costs have been assigned to individual intermediate products, the user is able to estimate the total unit costs of intermediate products by adding the product's direct costs (fixed and variable) and indirect costs.

Figure 3.3.6
Estimation of Indirect Costs and Total Unit Costs of Intermediate Products



3.4 Accuracy of Transition's Unit Cost Estimates

Using the Transition system methodology, there are several potential sources of measurement error when estimating the unit costs of products and services. Bias may occur when intermediate products are identified and when direct and indirect dollar values are assigned to each intermediate product.

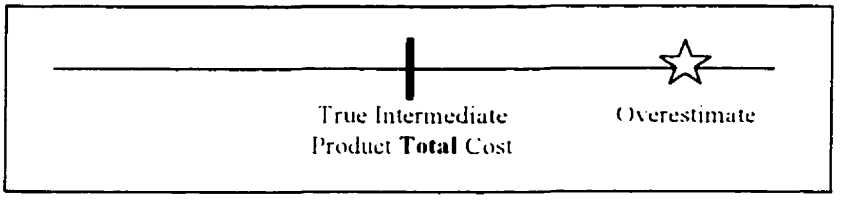
3.4.1 Cost Measurement Bias due to Incomplete Identification of Intermediate Products

In the second step of the Transition system methodology, procedures and services provided in patient care departments are selected and grouped into discrete intermediate products. The identification of the intermediate products at each department is generally based on the assumption that a relatively small number of procedures and services make up a high percentage of the department's costs. Department managers generally follow the "80/20 rule" thereby identifying the 20% of a department's products and services that

account for 80% of its costs (27). Nonetheless, this ratio is arbitrary and can vary among different hospitals and even among different departments within a single hospital.

Measurement bias arises here because department managers typically identify only a portion of the total number of intermediate products used in their department. The direct costs (incurred by the department) and the indirect costs (allocated to the department) are therefore assigned to the selected of intermediate products identified by the department manager. Consequently, the unit costs of individual intermediate products are overestimated.

Figure 3.4.1
Effects of Measurement Bias on Unit Cost Estimates
Due to Incomplete Identification of Intermediate Products



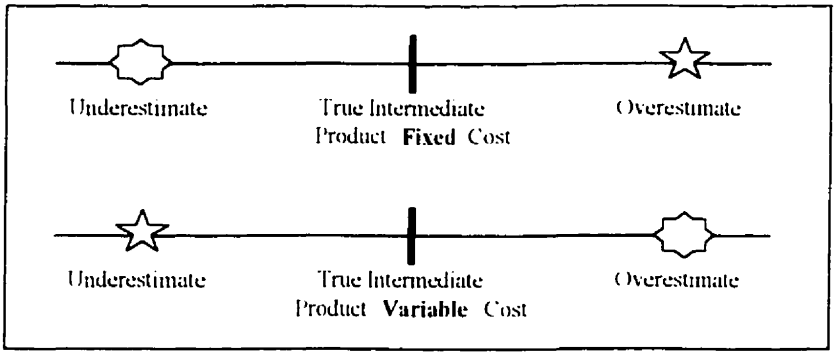
3.4.2 Measurement Bias Due to Misclassification of Fixed and Variable Costs

In the third step of the Transition system methodology, the RVUs of individual intermediate products are estimated based on the total resources consumed when the product or service is used in patient care. The potential for measurement bias arises here because a portion of the product's consumption of fixed costs may be considered as variable costs and, conversely, variable costs related to the product may be considered as fixed costs. Depending on the circumstances, the variable and fixed costs of a given intermediate product may be either overestimated or underestimated. In essence, an incorrect estimation a product's fixed costs will result in an incorrect estimation of its variable costs in the opposite direction, but not necessarily by the same dollar amount.

Consider, for example, the salaries of technicians in the department of radiology. If the technicians are employed on a full-time basis, their salaries should be considered as fixed costs to the department because they are independent of the volume of tests

performed. The technicians are paid a fixed monthly salary whether all of their time at work is spent on tests or whether a portion of their time at work is idle. Nonetheless, department managers may consider the technicians' salaries as variable costs if the portion of the technicians' idle time at work is relatively insignificant and if the monthly volumes of diagnostic tests are constant throughout the year

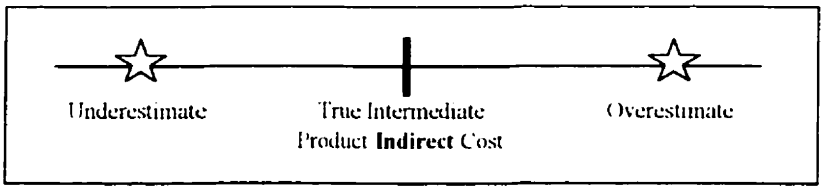
Figure 3.4.2
Effect of Measurement Bias on Unit Cost Estimates
Due to the Misclassification of Fixed and Variable Costs



3.4.3 Measurement Bias Due to the Use of Incorrect Allocation Basis

In the fourth step of the Transition system methodology, application rates are identified in order to allocate indirect costs to direct cost centers. Ideally, indirect costs should be allocated based on cost drivers that cause the minimum amount of distortion in cost allocation. Cost drivers used for allocating indirect costs typically include square footage, pounds of laundry, patient days, or total direct costs incurred by the department. The potential for measurement bias arises here because financial managers may allocate indirect costs to direct cost centers based on imperfect cost drivers. For example, indirect costs may be allocated to direct cost centers based on the total direct costs incurred by the patient care departments. In such cases, a given patient care department may be allocated a bigger or smaller portion of indirect costs than is truly appropriate. Consequently, indirect costs of individual intermediate products will be overestimated or underestimated depending on the circumstances (Figure 3.4.3).

Figure 3.4.3
Effects of Measurement Bias on Unit Cost Estimates
Due to the Use of Incorrect Allocation Basis



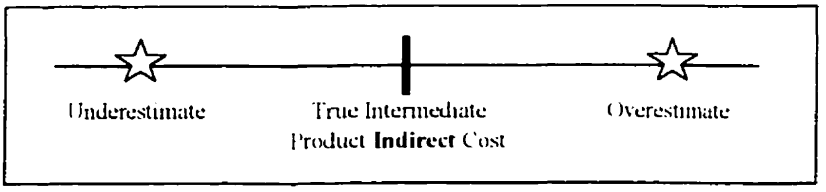
3.4.4 Measurement Bias Due to the Use of Incorrect Cost Allocation Algorithms

A common algorithm for allocating indirect costs to direct cost centers is the step-down method. Using this method, indirect cost centers are ranked in terms of decreasing amounts of service offered to other centers, and their costs are allocated one at a time in descending order. An important question to ask, however, is which department to allocate first. The order of allocation can have a significant impact on which department ultimately bears the costs of the organization (25). The potential for measurement bias may arise if the hierarchy of indirect cost centers is not accurate. Consequently, the costs allocated to service departments may be overestimated or underestimated, and indirect costs allocated to intermediate products may also be incorrectly estimated (Figure 3.4.5).

There are also numerous situations in which service departments service or interact with each other simultaneously (26). Administration offices, for example, are serviced by personnel from housekeeping, maintenance, and telephone services. In general, the step-down method will not be sufficiently accurate when extensive interactions exist among service departments. This is where the reciprocal method becomes valuable. Under the reciprocal allocation method, the total amount of a particular indirect cost center's cost that is allocated is affected by the reciprocity of services that each indirect cost center provides the other indirect cost centers. Once again, the potential for measurement bias arises if the step-down allocation method is used but there is truly a reciprocal relationship of costs among service departments. Costs allocated to service departments may be once again overestimated or underestimated and,

similarly, the indirect costs allocated to intermediate products may also be incorrectly estimated.

Figure 3.4.4
Effects of Measurement Bias on Unit Cost Estimates
Due to the Use of Incorrect Cost Allocation Algorithms



3.5 Accuracy of Transition's Inter-Hospital Cost Comparisons

The methodology used by the Transition software implies that there are several potential sources of measurement bias when estimating the unit costs of products and services used in the patient care. Additional source of bias may occur Transition system costs estimates are compared between two or more hospitals. Thus, the focus of this section is on the accuracy of inter-hospital cost comparisons using the Transition system.

3.5.1 Information Bias due to Differences in the Classification of Cost Centers

The classification of a hospital department as a direct or indirect cost center is relatively straightforward, and there is little reason to believe that a particular cost center would be treated as direct in one hospital and as indirect in another. A careful examination of the detailed list of cost centers at individual hospitals may nonetheless reveal inter-hospital differences in the classification of cost centers as direct or indirect.

Differences in the classification of direct and indirect cost centers may arise if hospitals outsource patient care services to independent contractors. In such cases, costs defined as direct in one organization may be categorized as indirect in another (28). Misclassification bias in cost estimates is likely to be differential and differences in costs may be either overestimated or underestimated.

Consider two hospitals, for example, where one hospital provides on-site computed tomographic scans while the other hospital purchases these services from an outside supplier. For the first hospital, the costs related to the scans (e.g., supplies and equipment) will be incurred by the radiology department, a direct cost center, and will be assigned to individual patients as direct costs. For the second hospital, however, the costs of the scans will be assigned to an indirect cost center and subsequently allocated to direct cost centers. In this particular example, differential misclassification will result in an overestimation of the difference in treating patients requiring computed tomographic scans. This is because, costs of treatment will be underestimated at one hospital thereby overestimating the difference in costs between the two hospitals.

3.5.2 Information Bias Due to Differences in RVU Estimates

The weighted procedure method for estimating the RVUs of intermediate products is a costly and time-consuming endeavor. In fact, this procedure is so costly that most department managers use industry standards rather than computing the RVUs themselves (25). The use of industry-wide standards, however, assumes that all hospitals are exactly the same, and that the resource consumption for each intermediate product relative to all other products is the same across all hospitals. This assumption is highly unlikely given that hospitals generally differ in the resources used in delivering care.

Differences in costs between two hospitals are not likely to be biased if RVUs are calculated by the department managers of each of the two hospitals. In fact, this ideal scenario will yield the most accurate cost estimates. The potential for information bias arises, however, if hospitals use industry standards to estimate RVUs. The effect of this bias will be different depending on whether only one hospital or both hospitals use the industry standards. If one hospital uses industry standards while the other estimates its own RVUs then misclassification of cost estimates is likely to be differential. In this scenario, differences in costs between the two hospitals may be overestimated or underestimated. If both hospitals use the same industry standards, then misclassification is likely to be nondifferential and differences in costs between the two hospitals are likely to be underestimated.

3.5.3 Information Bias Due to Differences in Indirect Cost Allocation

A careful examination of hospital cost centers may disclose the presence of unusual indirect costs at a particular hospital. Costs related to research activities, affiliated medical schools, bad debts, interest expense, or bond interest, for example, may be present in one hospital's indirect cost pool but not in another. The potential for bias may arise if such expenses cannot be removed from the cost analysis. In such cases, the misclassification is likely to be differential and the overall difference in costs between the two hospitals will be overestimated. Other potential sources of differential cost misclassification arise when hospitals use different application rates and allocation algorithms to allocate indirect costs to direct cost centers. Depending on the circumstances, indirect cost differences between hospitals may be overestimated or underestimated.

3.6 Study Examining the Accuracy and Use of the Transition Cost Accounting System

The next chapter presents the results of a three-stage study examining the accuracy of data derived from the Transition system as well as the potential use of this tool in health services research. In the first stage, audit documentation was obtained from a U.S. hospital in order to examine the reliability of the resource utilization and financial data obtained from the Transition system. In the second stage, a survey was carried out in order to examine cost accounting differences among hospitals using the Transition system. In the third stage, a case study was undertaken in order to examine differences in costs of treatment among hospitals using the Transition system.

3.6.1 Review of Audit Documentation

The hospital's Transition software and its functions are fully integrated such that data never has to be passed from one application to another (12). Rather, all of the

hospital's clinical and financial information is uniquely consolidated in one central database. Transition's various applications access the same central, single database, or Transition data warehouse. The system thus offers a comprehensive clinical and financial database for both hospital inpatients and outpatients. Maintained in the system are demographic and diagnostic data as well as a complete record of all hospital resources, and their costs, used in the treatment of each patient (12). Raw data are transferred into Transition from "feeder systems" such as the hospital's General Ledger (financial data), Medical Records (demographic and clinical data), and Billing systems (resource utilization data). As a "decision support umbrella", Transition consolidates all of this raw data and turns it into functional management information therefore reducing the need for required programming, subsequent transfer of data, and other data processing intervention that can result in increased expense, redundant data entry, and reduced accuracy (12). In spite of the integrative nature of the Transition software, the recording and transfer of data from the feeder systems into Transition's central database may result in reduced accuracy due to technical and human errors.

This analysis sought to assess the magnitude of discrepancies between information available in the Transition data warehouse and its feeder systems. Information on audits of financial information was obtained from a U.S. hospital that currently uses the Transition cost accounting system. At this hospital, utilization and financial data were compared between the Transition system and its three major feeder systems: the Medical Records system, the Billing System, and the General Ledger system. The data obtained represent audits for the months of January to March of 1999. For confidentiality purposes, the hospital providing the audit documentation cannot be identified except that it is a large, urban, university-affiliated hospital.

3.6.2 Survey of Inter-Hospital Cost Accounting Practices

The Transition methodology for estimating unit costs of products and services highlights several potential inter-hospital differences in cost accounting practices. These differences are important to consider because the may affect cost estimates at a single hospital as well as cost comparisons between hospitals. Thus, the objective of this

analysis was to examine differences in cost structures and cost accounting practices through a survey of hospitals that currently use the Transition cost accounting system. In all, 4 U.S. hospitals and 3 Canadian hospitals that currently employ the Transition system were asked to complete a questionnaire for these purposes. Survey questions were developed based on the understanding of potential cost accounting differences among hospital using the Transition cost accounting system. Most hospitals participating in this survey also participated in the following case study. The selection of these hospitals is discussed below.

3.6.3 Case Study Comparing the Costs of Treating Acute Myocardial Infarction in Canada and the United States

Acute myocardial infarction (AMI) is the leading cause of morbidity and mortality in North America (29). For this reason, several studies have investigated differences in treatment patterns and outcomes between AMI patients in Canada and the U.S. Following AMI, rates of coronary angiography, percutaneous transluminal coronary angioplasty (PTCA) and coronary artery bypass graft (CABG) surgery are significantly lower among Canadian patients than among U.S. patients (29-34). In spite of our substantial knowledge of practice variations, little is known about differences in costs of treatment of AMI between Canadian and U.S. hospitals. It is also unclear if the more common use of invasive cardiac procedures in the U.S accounts for higher in-hospital costs of treatment.

Until recently, it was difficult to compare the cost of treatment of AMI between the two countries because no single comprehensive cost accounting system was designed for that purpose However, the current use of the Transition cost accounting information system in Canadian and U.S. hospitals allows for the comparison of in-hospital resource utilization and costs of treatments for between patients admitted with AMI in Canadian and U.S. hospitals. Thus, the objectives of the case study were to collect data from the Transition system of Canadian and U.S. hospitals in order to determine 1) if there is a difference in the costs of treatment of AMI between Canada and the U.S. and 2) if the

higher rates of invasive cardiac procedures in the U.S. account for higher costs of treatment.

3.6.4 Hospital Selection and Sample Generation

In order to undertake these analyses, Canadian and U.S. hospitals that use that Transition cost accounting system were contacted to obtain aggregate demographic, resource utilization, and costs of treatment data on all AMI patients admitted to the hospital during the first quarter of 1997. Only hospitals in which coronary angiography and revascularization procedures are performed on site were included in the study. This is because studies have shown that the use of invasive cardiac procedures is strongly affected by the availability of on-site cardiac catheterization and bypass surgery (53-54). In addition, participating hospital were instructed to exclude patients with a previous occurrence of a myocardial infarction as well as patients that were transferred into or out of the hospital during their hospitalization for AMI. The latter group of patients was excluded from the analysis because it is difficult to capture all in-hospital costs of treatment for patients that are transferred for procedures to different hospitals.

Participation in this study was voluntary, and, in all, aggregate data were obtained on 215 consecutive patients from 2 Canadian hospitals and 752 consecutive patients from 7 U.S. hospitals admitted with a primary diagnosis of AMI (ICD-9 code 410) between January 1 and March 31, 1997. All participating hospitals were large, urban, university-affiliated hospitals. Throughout the year beginning January 1 and ending December 31, 1997, Canadian hospitals had fewer licensed beds than the U.S. hospitals (mean 437 vs 580 beds, respectively) and admitted fewer AMI patients than the U.S. hospitals (mean 379 vs 454 AMI patients, respectively). During the same period, the total number of PTCA procedures performed was similar among the Canadian and U.S. hospitals (mean 688 vs. 691 procedures, respectively), but the total number of CABG procedures was higher among the Canadian hospitals than among the U.S. hospitals (681 vs. 484 procedures, respectively).

CHAPTER 4: RESULTS

4.1 Review of Resource Utilization & Financial Audit Documentation

The first audit report compared the total number of encounters recorded in the Medical Records with that transferred into the Transition system (Table 4.1.1a). An *encounter* is an *inpatient* admitted into the hospital or an *outpatient* receiving medical services without being admitted. The total number of encounters in a given month is the aggregate of the total number of inpatient admissions and the total number of outpatient visits throughout the month.

The results of this audit report indicate that monthly totals of encounters in the Transition system corresponded perfectly to those in the Medical Records system, such that the variance in counts of encounters was nil for each of the first 3 months in 1999. This suggests that, at this hospital, data on encounter numbers were accurately transferred from the Medical Records system into the Transition system data warehouse. Stated otherwise, encounter number information in Transition is as reliable as that in the Medical Records system.

Table 4.1a
Audit of Encounter Numbers: Medical Records System vs. Transition System

	January	February	March
Medical Records System:			
Total Inpatient (IP)	22,785	25,681	28,374
Total Outpatient (OP)	80,936	91,659	101,911
Total Encounters	103,721	117,340	130,285
Transition System:			
New Inpatients	3,683	2,894	2,699
New Outpatients	13,479	10,804	10,134
Old Inpatinets	19,102	22,787	25,675
Old Outpatients	67,457	80,855	91,777
Total Encounters	103,721	117,340	130,285
Variance:	**0**	**0**	**0**

The second audit report compared the total amount of charges recorded in the Billing System with that transferred into the General Ledger system (Table 4.1.1b). Hospitals in the U.S. typically charge third-party payers for all medical services provided to patients. Charges are computed every day by the Billing System and are based on the resources used to treat patients. Charge information is subsequently transferred into the hospital General Ledger system so as to record the revenues earned by the hospital throughout the day. The *General Ledger* is a comprehensive list of the hospital's financial information including the asset, liability, revenue, and expense accounts.

The results of the audit indicate that, throughout the first quarter of 1999, total information on charges was accurately transferred into the General Ledger system. This information was as reliable in the General Ledger system as in its original source, the Billing System. Except for small variances (< 0.01%), total charges in the two systems corresponded perfectly.

Table 4.1b
Audit of Charges: Billing System vs. General Ledger

	January	February	March
Billing System:			
Charges	$55,597,350	$52,138,822	$54,845,277
Old Date Charges	$ 5,708	$ 1,566	$ 1,106
Total Charges	$55,603,058	$52,140,388	$54,846,383
General Ledger:			
Total Charges	$55,596,022	$52,139,567	$54,845,646
Variance:	**$ 7,036**	**$ 821**	**$ 737**

The third audit compared the total number of payments recorded in Billing System with that transferred into the Transition system (Table 4.1.1c). For the months of February and March, number of payments corresponded perfectly between the two systems. In January, 239 payments were missing in the Transition system, as compared to the Billing System. A brief analysis of this information, however, indicates that only

0.5% of all monthly payments were missing, or 16% of payments made on a single day during the month.

Table 4.1c
Audit of Payments: Billing System vs. Transition System

	January	February	March
Billing System:			
Total Number of Payments	44,904	41,926	45,732
Transition System:			
Total Number of Payments	44,665	41,926	45,732
Variance:	**239**	**0**	**0**

The last audit represents an ad-hoc verification of information extracted from the Medical Records system (Table 4.1.1d). Information on mean age, length of hospital stay, and charges were extracted for inpatients and outpatients treated during the month. Although this data is not directly compared with data extracted from another hospital information system, it is useful to identify major errors in data entry and transfer at the hospital.

Table 4.1d
Audit of Medical Records System

	January	February	March
Medical Records System:			
Mean Length of Stay per Inpatient	4.905	4.955	5.000
Mean Charges per Inpatient	13900	13973	14011
Mean Age of Inpatients	39.75	39.809	39.91
Mean Charges per Outpatient	892.4	896.09	895.44
Mean Age of Outpatients	40.59	40.488	40.43
Inpatients Missing Discharge Date	499	494	440
Outpatients Missing Discharge Date	1141	1231	913

4.2 Survey of Inter-Hospital Cost Accounting Differences

4.2.1 Implementation, Use & Auditing

In order to assess the reliability of their Transition system data, hospitals were surveyed about their system implementation process and data auditing practices (Table 4.2.1). Among the 3 Canadian and 4 U.S. hospitals surveyed, 5 had purchased and implemented their Transition cost accounting system over the past 5 years. While all 4 U.S. hospitals completed the implementation process, at 2 of the 3 Canadian hospitals the implementation process was still ongoing. With the exception of one U.S. hospital, all hospitals surveyed used their Transition system for internal financial and clinical analysis purposes.

The results of the survey also suggest that audits are regularly performed to assess the validity of the data in the Transition data warehouse. In general, hospitals undertake monthly audits so as to verify that encounter, resource utilization, payment, charge, payroll, and general ledger data are accurately transferred from the feeder systems into the Transition data warehouse. Not all hospitals perform all types of audits however. Four of the hospitals, for example, do not audit the clinical information in the Transition data warehouse. As compared to Canadian hospitals, U.S. hospitals were more likely to have completed their Transition implementation process and to audit the clinical and financial data in the Transition data warehouse.

4.2.2 Cost Accounting Practices

In order to assess the validity of their Transition system data, hospitals were surveyed about the completeness of the financial information in their respective systems (Table 4.2.2). All hospitals surveyed, but one Canadian hospital (G), reported that their Transition data warehouse included all direct and indirect cost centers. Another Canadian hospital (E) reported that while all direct cost centers are included in its system, not all intermediate products have been identified at each patient care department.

Table 4.2.1
Inter-Hospital Differences in the Implementation, Use & Auditing of Transition Data

	U.S. Hospitals				Canadian Hospitals		
	A	B	C	D	E	F	G
1. Year of implementation	1995	1987	1994	1995	1990	1996	1996
2. Completed implementation	Yes	Yes	Yes	Yes	No	Yes	No
3. Use of Transition							
• Financial analysis?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
• Clinical analysis?	Yes	Yes	No	Yes	Yes	Yes	Yes
4. Types of audits performed							
• In/outpatient count?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
• Volumes of products & services?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
• Clinical diagnoses?	Yes	No	No	Yes	Yes	No	No
• Account level financial data?	Yes	Yes	Yes	Yes	Yes	Yes	No
• Payroll data?	Yes	Yes	Yes	Yes	Yes	No	Yes
• Charges from Billing System?	Yes	Yes	Yes	Yes	N/A	N/A	N/A
5. Frequencies of financial audits	Mo.	Mo.	Mo.	Mo.	Mo.	Mo.	Mo.

N/A: Not Applicable as there are no charges or billing systems in Canadian Hospitals
Mo.: Indicates monthly audits

Among the 4 U.S. hospitals surveyed, only one hospital (D) outsourced patient care services (magnetic resonance imaging, dialysis) and non-patient care services (housekeeping, information systems). This hospital reported that all outsourced services were treated as indirect costs and subsequently allocated to direct cost centers. In contrast, one Canadian hospital (E) outsourced patient care services (some laboratory tests) and treated these expenditures as direct costs. Two Canadian hospitals outsourced non-patient care services (food services, housekeeping) and treated these expenditures as indirect costs.

All hospitals surveyed reported that employee salaries and fringe benefits in patient-care departments were treated as direct costs. However, the treatment of costs related to a patient care department's overhead and equipment depreciation was not consistent among all hospitals. In 2 of the 4 U.S. hospitals surveyed (A, D), overhead and depreciation costs in patient care departments were treated as indirect costs.

When asked which statistic, or basis, was used to assign indirect costs to direct cost centers, hospitals generally reported that the statistic varied depending on the department. Examples of allocation bases included square footage, pounds of laundry, total salaries, and total costs. One U.S. hospital (D), however, reported allocating indirect costs based on the department's share of total costs, i.e. percentage of total costs incurred by all departments. In contrast, one Canadian hospital (E) reported allocating indirect costs to patient care departments using a fixed rate for all departments.

Of the 7 hospitals surveyed, 3 U.S. reported using the Step-Down algorithm for allocating indirect costs. One U.S. hospital and 2 Canadian hospitals reported using the Simultaneous Equation Allocation Method (SEAM) for indirect cost allocation. The only hospital that did use an algorithm to allocate indirect costs is the Canadian hospital (E) that uses a fixed rate for all hospital departments and products.

A review of the list of cost centers at each participating hospital was useful in identifying unusual costs at a particular hospital. For instance, of the 4 U.S. hospitals surveyed, 2 hospitals identified the costs related to interest expense and bond interest as indirect costs. One of the hospitals also incorporated the costs of its research activities and affiliated medical school to its indirect cost pool. One Canadian hospital, on the other hand, did not report any indirect costs related to financing activities, research, or affiliated medical schools. Similarly, 2 U.S. hospitals reported treating bad debt expense (expenses related to uncollectable invoices or medical bills to patients) as a discount to revenue, whereas the third hospital treated bad debt expense as an indirect cost that was subsequently allocated to direct cost centers. Bad debts treated as discounts to revenue are simply deducted from the total revenues without being assigned to any department, product, or patient. In Canada, bad debts are rare and do not represent material costs to hospitals.

Several differences in cost accounting practices exist between the Canadian and U.S. hospitals participating in this survey. Because these hospitals also participated in the case study on the cost of treatment of AMI, it is important to assess the impact of these differences on the estimation of intermediate products costs. Based on the survey results, the most important inter-hospital variation in cost estimation is the measurement and allocation of indirect costs. Indirect costs at all 4 U.S. hospitals included "unusual costs" that are not necessarily included in the pool of indirect costs of the Canadian hospitals. Hospital A, for example, is part of a health care system that includes several hospitals. For each of the network's hospitals, indirect costs include corporate-related expenditures such as the salaries of high-level management personnel. It is therefore likely that indirect costs are higher at this hospital than in the other hospitals participating in the study. In fact, in Figure 4.3.3 of the case study results (page 43), this health system is represented by hospitals H and I. Clearly, indirect costs at these two hospitals are the highest among all hospitals.

Another difference between the hospitals participating in the survey is the allocation of indirect costs. Hospitals A and B, for instance, allocate indirect costs to patient care departments using the Step-Down and SEAM methods, respectively. Although the effects of such differences on the estimation of unit costs must be examined in a more thorough analysis, it is likely that the unit indirect costs are not importantly affected by the choice of allocation method. This is because a given indirect cost pool is typically allocated to all patient care departments, and each of these departments contains a multitude of intermediate products. The indirect costs that are assigned to a given intermediate product may therefore not be very different when using the Step-Down or SEAM method to allocate indirect costs.

Table 4.2.2
Inter-Hospital Differences in Cost Structure and Cost Accounting Practices

		U.S. Hospitals				Canadian Hospitals		
		A	B	C	D	E	F	G
1.	All direct costs Captured	Yes	Yes	Yes	Yes	Yes	Yes	No
2.	All indirect costs captured	Yes	Yes	Yes	Yes	Yes	Yes	No
2.	Any patient care services outsourced	No	No	No	Yes	Yes	*	No
3.	Any non-patient care services outsourced	No	No	No	Yes	Yes	*	Yes
4.	Salaries & fringe benefits treated as...	Direct Costs	Direct Costs	Direct Costs	Direct Costs	Direct Costs	Direct Costs	Direct Costs
5.	Overhead & depreciation treated as...	Indirect Costs	Direct Costs	Direct Costs	Indirect Costs	Direct Costs	Direct Costs	Direct Costs
6.	Statistic used to allocate indirect costs	Varies	Varies	Varies	% Total Costs	Fixed Rate	Varies	Standards
7.	Algorithm for allocating indirect costs	Step-Down	SEAM	Step-Down	Step-Down	None	SEAM	SEAM
8.	Basis for allocating indirect costs to IP	Direct costs	Direct Costs	RVUs	Direct Costs	None	RVUs	Direct Costs
9.	Unusual Indirect Costs	Yes	Yes	Yes	Yes	No	*	No
10.	Bad debts are treated as	Indirect Costs	Direct Cost	Discounts to Revenues	Discounts to Revenues	N/A	N/A	N/A

* Information was not available

4.3 Case Study on the Costs of Treatment of Acute Myocardial Infarction in Canada and the United States

4.3.1 Objectives

The objectives of the case study were 1) to determine if there is a difference in in-hospital costs of treatment of AMI between Canadian and U.S. hospitals, and 2) to determine if the higher rates of invasive cardiac procedures in the U.S. account for higher costs of treatment.

4.3.2 Data Analysis

Demographic, resource utilization, and costs of treatment information are presented as grouped data (Canada vs. U.S.), and average values in each country represent weighted averages based on the number of patients at each hospital. Fisher's exact test was used to compare differences in rates of utilization of invasive cardiac procedures and differences in in-hospital mortality rates between the Canadian and U.S. hospitals. Statistical testing was two-tailed and a p-value ≤ 0.05 was considered to be statistically significant.

The costs of treatment data collected were separated into direct and indirect costs, and direct costs were further separated into 4 sub-categories: nursing costs; pharmacy, laboratory, and radiology costs; cardiac catheterization and operating room costs; other direct costs. Canadian dollar costs were converted into U.S. dollars using the average market exchange rate of the first quarter of 1997 (1 CAD = 0.75 USD), and all dollar amounts presented are expressed in U.S. dollars. Physicians' fees and costs related to diagnostic procedures, nuclear medicine, and emergency rooms were excluded from our analysis because they were not available in every institution. Importantly, aggregate data were obtained and not patient-level data, and our cost estimates therefore represent the costs incurred by the average patient admitted into the hospital with AMI. For example, costs associated with the cardiac catheterization laboratory and cardiac operating rooms were allocated to all patients, to those that underwent invasive cardiac procedures and to

those that did not. As such, the cost estimates presented in this paper reflect both differences in rates of utilization and differences in costs between the Canadian and U.S. hospitals participating in the study.

One of the two Canadian hospitals participating in the study was unable to provide information on costs associated with cardiac catheterization laboratory procedures. A sensitivity analysis was therefore performed using the invasive cardiac procedure rates at this hospital and three different cost scenarios derived from the information provided by the other participating Canadian hospital. The average cost per cardiac catheterization procedure at this hospital was first calculated (average cost per angiography or PTCA = $1,059). This estimate was then used to obtain total cardiac catheterization laboratory costs for the hospital with missing information using the invasive cardiac procedure rates at this hospital. Finally, total cardiac catheterization laboratory costs were divided by the total number of patients to obtain the average cardiac catheterization laboratory cost per patient.

In the "best case" scenario, average cardiac catheterization laboratory cost per patient was estimated to be $530, that of the other Canadian hospital. In the "worst case" scenario this cost was estimated to be $1,059 (twice that of the other hospital), and in the "likely case" scenario this cost was estimated to be $794 (the average of the "best case" and "worst case" scenarios' costs). In the analyses, the "likely case" cardiac catheterization laboratory cost per patient was used. Additionally, a separate sensitivity analysis 1) added $500 per patient at one Canadian hospital to account for missing depreciation costs, and 2) recalculated the costs in Canada using higher and lower exchange rates.

4.3.3 Results

Among the patients included in the case study, a significantly higher proportion of men were admitted with AMI in Canada than in the U.S. (72% vs 64% respectively, p=0.05), but the mean age for men and women was similar in both countries (66 years) (Table 1). On average, mean length of hospital stay was 1.2 days longer in Canada than in the U.S. (range 5.7-7.4 days vs 4.6-7.7 days, respectively). Rates of coronary

angiography procedures were significantly lower in Canada (p<0.001), ranging between 28% and 43% among the Canadian hospitals and between 45% and 80% among the U.S. hospitals. Rates of use of PTCA were also significantly lower in Canada (p<0.0001), ranging between 19% and 22% among the Canadian hospitals and between 28% and 55% among the U.S. hospitals. In contrast, it was noted that Canadian and U.S. patients had similar rates of CABG procedures (range 11%-20% vs 5%-25%, respectively, p=NS) and similar rates of in-hospital mortality (range 8%-11% vs 0%-12%, respectively, p=NS).

Average in-hospital costs per patient in Canada ($6,181, range $4,856-$6,456) were 40% of the costs in the U.S. ($15,631, range $13,130-$18,773) (Table 2, Figure 7). Indirect costs in Canada (mean $1,385, range $1,128-$1,438) were less than one-fourth of indirect costs in the U.S. (mean $5,830, range $3,939-$9,387), and direct costs in Canada (mean $4,796, range $3,728-$5,166) were one-half of direct costs in the U.S. (mean $9,801, range $9,191-$10,225).

Table 4.3.3a
Resource utilization data on 967 patients admitted with AMI
at 2 Canadian hospitals (n=215) and 7 U.S. hospitals (n=752)

	Canada	U.S.	P Value
Age, mean years	65.8	66.0	*
Males, %	71.6	64.2	0.05
Length of hospital stay, mean days	7.1	5.9	*
Coronary angiography, %	30.7	58.6	<0.0001
PTCA, %	21.4	41.8	<0.0001
CABG, %	18.6	16.6	0.53
In-hospital death, %	10.2	6.9	0.11

* Could not be calculated because standard deviation was not available.
PTCA = percutaneous transluminal coronary angioplasty
CABG = coronary artery bypass graft surgery

Canadian hospitals spent proportionately less on indirect expenditures than U.S. hospitals (Table 2). The proportion of total costs attributable to indirect costs was 22% in Canada (range 22%-23%) and 36% in the U.S. (range 28%-50%). Conversely, direct

costs represented approximately 78% of total costs in Canada (range 77%-78%) but only 64% in the U.S. (range 50%-72%). The $9,450 difference in total costs between Canada and the U.S. was almost equally attributable to differences in direct costs and to differences in indirect costs (53% and 47%, respectively). Importantly, differences in direct costs of coronary angiography, PTCA, and CABG procedures accounted for only 21% of the total difference in costs between the Canadian and U.S. hospitals.

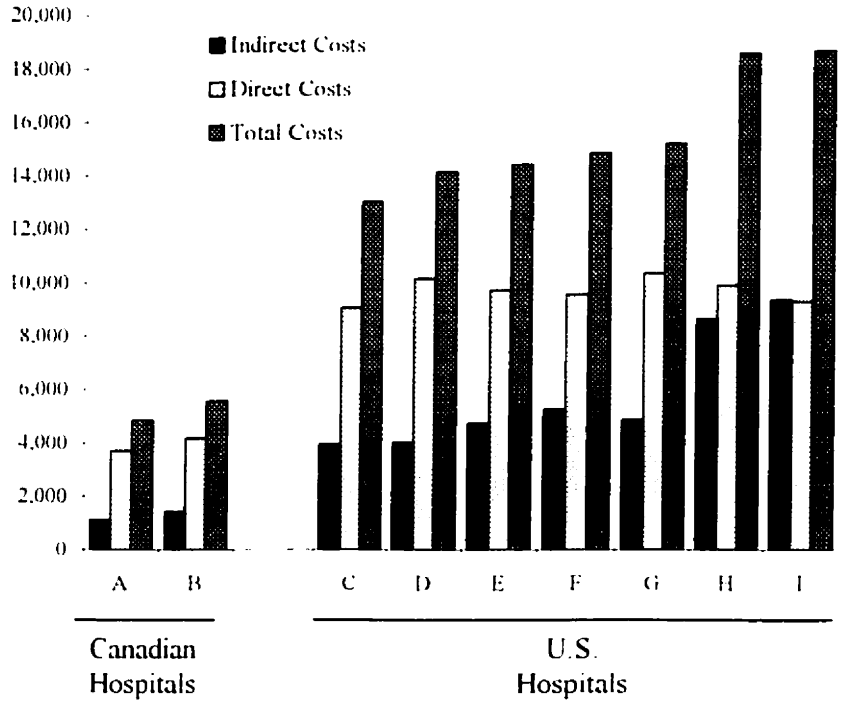
Table 4.3.3b
Per patient in-hospital cost of treatment of AMI at 2 Canadian (n=215) and 7 U.S. hospitals (n=752)[ψ].

	Canada	(%)	U.S.	(%)
Total direct costs	4,796	(78)	9,801	(64)
Nursing	2,547	(42)	3,743	(24)
Angiography, PTCA & CABG	1,520	(24)	3,541	(23)
Pharmacy, laboratory & radiology	663	(11)	1,747	(11)
Other direct costs	67	(1)	770	(5)
Total indirect costs	1,385	(22)	5,830	(36)
Total in-hospital costs	6,181	(100)	15,631	(100)

ψ In 1997 U.S. dollars and excluding physicians' fees and costs related to diagnostic procedures, nuclear medicine, and emergency room.
PTCA = percutaneous transluminal coronary angioplasty
CABG = coronary artery bypass graft surgery

Figure 4.3.3

Costs of treatment of AMI at 2 Canadian hospitals and 7 U.S. hospitals



* In 1997 U.S. dollars and excluding physicians' fees and costs related to diagnostic procedures, nuclear medicine, and emergency rooms.

Several sensitivity analyses were undertaken in order to examine the effect of our assumptions. First, average cardiac catheterization laboratory cost per patient was estimated in one of the Canadian hospitals according to the different cost scenarios described earlier. Using the "best case" scenario cost ($530 per patient), total in-hospital costs in Canada decreased from $6,181 (using the "likely case" cost estimate) to $5,961 (38% of total costs in the U.S.). Using the "worst case" scenario cost ($1,059 per patient), total costs in Canada increased to $6,400 (41% of total costs in the U.S.). In a second sensitivity analysis, $500 per patient were added to indirect costs at one Canadian hospital to offset missing depreciation costs. As a result, total in-hospital costs in Canada increased to $6,267 (40% of total costs in the U.S.).

In a third analysis, Canadian dollar costs were converted to U.S. dollars using the following two exchange rates: 1 CAD = 0.70 USD and 1 CAD = 0.80 USD. Total costs in Canada were $5,769 in the first case and $6,593 in the second case (37% and 42% of total costs in the U.S., respectively). Finally, when the "worst case" cardiac catheterization cost and the 0.80 USD exchange rate were used while simultaneously adding the missing depreciation costs, total costs per patient in Canada increased to $6,918, representing 44% of total costs in the U.S. Thus, even when accounting for potential methodological limitations, total costs in Canada were less than half the costs in the U.S.

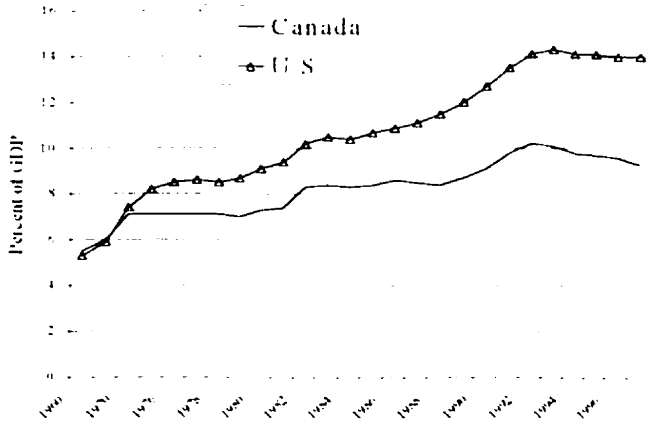
CHAPTER 5: DISCUSSION

5.1 Healthcare Expenditures in Canada and the United States

5.1.1 Introduction

Over the past four decades, total healthcare expenditures have been higher in the U.S. than Canada, and the gap in healthcare spending between the two countries has widened throughout the years. Between 1960 and 1997, the proportion of gross domestic product (GDP) spent on healthcare increased from 5.5% to 9.3% in Canada and from 5.3% to 14.0% in the U.S. (69% and 164% and increase, respectively) (Figure 5.1.1). Studies have generally concluded that virtually the entire difference in total healthcare expenditures between the two countries is accounted for by differences in the 1) costs of administrative services, 2) costs of physicians' services, and 3) costs of hospital services (2, 4, 35-38, 41-48). In most of these studies, aggregate healthcare expenditures were obtained from government publications and from national public-use databases.

Figure 5.1.1
Healthcare spending as percent of GDP in Canada and the U.S., 1960-1997



Sources: Canadian Institute for Health Information, National Health Expenditure Trends, 1975-1998, Ottawa, 1998. Health Canada, National Health Expenditures in Canada, Ottawa, 1997.

5.1.2 Costs of Administrative Services

Using 1987 data, Woolhandler and Himmelstein examined 4 components of administrative costs in the Canadian and U.S. health care sectors, including insurance overhead, hospital administration, nursing home administration, and physicians' overhead and billing expenses (35). In all of these categories, per capita costs were several-fold higher in the U.S. than in Canada as national-level spending on administration reached $100 billion in the U.S. but only $4 billion in Canada. This difference in administrative expenditures accounted for approximately 48% of the total difference in health care expenditures between Canada and the U.S.

In another study by Woolhandler and Himmelstein, state-level administrative costs were examined using 1990 data submitted to Medicare by most acute care hospitals (36). Administration accounted for an average of 25% of hospitals' spending nationwide, and administrative salaries accounted for 22% of the average hospital's salary costs. No state had administrative costs comparable to those at most Canadian hospitals, however, ranging from 9% to 11% of total hospital expenditures (37-38). A subsequent analysis by Woolhandler and colleagues examined 1994 Medicare data in 6,227 nonfederal hospitals and 5,201 acute care hospitals in the U.S. (36). The proportion of total hospital costs consumed by administration in 1994 was 26%, up from 25% in fiscal year 1990.

5.1.3 Costs of Physicians' Services

From 1971 to 1985, the share of the GDP spent on physicians' services increased by over 40% in the U.S. and by 10% in Canada (1). This difference has been primarily attributed to the faster increase in U.S. physicians' fees (2, 39-40). Studies have generally concluded that, after adjusting for differences in case mix of specialties, physicians' incomes are higher in the U.S. than in Canada (2, 41-44). In 1985, for example, net income per office-based physician was $112,199 in the U.S. but only $73,607 in Canada (41-42).

A study by Fuchs and Hahn concluded that, in 1985, the higher expenditures related physicians' services were almost entirely explained by higher physicians' fees in the U.S. (2). Fees were higher in the U.S. for procedure-oriented services (U.S./Canada ratio: 3.34), for evaluation and management services (ratio: 1.82), and for all physician services combined (ratio: 2.39). The higher fees charged by U.S. physicians were primarily attributable to the fact that, compared to Canada, the U.S. health care sector uses a larger quantity of resources to produce a given quantity of physician services (ratio: 1.84). An update of these ratios using 1987 data indicated that the U.S. sector continued to employ even more resources to produce a given quantity of physicians' services (ratio: 1.98).

5.1.4 Costs of Hospital Services

Early reports have observed that most of the increase in hospital expenditures in Canada and the U.S. are accounted for by increases in the use of real inputs per patient-day (45-46). In comparing 1981 and 1985 hospital wages in the two countries, for example, it was found that U.S. wages were about 90% of Canadian wages (3). Because hospital expenditures were higher in the U.S., it was hypothesized that real inputs differed in the Canadian and U.S. hospital sectors. A subsequent study validated this hypothesis by comparing the increase in real inputs between the Ontario and the U.S. hospital sectors (47). Between 1968 and 1981, real inputs per patient-day grew at an average annual rate of <1% in Ontario compared with an average annual rate of 5% in the U.S. It was also estimated that the increase in real inputs accounted for 14% of the increase in costs per patient-day in Ontario, as compared with 81% in the U.S.

A similar analysis compared 1985 data on hospital expenditures and staffing patterns for all acute care general hospitals in Ontario, British Columbia, New York, and California (48). Wages and benefits alone represented 74% of expenses in the Canadian hospitals and 60% in the U.S. hospitals. The ratio of staff per adjusted day was lower in Canada, mainly because the Canadian hospitals had only one third of non-clinical staff day as compared to the U.S. hospitals. It was concluded that hospital expenses were higher in the U.S. because hospitals employed a larger number of non-clinical staff and

expended a higher proportion of total resources for non-labor inputs, such as capital assets and supplies.

Fuchs and Hahn examined 1985 data on total health care expenditures in Canada and the U.S. (2). Admission rates and numbers of hospital beds were similar in Canada and the U.S. (136 vs 140 admissions per 1000 and 4.43 vs 4.20 beds per 1000, respectively). There were more physicians per capita in Canada (2.05 vs 1.81 per 1000) and hospital stays were longer among Canadian patients (1,293 vs 994 days per 1000). Interestingly, however, per capita spending related to hospital expenditures was 25% lower in Canada than in the U.S. during the same year ($520 vs $698).

In a subsequent analysis, Redelmeier and Fuchs compared 1987 costs for acute care hospitals in Canada and the U.S. (4). The number of hospital beds per capita was 39% higher in Canadian hospitals than in U.S. hospitals. Canadians were admitted to hospitals more frequently than Americans, and length of hospital stay was longer in Canada than in the U.S. In spite of these differences, U.S. hospitals had 26% higher expenditures per capita and 39% higher expenditures per admission. Even after controlling for the 14% more complex case mix in the U.S. hospitals and for the 4% higher prices of resources in the U.S., inpatient resources per adjusted admission were 24% higher in the U.S.

5.1.5 Controlling the Costs of Hospital Services

The Canadian success in hospital cost containment has been primarily explained by the superior regulatory strategies implemented for this purpose. Studies have generally focused on global budgeting and government regulations as the principal mechanisms of cost control in Canadian hospitals (1, 47). In Canada, individual hospitals negotiate annual global operating budgets with their respective provincial governments. In addition, capital expenditures (new facilities, equipment, major renovations) are funded by various sources (e.g., donations, fundraising campaigns) but require the approval of the same provincial agency, which generally also contributes to the major share of the financing. The process of centralized approval prohibits hospitals from accessing private capital markets and therefore limits their efforts to support expansions

of capacity. The effectiveness of this regulatory mechanism in controlling hospital expansion and the diffusion of medical technology in the Canadian health care sector has been described in several published papers (47, 49-51).

In spite of the success in cost containment, the marked effort in restricting the purchase and use of modern technology in Canadian hospitals has resulted in a decreased availability of modern medical equipment and techniques. For this reason, there is a growing and ubiquitous conflict over the availability of modern technology and the quality of care of the Canadian health care system. One study, for instance, demonstrated that, compared with Germany and the U.S., Canada has slowed the diffusion of organ transplantation, radiation therapy, extracorporeal shock-wave lithotripsy, magnetic resonance imaging, open-heart surgery, and cardiac catheterization (52). Because of the less intensive use of equipment and personnel in Canadian hospitals, specialized procedures are performed in a relatively small number of large hospitals. The centralization of procedure use, the reliance on referral, and the establishment of waiting lists in Canadian hospitals has resulted in a fuller use of capacity, in less idle time for high cost equipment and personnel, and, consequently, in reduced hospital expenditures (4).

A prominent example illustrating differences in the availability and use of modern medical technology between Canada and the U.S. is that of the treatment of AMI, the leading cause of morbidity and mortality in North America. It has been shown that the use of invasive cardiac procedures in the treatment of coronary artery disease is strongly affected by the availability of on-site cardiac catheterization and bypass surgery (53-54). Consequently, several studies have investigated differences in AMI treatment patterns between Canadian and U.S. hospital. The general consensus is that rates of use of invasive cardiac procedures following AMI are significantly lower in Canadian hospitals than in U.S. hospitals.

The Survival and Ventricular Enlargement study examined differences in treatment patterns and outcomes between 658 Canadian patients and 1,573 U.S. patients admitted to hospitals with AMI (30). Compared to U.S. patients, Canadian patients underwent less frequent coronary angiography (35% vs 68%, $p<0.001$), PTCA procedures (8% vs 22%, $p<0.001$), and CABG surgery (5% vs 10%, $p<0.001$). In

another study, Tu et al. compared AMI treatment patterns between 224,258 elderly U.S. Medicare beneficiaries and 9,444 Ontario elderly patients (29). Rates of use were significantly lower in Canada than in the U.S. for coronary angiography (7% vs 35%, $p<0.0001$), PTCA (2% vs 12%, $p<0.0001$), and CABG surgery (1% vs 11%, $p<0.0001$). The Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries (GUSTO) trial examined differences in treatment patterns following thrombolysis for AMI among 23,105 U.S. patients and 17,916 non-U.S. patients, which also included Canadian patients (32, 54). A GUSTO sub-study reported that rates of use were lower in Canada than in the U.S. for coronary angiography (25% vs 72% respectively), PTCA (11% vs 29% respectively) and CABG surgery (3% vs 14% respectively) (34).

In spite of our substantial knowledge of practice variations in the treatment of AMI in Canada and the U.S., little is known about differences in the costs of treatment of AMI between Canadian and U.S. hospitals. It is also unclear if the more common use of invasive cardiac procedures in the U.S accounts for higher in-hospital costs of treatment. It is in this frame of mind that, in this thesis, a case study was undertaken in order to determine 1) if there is a difference in in-hospital costs of treatment of AMI between Canadian and U.S. hospitals, and 2) if the higher rates of invasive cardiac procedures in the U.S. account for higher costs of treatment. Costs of treatment were compared between patients admitted with AMI at 2 Canadian hospitals and patients admitted with AMI at 7 U.S. hospitals. Aggregate resource utilization and costs of treatment data were collected from each hospital's Transition cost accounting information system.

The results of the case study indicate that the use of invasive cardiac procedures was lower among Canadian patients than among U.S. patients for coronary angiography (31% vs 59%) and PTCA procedures (21% vs 42%). In contrast, rates of CABG surgery were similar in the two countries (19% vs 17%). Mean total costs per patient in the Canadian hospitals ($6,181) were 40% of the costs in the U.S. hospitals ($15,631). Differences in direct costs of invasive cardiac procedures accounted for 21% of the difference in total costs while differences in indirect costs accounted for 48% of the difference in total costs. Given the methodological limitations of the case study,

however, it is unclear how accurately the estimated case study costs represent the true costs of treatment in Canada and the U.S.

5.2 Accuracy of Case Study Comparing Costs of AMI Treatment in Canada and the United States

5.2.1 Comparison of Case Study Estimates with Published Data

Few published studies examined in-hospitals costs of treatment of AMI in U.S. hospitals (11, 55-56), but data on AMI treatment costs in Canada have not yet been available. In one study, Paul et al. examined the costs of treating 178 women and 383 men admitted with AMI at a single university-affiliated U.S. hospital (11). It was estimated that median direct costs per patient, excluding physicians' fees, were $13,548 for women and $14,075 for men. In another study, Krumholz et al. examined the costs of treating 2,628 Medicare patients (≥65 years of age) admitted with AMI at 32 Connecticut hospitals (55). Mean costs of treatment, excluding physicians' fees, were estimated to be $14,772. While the case study estimates of Canadian costs cannot be corroborated by previous studies, published data support the study's estimates of the costs in U.S. hospitals.

The case study's cost estimates exclude costs related to physicians' services and therefore underestimate the true total in-hospital costs of treatment of AMI. Based on published data, however, there is little reason to believe that the inclusion of physicians' fees in the analysis will reduce the gap in costs of treatment of AMI between the Canadian and U.S. hospitals. Physicians' fees have been shown to be higher in the U.S. than in Canada (1-2, 39-44) and including these costs in the analysis would have widened the gap in total costs of treatment of AMI between the Canadian and U.S. hospitals.

The results of the case study estimated that indirect costs were 22% of total costs in the Canadian hospitals and 36% in the U.S. hospitals. These estimates are consistent with previous studies examining differences in administration-related hospital expenditures in Canada and the U.S. (25-38). If depreciation and hospital overhead costs are similar at the Canadian and U.S. hospitals participating in the case study, then

differences in administrative costs may explain the 14% difference in the proportion of total costs allocated to indirect expenditures.

5.2.2 Case Study Limitations

Several potential limitations of the case study are worth mentioning. First, only 2 Canadian hospitals and 7 U.S. hospitals participated in this study. These hospitals are not necessarily representative of all Canadian and U.S. hospitals, and, consequently, the cost estimates obtained may be different from the true, national-level costs. In spite of this limitation, the results of the case study are crucial for generating hypotheses for future investigation. Second, although rates of invasive cardiac procedures were lower in the Canada hospitals than in the U.S hospitals, it is possible that the Canadian patients were readmitted to the hospital for cardiac procedures after their initial admission for AMI. If revascularization procedures were performed throughout the 3 to 6 months following the initial admissions for AMI among Canadian patients, then total costs of treatment in the Canadian hospitals should include the costs associated with such readmissions and follow-up procedures. In this case, the case study would have underestimated the costs of treatment of AMI in the Canadian hospitals and therefore overestimated the difference in costs between the hospitals in the two countries.

Third, inter-hospital differences in costs of treatment of AMI may be due to inter-hospital differences in cost accounting practices. Several potential sources of measurement error compromise the accuracy of the estimated differences in costs between Canada and the U.S. The cost accounting choices that are made when estimating the direct and indirect costs of individual products and services may overestimate or underestimate the true difference in costs between the hospitals. Because aggregate data were collected in this study, it is impossible to examine the effects of such differences on the cost estimates. Given the estimated difference in costs of treatment of AMI, however, it is likely that an important difference in costs will remain between Canadian and U.S. hospitals even after controlling for cost accounting differences.

Lastly, the methodology of the case study suggests that the cost estimates obtained may suffer to a certain extent from confounding bias. Two important limitations

of the case study are that aggregate data and not patient-level data were collected from each participating hospital, and that the analysis did not take into account differences in clinical characteristics between the Canadian and U.S. patients. In the absence of patient-level data, especially demographic and clinical data, it was impossible to develop a well-specified regression model to control for the influence of confounding variables, if any, upon the direct and indirect in-hospital costs of treatment. If the U.S. patients in the study were older and sicker than the Canadian patients, then the higher costs of treatment in the U.S. would be justifiable because older and sicker patients incur more costs. In this case, it would be said that the true costs of treatment of AMI in the U.S. hospitals are lower than those estimated in the study, and that confounding overestimated the difference in costs between the two countries. If, on the other hand, it is the Canadian patients that were sicker, then it would be expected that the true costs of treatment of AMI in the Canada hospitals are even lower than those estimated in the study. In this case, confounding would have underestimated the difference in costs between the hospitals in the two countries.

5.2.3 Conclusions of Case Study

The costs of treating patients with AMI in the Canadian hospitals participating in this study were found to be less than half the costs in the U.S. hospitals. The difference in total in-hospital costs between the Canadian and U.S. hospitals was almost equally attributable to differences in direct costs and to differences in indirect costs. Nonetheless, only one-fifth of the difference in total costs was attributable to the higher rates and direct costs of angiography, PTCA, and CABG procedures in the U.S. hospitals. Consequently, the reduction of the use of invasive cardiac procedures in the U.S. hospitals to the Canadian levels may not have a large impact on the reduction of the costs of treatment of AMI. Rather, cost containment in the U.S. hospitals participating in this study should focus on the reduction of the indirect costs associated with patient care.

5.2.4 Future Directions for Health Services Researchers

Given the limitations of the case study, there are several methodological issues to consider when designing future studies to examine in-hospital costs of treatment of AMI in Canada and the U.S. First, the recruitment of a larger number of hospitals, both in Canada and the U.S., will increase the external validity, or generalizability, of the cost estimates. Second, a larger patient sample size will increase the precision of the unit costs under investigation in the study. Third, a longer time frame will capture readmissions for cardiac procedures yielding measurements that more accurately estimate total resource utilization. Fourth, the collection of patient-level clinical data will be useful to construct statistical models that will estimate costs of treatment while controlling for the patients' demographic and clinical characteristics. Estimated differences between Canada and the U.S. will not only reflect differences in resource utilization and unit costs but also differences in co-morbidity and severity of illness. Fifth, the collection of patient-level resource utilization data will allow researchers to develop regression models investigating the influences of different factors upon total costs. Because patients within the same hospital are subject to the same accounting system and will also tend to have similar care, a model may be constructed to examine the effect of hospital of treatment on costs. Sixth, the collection of patient-level cost of treatment data will allow researchers to undertake inferential statistical testing to compare costs of treatment between Canada and the U.S. Lastly, to the extent that the Transition cost accounting information system will be used to compare costs between Canada and the U.S., the investigator will have to undertake a thorough analysis examining the accuracy of the system's cost estimates at individual hospitals.

Several published studies have previously used the Transition cost accounting system to estimate the costs of health care services at individual hospitals. One study, for instance, compared the procedural and recovery costs between two surgical techniques in a single hospital: transcatheter coil occlusion and surgical patent ductus arteriosus closure (57). Other studies examined the costs of caring for patients with suspected coronary artery disease (59) and for injured patients discharged from trauma services (62-63). Several studies have also used the Transition system to identify predictors of in-hospital

costs in patients undergoing percutaneous balloon mitral valvuloplasty (58), abdominal aortic aneurysm repair (60), and percutaneous transluminal coronary revascularization (61). The primary limitation of these studies, however, is that very little information was available in order to assess the accuracy of their measurements. This is unfortunate because several sources of measurement error may compromise the accuracy of their estimated costs. In general, the accuracy of the Transition system's measurements relies primarily on the accuracy of the data extracted from the hospital's feeder systems and on the hospital's specific choices for estimating unit costs of products and services with the Transition software.

5.3 Accuracy of Transition's Measurements

5.3.1 Accuracy of Transition's Feeder System Data

The Transition cost accounting system integrates large volumes of patient-level information in a single database. Raw data are typically transferred into the Transition system from the hospital General Ledger, Payroll, Billing, and Medical Records systems. The General Ledger and Payroll systems provide department-level financial information while the Billing and Medical Records systems provide patient-level resource utilization and clinical information, respectively. In U.S. hospitals, patient-level resource utilization is first recorded at individual patient care departments, subsequently transferred into the Billing System, and finally transferred into the Transition system. In contrast, Canadian hospitals do not maintain billing systems and department-level resource utilization data are directly transferred into Transition's data warehouse.

The assessment of the accuracy of Transition's financial, clinical, and resource utilization information must consider two major sources of measurement error. The first concerns the accuracy of the original data, i.e. the extent to which the data in the feeder systems are recorded precisely and without bias. Because large quantities of data are recorded in different hospital departments on a daily basis, measurement error may occur due to variations inherent to the individuals recording the data. *Inter-observer variation* results from inconsistencies between different individuals recording the data, and *intra-*

observer variations results from inconsistencies by the same observer on different occasions (19). The second source of measurement error concerns the accuracy of Transition's data, i.e. the extent to which the information in Transition's data warehouse accurately estimates the information that was originally recorded in the feeder systems.

The first-level analysis undertaken in this study suggests that the Transition data warehouse is likely to contain information that is as accurate as that recorded in its feeder systems. The examination of documentation auditing of the feeder systems at a U.S. hospital suggests that accuracy of data is not likely to be compromised when information is transferred from one system to another. Further, the survey of Canadian and U.S. hospitals suggests that hospitals typically perform monthly audits to verify the accuracy of the data in their different information systems. Thus, the results of this analysis suggest that Transition data warehouse is likely to contain accurate financial and resource utilization information as long as data verification is performed on a regular basis.

The current standardized use of hospital-based information systems also suggests that Transition's feeder systems are likely to contain data that are both reliable and valid. Financial information is generally recorded and manipulated according to generally accepted accounting principles, taxation laws, and other government regulations. In the U.S., hospitals that operate cost accounting systems are bound by the guidelines set by the federally-administered Medicare program and by the American Hospital Association. In Canada, such hospitals are bound the Management Information System Guidelines, which are national standards that provide an integrated approach to managing financial and statistical data related to the operations of Canadian health care organizations (64).

Similarly, the standardized use of clinical information systems in Canadian and U.S. hospitals suggests that their Medical Records systems are also likely to contain data that are accurate. Using the clinical information recorded in the Medical Records system, hospitals classify patients into distinct diagnosis-related groups (DRGs). This classification is based on the patient's demographic and clinical characteristics and course of treatment in the hospital. The accurate classification of DRGs is important for U.S. hospitals because patient-level reimbursement is based on DRG-specific charges that are negotiated with private and public third-party payers. Similarly, the accurate classification of patients into DRGs is important for Canadian hospitals in the negotiation

of yearly global operating budgets with provincial governments. An increase in the rate of admissions of a resource-intensive DRG, for example, may allow the hospital to see its budget increased in order to defray the additional costs of providing services. In the province of Quebec, however, hospital reimbursement is not based on DRGs. Rather, global budgets are based on adjustments of historical budgets and government regulations such as zero-deficit laws.

5.3.2 Accuracy of Transition's Cost Estimates

The review of the Transition system methodology for estimating costs indicates that several sources of measurement error may occur in the measurement of the direct and indirect costs of products and services. First, the incomplete identification of intermediate products in patient care departments is likely to result in overestimated unit costs of products and services. Second, an incorrect estimation an intermediate product's variable or fixed costs will result in an incorrect estimation of its fixed ands variable costs. Third, the potential for measurement error may arise when financial managers decide allocate indirect costs to direct cost centers based on imperfect cost drivers. Finally, measurement bias may arise if the algorithm chosen to allocate indirect cost pools is not representative of the interaction between centers.

The survey of Canadian and U.S. hospitals using the Transition system indicates that additional sources of bias may occur when Transition system costs estimates are compared between two or more hospitals. First, differences in the classification of direct and indirect cost centers between hospitals may results in differential misclassification of costs. This type of measurement error is most likely to occur if hospitals outsource selected patient care or non-patient care services. Second, the use of industry-wide RVU standards among hospitals will result in differential or non-differential misclassification of costs, depending on whether the hospitals under comparison use the same standards or not. Third, non-differential misclassification may occur if distinct indirect costs are included in one hospital's indirect cost pools but not in another's. Finally, measurement errors may occur when hospitals use different application rates or allocation algorithms to allocate indirect costs to direct cost centers. Although different sources of measurement

error have been identified, it is unclear to what extent each of these potential errors may affect the estimates of the costs under study. Consequently, more elaborate studies must be undertaken in order to measure the effect that each source of error may have on estimates of unit costs of intermediate products as well as on estimates of cost differences between two or more hospitals.

5.3.3 Future Directions for Health Services Researchers

It has been shown that the use of hospital-based information systems is increasingly standardized in Canada and the U.S., and that regular, internal audits of such systems can identify sources of error and therefore increase the accuracy of their data. In spite of these observations, the potential widespread use of the Transition system to measure clinical and resource utilization information relies primarily on the outcomes of more quantitative analyses. Health services researchers interested in using the Transition data warehouse to measure patient-level resource utilization and clinical data are encouraged to undertake validation studies examining the accuracy of the feeder system data at individual hospitals. Audit documentation may or may not be sufficient to assess the accuracy of the information in each of Transition's feeder systems. It should be noted, however, that the different types of data in Transition's data warehouse will only be as accurate as the information recorded in their respective feeder systems. Errors in the recording of clinical diagnoses, for example, will be transferred from the Medical Records system into the Transition system, unless they are identified and rectified before the transfer of information takes place.

As for errors compromising the measurement of costs, more extensive studies must be undertaken in order to assess their individual effects on the Transition system's cost estimates. First, there is a need to examine the effects of using industry-wide RVUs to allocate direct and indirect costs to intermediate products as compared to the RVUs measured by individual department managers. Second, researchers must measure the magnitude of measurement error due to the misclassification of fixed and variable department-level expenditures. Finally, the effects of different allocation algorithms and

cost bases for allocating indirect costs must be investigated so as to minimize errors in estimating the indirect costs of intermediate products.

5.4 Conclusions

Recent technological innovations and the increasing complexity of medical care in the Canadian and U.S. health care sectors have emphasized the need for a cost-effective approach to the care of patients admitted to health care institutions. Popular interest in comparing the Canadian and U.S. health care systems has incited researchers to compare the provision of health care services in Canadian and U.S health care organizations. This is especially true for Canadian and U.S. hospitals which devour one-third of total health care expenditures, a proportion that is much bigger than the total costs of physicians' services. Nonetheless, the complexity in measuring medical resource utilization and costs of treatment in health care organizations has resulted in only few studies examining differences in the costs of treating specific diseases or providing specific services in Canadian and U.S. hospitals.

The Transition cost accounting system integrates clinical, resource utilization, and financial information and is currently being used by several hospitals in Canada and the U.S. to calculate the costs of products and services used in patient care. The potential use of the Transition system for estimating in-hospital costs of products and services, however, depends on the accuracy of its measurements. The understanding of the Transition system methodology is the first step to reducing measurement error when using this system to estimate costs of treatment. The distinction between variable, fixed, direct, and indirect costs is crucial in order to analyze costs at the procedure level. It is also critical to consider the effects of inter-hospital variations in cost accounting practices on the estimates of costs. The identification of department-level intermediate products and the allocation of indirect costs are among the issues to consider. In future research, the study methodology employed to measure costs must be designed so that precision in measurement is maximized and bias is minimized when estimating unit costs and comparing costs of treatment between hospitals.

In order to illustrate the use of the Transition system in health services research, this thesis presented a case study comparing in-hospital costs of treatment of AMI between 2 Canadian hospitals and 7 U.S. hospitals. This investigation is timely as AMI is the leading cause of morbidity and mortality in North America. Undoubtedly, the costs of treating millions of Canadians and Americans for AMI imposes an important burden on their respective health care systems. Although several studies have investigated differences in treatment patterns and outcomes between AMI patients in Canada and the U.S., little is known about differences in costs of treatment of AMI between Canadian and U.S. hospitals. The results of the case study suggest that the cost of treating a patient with AMI in the Canadian hospitals is less than half the cost in the U.S. hospitals, and that cost containment in these U.S. hospitals should focus on the reduction of indirect costs related to patient care.

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