Minding our Ps and Qs: Using administrative data to measure hospital expenditure in constant dollars

Discussion Paper

Ronald Wall, MASc, PEng, MBA, PhD

Executive summary

The measurement of the health expenditure series in real dollars provides important information used by decision-makers to monitor changes in the production of health services output. Over the past few years, the Canadian Institute for Health Information (CIHI) has examined the feasibility of using the National Health Expenditure Database (NHEX) to develop indexes to report real spending on health care. These feasibility studies investigated price indexes used in national health expenditures (ref) and developed an output price index for hospital inpatient acute care (ref). The review of the output price index work concluded that the organization and financing of hospital production in Canada and the characteristics of national clinical and accounting administrative data argued for developing an output volume index.

This report provides the foundation for future work to implement an output index using administrative data available to NHEX. In particular, the report discusses how the reporting of clinical and financial data affects

- how hospital acute care output can be measured (inpatient acute care and day surgery),
- how the price of output is estimated (shadow price imputed as expected average total cost),
- how the volume of output is measured (count of inpatient discharges by categories defined by the prevailing case-mix grouping methodology),
- the analytical perspective of measurement (changes in volume versus price),
- the analytical formula used to calculate the index (price versus volume fixed-weights), and
- the set of outputs included in the measurement basket.

The specification of the output basket is determined by decisions defining the universe in which measurement occurs, such as:

- the jurisdictions included, the hospitals included in each jurisdiction, the outputs included for these hospitals, as well as,
- the set of outputs monitored after omitting categories containing low counts of discharges.

Measurement is further complicated by changes in case mix methodology used to group discharged inpatients into output categories and the calibration of the resource intensity weights used to impute shadow prices.

Finally, if the calculation of an output index time series were to be undertaken, substantial additional issues will first need to be analyzed and addressed.
Introduction

This paper builds on work from previous studies to develop indexes for the National Health Expenditure Database (NHEX) to enhance measurement of health services expenditure in constant (real) dollars.

The first paper, *Price indexes used in national health expenditure* (CIHI 2001), reviewed the indexes available to NHEX by category of expenditure. The NHEX Expert Group endorsed the recommendation to study the feasibility of developing an output price index to measure hospital production in real dollars.

The second paper, *CIHI Hospital Price Index Feasibility Study* (CIHI 2003), developed an output Passche Price Index (PPI). The PPI was developed to use the comprehensive input (cost) and output (inpatient discharges) data compiled by CIHI to measure hospital inpatient acute care production in real dollars.

The *Review of the CIHI Hospital Price Index Feasibility Study* (CIHI 2004a) refined the preliminary work of the *Feasibility Study* by addressing four questions:
1. Which component of the hospital expenditure series – price or quantity – should an output index account for to measure production in real dollars?
2. Is the output PPI consistent with macroeconomic approaches for decomposing aggregate expenditure into changes in price and quantity?
3. If so, are the administrative data available from CIHI suitable for estimating changes in prices and quantities over the duration expenditure series?
4. If not, which of the alternative formulations of the output index could better measure real hospital expenditure in NHEX?

The review concluded that the economics of health care and the practice of measurement using administrative data available from CIHI argue for developing an output Laspeyres Volume Index (LVI) to measure hospital production in real dollars. The NHEX Expert Group endorsed the concept and methodology of the LVI.

This paper discusses the development of the hospital output index in terms of information needs, the economics of hospital production, and the practice of measurement using administrative data available to CIHI. Questions for future analytical work are presented to indicate what next steps would be required to guide the application of the LVI to CIHI’s clinical and financial administrative data.

Until fiscal year 2006-2007 when hospital discharge data is anticipated to be reported using the redeveloped case mix/RIW methodology, consider
- using the current methodology to report the NHEX hospital expenditure series in real (1997) dollars,
- future empirical work to advance the output index development by using clinical and financial administrative data for Ontario for the fiscal years 1997-1998 to 2000-2001 (and 1997-1998 to 2000-2001 data for national analysis) to address the questions posed above about the specification of the output volume index,

– and –
• the development of a CIHI hospital input index to deflate the historic cost series for changes in the prices of inputs.

Expenditure as a measure of aggregate health services output

What is health expenditure?

Health expenditure (spending) is the economic value of transactions made to purchase health services to directly improve or prevent the deterioration of health status. The National Health Expenditure database (NHEX) provides information on health expenditure in terms of category of spending and source responsible for payment — for example, total expenditure on hospital services is the sum of spending by all public and private payers.

NHEX annual estimates of current (nominal) dollar expenditure are prepared from data extracted manually from diverse public documents, including national and provincial/territorial public accounts and other financial reports. Other sources of data include private insurance companies, AC Nielsen, and Statistics Canada. To facilitate comparison across the provinces/territories (jurisdictions) and over time, the National Health Expenditure series of reports also measures total expenditure in constant (real) 1997 dollars.

What does expenditure measure?

Expenditure, a single number that summarizes diverse health services output using the dollar metric (volume weighted for price), has little utility in itself. Rather, meaning is derived from the perspective of analysis (payers versus providers), comparison against benchmarks (changes over time), and distinguishing between changes in price and volume. Trends in nominal expenditure reflect changes in the volume of outputs produced and/or the prices paid for these outputs.

Two sets of identities account for the flow of funds within the health-care system (see Evans 1984, 2001):

\[
\begin{align*}
\text{\textbf{\equiv}} & \text{ total spending on the outputs of health services production} \\
\text{\textbf{\equiv}} & \text{ total income from the outputs of health services production} \\
\end{align*}
\]

\[
\begin{align*}
\equiv & \text{ total spending on the inputs of health services production} \\
\equiv & \text{ total income from the inputs of health services production.}
\end{align*}
\]
The first set of identities is the output expenditure relationship that is reported in NHEX: the cost of health services to public/private payers of financing health services is equal to the income (or revenue) to hospitals and other producers of outputs.

The second set of identities is the input expenditure relationship that is reported in cost databases: total spending on inputs by the producers of health services is equal to the income to the suppliers of labour, supplies, capital, and other inputs. The Canadian Management Information System (MIS) Database (CMDB) reports on the input expenditure relationship between hospital spending and the incomes of nurses/other suppliers of resources used in health services production. These data are reported by acute MIS hospitals to CIHI, where they are compiled into the national CMDB.

These two sets of identities are not equal when the financing of output by payers does not cover the cost of health services production: that is, producers report deficits or surpluses. NHEX adjusts output expenditure for hospital deficits for these imbalances only when the provincial government assumes them. The adjustment is made to the year that the deficit or surplus was reported.

These two sets of identities suggest complementary approaches for measuring output expenditure in real dollars:

• Spending by public/private payers on health services provides a comprehensive measure of the real output of the entire health care system or the categories reported in NHEX (e.g., hospitals).
• In contrast, spending on the inputs of health services production provides an approach for measuring the real outputs of health services production that is not measured by NHEX (e.g., hospital inpatient acute care).

What does expenditure in real dollars measure?

Measurement of expenditure in constant dollars provides an estimate of the real output that was produced. Comparison of real expenditure across jurisdictions and/or over time attempts to measure changes in the aggregate volume of the health services that were produced: does greater spending produce more health services?

How can expenditure be measured in real dollars?

In NHEX, real expenditure on health service production is measured in 1997 dollars by deflating nominal spending reported by:

• public sector payers using the GDP Implicit Price Index (IPI) for government current expenditure and
• private sector payers using the health component of the Consumer Price Index (CPI).

CIHI (2001) discussed the limitations of these two indexes to deflate health services spending.

The increasing availability of national health administrative data in OECD nations has fostered interest in developing output approaches that are specifically designed to measure health services production (Brathaug 2003, CIHI 2001). A study on the
feasibility of developing a hospital output index (CIHI 2003) and its review (CIHI 2004a) are evidence of CIHI’s efforts to advance the measurement of Canadian hospital production. The availability of comprehensive clinical and financial data has focused CIHI’s work on developing output indexes for hospital inpatient acute care production.

The output price approach recommended by CIHI (2003) deflates the nominal cost of inpatient acute care production for changes in the price of output. Output is measured using a representative basket of discharged inpatients grouped into clinically meaningful categories. Both the basket items and their quantities are held constant over the period of analysis – typically four or five years. The shadow prices of outputs are imputed as the average total cost per discharged inpatient by output category. Although conceptually superior to the current NHEX method for measuring hospital production, the output price approach is restricted by the meaning of price in the context of the financing and organization of Canadian health care delivery and limited by the administrative data available to estimate average total cost (CIHI 2004a). Day surgery, a large and growing component of hospital production, was also excluded.

In contrast, the output volume approach extrapolates the base year cost of hospital inpatient acute care production over time by adjusting for changes in the quantity of output (CIHI 2004a). As above, output is measured using representative basket of discharged inpatients grouped into clinically meaningful categories. Also, the shadow prices of these outputs are imputed as the average total cost per discharged case. In contrast to the output price methodology, however, the basket items and their shadow prices are held constant over the period of analysis. As clinical administrative systems report comprehensive data on the quantities of outputs produced by hospitals the output volume index offers theoretical and measurement advantages compared to the price index approach. These advantages are discussed in detail in following sections.

The input approach provides an alternative to the above output methods for measuring hospital production in real dollars. The input approach assumes that an increase in the real aggregate input used translates into a corresponding change in the real aggregate output produced. In not accounting for changes in productivity and/or in the mix of resources used, however, measurement may understate the increase in the real output produced. Although not used in NHEX reports, Canadian researchers have applied input methods to analyze hospital cost series (e.g., see Auer and Weser 1993, Barer and Evans 1983, 1986).

**Beyond real dollar expenditure: measuring changes in productivity.**

The difference between real dollar expenditure measured by output and input approaches is an estimate of the productivity of health services production: *is more (aggregate) output being produced for the (aggregate) input used?*

An increase of productivity, measured as the ratio of output to input, should not be confused with a corresponding improvement of hospital performance. A more productive hospital (lower cost per treated case) is not necessarily more effective or efficient. Measurement of performance requires information about the outcome achieved for the input used and the appropriateness of the health conditions that are managed in this setting.
Output indexes for measuring expenditure in real dollars

In Figure 1, the value of health services output is the sum of the expenditure on the individual items produced (consumed). In turn, the value of each item is the respective multiplicative product of the price paid times the volume consumed.

Index numbers are used to decompose the ratio of the value of a well-defined set of transactions between two periods of time into changes in price (price output index) or changes in quantity (volume output index) (Brathaug 2003; Diewert 1987). In holding one factor constant, say the price paid for a basket of output, the effect of change in quantity on expenditure can be quantified. Hence, the value index identity is the multiplicative product of the price index time the volume index (see Figure 1). The value identity denotes two approaches for reporting expenditure in real dollars: deflate current year (nominal) value for change in price since the base year or extrapolate base year value for change in volume for the current year.

Table 1 displays the alternative formulations of the fixed-weight output index that can be used to measure health services production in constant dollars. These approaches differ in how they measure

- what changes, price versus volume: Paasche and Laspeyres Price Indexes and Paasche and Laspeyres Volume Indexes; and
- what is held constant, volume versus price: base year volume or base year price Laspeyres indexes and future year price or future year volume Paasche indexes.

<table>
<thead>
<tr>
<th>Value</th>
<th>Paasche (future year weights)</th>
<th>Laspeyres (base year weights)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sum (p_{1,i} \cdot q_{1,i}) )</td>
<td>( \sum (p_{1,i} \cdot q_{1,i}) )</td>
<td>( \sum (p_{1,i} \cdot q_{0,i}) )</td>
</tr>
<tr>
<td>( \sum (p_{0,i} \cdot q_{0,i}) )</td>
<td>( \sum (p_{0,i} \cdot q_{0,i}) )</td>
<td>( \sum (p_{0,i} \cdot q_{0,i}) )</td>
</tr>
<tr>
<td>Volume (q) (price weights)</td>
<td>( \sum (p_{1,i} \cdot q_{1,i}) )</td>
<td>( \sum (p_{0,i} \cdot q_{0,i}) )</td>
</tr>
<tr>
<td>Price (p) (volume weights)</td>
<td>( \sum (p_{1,i} \cdot q_{1,i}) )</td>
<td>( \sum (p_{0,i} \cdot q_{0,i}) )</td>
</tr>
</tbody>
</table>
Calculation using output indexes requires a frame for measuring change in hospital production (a representative basket of output items) and a data series reporting the prices (p) paid or the quantities (q) produced for these items at two time periods (base year versus future year, respectively, t = 0 and t = 1). These formulas differ in terms of analytical focus (i.e., change in price versus change in volume of output) and the fixed-weights used to calculate change in price or quantity (i.e., future year versus base-year). The following sections discuss the development of output indexes for use with clinical and financial administrative data that measure the production of hospital output.

**Hospital inpatient acute care production**

Figure 2 displays the use of hospital inputs to produce inpatient acute care outputs and outcomes. Data sources that can be used to estimate the relationships between these stages are also noted in Figure 2. As the administrative data available to measure inpatient outcomes is further developed, measurement of spending will focuses on hospital production output.

**Figure 2: CIHI data measuring the use of hospital resources to produce patient outputs & outcomes:**

<table>
<thead>
<tr>
<th>Inputs (CMDB)</th>
<th>Outputs (DAD)</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct/indirect cost of support, service, &amp; care resource used by hospitals to treat inpatients</td>
<td>Discharged inpatients’ episodes of care by hospital</td>
<td>Change in:</td>
</tr>
<tr>
<td>Hospital resources: + time &amp; supplies. + equipment depreciation + share of overhead support</td>
<td>Inpatient discharges are grouped into homogenous categories of output on the basis of their clinical characteristics: case-mix, case-complexity, age-group + resource use: length-of-stay</td>
<td>Proxy measures:</td>
</tr>
<tr>
<td>CIHI data sources: + The Canadian MIS Database (CMDB) reports hospitals’ financial data. + The Discharge Abstract Database (DAD) reports inpatients’ clinical data.</td>
<td></td>
<td>+ readmissions + adverse events + rates of death + good clinical practice + patient satisfaction</td>
</tr>
</tbody>
</table>

**Measuring the output of hospital inpatient acute care production:**

Case mix methodology provides a frame for measuring hospital output. Acute care inpatients sharing similar clinical and resource utilization characteristics are grouped into homogenous categories using CIHI’s Case Mix Group and Complexity Overlay grouping methodology:
1. International Classification of Disease (ICD) diagnosis codes broadly categorize inpatients into Major Clinical Categories (MCCs). This is based on the diagnosis determined to have been responsible for the greatest portion of the inpatient's length of stay, the Most Responsible Diagnosis (MRDx).
2. The MCCs are divided into two partitions distinguishing between medical and surgical case mix groups (CMG). Inpatients that had a procedure performed are assigned to the surgical partition, while those without a procedure are assigned to the medical partition.
   a. For cases assigned to the medical partition of a MCC, a list of diagnosis codes (grouped according to similarities in length of stay and resource requirements) is used to assign the CMG.
   b. For cases assigned to the surgical partition of a MCC, a hierarchical list of procedure codes is used to assign the CMG.
3. Assignment of case complexity (Plx) further refines classification to reflect additional diagnoses that influence an inpatient's overall use of resources. These co-morbid conditions may be present either at time of admission, or may arise during the hospital stay. Cases are assigned to one of four Plx Levels. Level 1 denotes the absence of co-morbid conditions, while Level 4 denotes the presence of co-morbid conditions that may be potentially life threatening.
4. Finally, Plx with an age adjustment improve the estimate of the resources required to treat certain classes of inpatients, specifically the very young, the elderly and the medically complex.
5. CIHI's grouping methodology yields an output measurement frame consisting of 4746 categories accounting for case mix, case complexity, and age adjustment (APlx categories: case-mix with case complexity overlay and age adjustment). For each fiscal year of an output series, discharged acute inpatients are grouped into these categories either using the year-specific grouping methodology or regrouped using one single grouping methodology applied across the output series.

**Counting the volume of hospital inpatient acute care output:**

The quantity of acute care production is estimated as the count of inpatients discharged during the fiscal year (April to March). The Discharge Abstract Database (DAD) is the national repository of demographic, administrative, and clinical data on hospital discharges across Canada. CIHI generally receives these data directly from participating facilities, including acute hospitals except for the Province of Quebec and Manitoba outside of the Winnipeg and Region Health Authority.

The count of inpatients for the $i^{th}$ APlx category, $q_{t,i}$, is sensitive to the grouping methodology used to assign cases to the APlx measurement frame (year-specific or regrouped) and the clinical population of inpatients analyzed: typical discharges or total (= typical and atypical) discharges.

**Imputing the shadow price of hospital output:**

Although output indexes are concerned with changes in the price paid for hospital output, the economics of hospital production in Canada requires the focus of measurement to shift from price to shadow price. Shadow price is the price that otherwise would have been paid for these output items in a competitive market and it is imputed as the average total cost of the inputs used to produce these items.
Cost includes operating expenses (labour, consumable supplies) and the use of equipment (estimated as depreciation) used in hospital activities. Total cost is the sum of the direct cost of therapeutic/diagnostic services provided to acute care inpatients plus a share of the indirect cost of hospital activities that support patient care (e.g., housekeeping, administration).

The average total cost of the output of these APIx categories can be estimated as
- **actual** average cost calculated as the arithmetic mean (or other estimate of central tendency) of the cost of the inpatients assigned to each APIx category or
- **expected** average cost imputed as the proportion of overall acute care cost that the inpatients grouped to each APIx category are expected to generate.

With the exception of selected hospitals in Ontario, Alberta, and British Columbia (ref CIHI RIW web), total cost is not reported for individual acute care inpatients. Rather, hospitals report financial and statistical data to CMDB by direct care functional area: acute inpatient care, ambulatory care, extended care (ref link to CMDB web). The accounting structure, including the methods used to allocate indirect costs to direct patient care functional areas, is defined by the *Guidelines for Management Information Systems in Canadian Health Care Facilities*. The RIW provides a mechanism for distributing hospital total inpatient cost (TIP) across the acute care output categories. The expected average total cost of the $i^{th}$ APIx category is the ratio of imputed total cost to the sum of discharged inpatients.

Note: economic and accounting definitions of cost differ. Accounting and economic estimates of cost are equivalent for inputs purchased in competitive markets where the price paid reflects the opportunity cost of producing these goods and services; however, accounting cost does not assign value to non–market inputs (e.g., volunteered time, donated space; see Kaplan 1998). Also, the opportunity cost of equipment is underestimated by accounting depreciation (see Richardson and Gafni 1980).

**Calculating expected average total cost of output by the category of hospital production:**

The expected average total cost of each category of hospital output is estimated using the Resource Intensity Weight (RIW). Upon discharge from hospital, acute care inpatients are assigned an RIW value based on the APIx category into which they are grouped. For the $i^{th}$ APIx grouping of inpatients, the RIW ($r_{i}$) estimates each group’s expected average use of hospital resources relative to the average inpatient contained in the DAD (ref link to RIW web).

For the $t^{th}$ fiscal year, the expected total cost of the output of the $i^{th}$ APIx category (TIP$_{i}$) is calculated as the multiplicative product of total inpatient cost (TIP$_{t}$) times the ratio of the weighted cases of the $i^{th}$ APIx (WQ$_{t,i}$) to the sum of all weighted cases produced (WQ$_{t}$),

$$TIP_{i,t} = TIP_{t} \times \frac{(WQ_{t,i})}{WQ_{t}}$$

where

$$WQ_{t,i} = r_{i} \times q_{i}$$

and

$$WQ_{t} = \sum (r_{i} \times q_{i})$$

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Note: although the above formula could have been stated as the sum of RIW values – respectively, $\sum r_{t,i}$ for the $i^{th}$ APlx output and $\sum r_{t,i}$ for hospital output – using weighted cases distinguishes between the RIW as a measure of the expected resource utilization of each APlx category and the quantity of output produced.

The expected average total cost of the output of the $i^{th}$ APlx category ($p_{t,i}$) is calculated as the quotient of $TIP_{t,i}$ divided by the corresponding sum of inpatient output discharged during this period,

$$p_{t,i} = \frac{TIP_{t,i}}{q_{t,i}},$$

$$= r_{t,i} \times \frac{TIP_{t}}{WQ_{t}},$$

$$= r_{t,i} \times CPWC_{t},$$

where $CPWC_{t} = TIP_{t} / WQ_{t}$.

Cost per weighted case (CPWC; see CIHI 2004b), the overarching price of aggregate hospital output, provides an alternative starting point to calculating shadow price that was used to estimate the price output index (CIHI 2003).

**Beyond output, what is the outcome of hospital production?**

The outcome of hospital inpatient acute care can include changes in health status, satisfaction with care received, and the quality of care provided. While progress is being made in measuring these outcomes, such data are not yet routinely reported to CIHI. Methods for outcome measurement have been developed for specific diseases (see Triplett 1999).

**Measurement issues:**

The dissemination of new goods and services into the economy typically leads their measurement in statistical information systems (Wolfson 1999). For goods and services characterized by significant increasing returns to scale, failure to measure their rapid decrease in prices may bias measurement of real economic production.

For health services production, technological change has the potential to affect the shadow price (i.e., average total cost) and/or the characteristics of output

- within settings (e.g., the transition from surgical to medical treatment of peptic ulcer) and
- between settings (e.g., the shift from inpatient to outpatient cataract surgery).

In respond to changes in hospital output from the incidence of new diseases (e.g., AIDS) or how clinical conditions are managed (e.g., new health care technologies), CIHI periodically revises its disease/intervention classification systems. The switch from the ICD-9/CM/CCP to the ICD-10/CA/CCI marked a major change in how acute care inpatients are coded and classified into case mix groups. Hence, the basket of output items should be periodically updated to account for these changes to the measurement frame (i.e., APlx categories).

As not all cases are equal in terms of their need for (and utilization of) hospital resources, cases weighted for their respective RIW provides a common metric for
aggregating output items across the APlix measurement frame. As a proxy measure of expected average total cost, however, estimation is sensitive to how RIWs are calibrated. As valid and accurate relative weights, the RIW can be used to estimate price weights for an output volume index; however, for calculating an output price index, these relative weights also must hold over time.

Finally, while the count of inpatient discharges (or weighted cases) is a widely used measure of hospital acute care output, it is only a proxy for the production of a complete episode of patient care. The composition of the acute care inpatient population may change over time and across jurisdictions with differences in the rate of readmission (and discharge), the use of ambulatory care to facilitate earlier inpatient discharge, and the substitution of day for inpatient surgery may bias the estimation (and interpretation) of output volume indexes. Moreover, along with the aging of the Canadian population and technological advances, the nature of inpatient acute care, itself, is transforming from a setting to manage complete episodes of acute conditions to one component of the continuum of care where the acute phases of chronic conditions are managed.

Using administrative data to measure hospital production

This section discusses issues that may affect real dollar measurement using output indexes applied to administrative data available from CIHI. While most jurisdictions report clinical and financial/statistical data to CIHI (and all are expected to for fiscal 2005-06), the duration of these data series vary due to differences in their start date, changes in grouping/RIW methodology, and other factors that limit their usefulness for analysis. Table 2 notes restrictions on the use of data series that derive from changes made to the measurement of clinical/cost data, RIW calibration, and inpatient disease/intervention classification systems.

<table>
<thead>
<tr>
<th>Table 2: availability of CIHI clinical data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>Provinces reporting acute inpatient data to the DAD:</strong></td>
</tr>
<tr>
<td>– All provinces with the exception of MB outside WRHA and PQ, 1998+ .</td>
</tr>
<tr>
<td>• <strong>Inpatient disease classification system:</strong></td>
</tr>
<tr>
<td>– ICD-9, 1973 to 2001-03 (revised periodically; trend analysis using regrouped data recommended)</td>
</tr>
<tr>
<td>– ICD-10/CA/CCI, 2001-05 [no national data for trend analysis; analysis possible for provinces remaining ICD-9 – e.g., Ontario].</td>
</tr>
<tr>
<td>• <strong>Inpatient grouper methodology:</strong></td>
</tr>
<tr>
<td>– CMG (Canadian version of DRG), 1985.</td>
</tr>
<tr>
<td>– CMG (Canadian redevelopment), 1990.</td>
</tr>
<tr>
<td>– APlix (CMG, Plx, age-group), 1997.</td>
</tr>
<tr>
<td>– Grouper redevelopment expected for 2006.</td>
</tr>
<tr>
<td>• <strong>Sources of case costing data used for RIW calibration:</strong></td>
</tr>
<tr>
<td>– Maryland charge data only, 1997.</td>
</tr>
<tr>
<td>– Maryland charge/CA cost data, 1998 (ON) and 1999 (ON and AB).</td>
</tr>
<tr>
<td>– CA cost data, 2000+ (ON &amp; AB), 2002+ (ON, AB, and BC).</td>
</tr>
</tbody>
</table>
Table 2 (cont): availability of hospital cost data.

- **Financial/statistical data:**
- **Cost per weighted case (CPWC) estimates:**
  - 1999 and 2000 values have been published.
  - (2001 values were not released).
  - 2002 values expected to be published in 2005.

The universe of acute hospitals:

The output Price Index was developed for the acute institutions that report to the DAD (multi-product general hospitals) and include:

- all acute inpatients discharged from medicine, surgery, paediatrics, psychiatry, obstetrics, and newborn inpatient services plus
- inpatients discharged from alternative level of care inpatient service, but
- exclude extended (chronic) care inpatients.

The criterion of joint reporting to the DAD and to the CMDB defines the set of hospitals and, thereby, the quantities and shadow prices of the outputs, that can be used to measure acute care production. For fiscal year 2005-2006, it is anticipated that all general hospitals in Canada will report clinical and accounting data to CIHI. Where the joint reporting criterion is not met, however, measurement should ensure that only data from jurisdictions (or individual hospitals, as in Manitoba) that jointly report for the full duration of the output series are used (inpatient cost and discharges).

CPWC is calculated by jurisdiction for all hospitals and for the trimmed subset that excludes hospitals with outlier CPWCs. If the trimmed CPWC is used to estimate shadow prices, then measurement should be restricted to data reported for the trimmed set of hospitals.

The universe of patients:

General hospitals produce multiple outputs:

- acute care inpatients (included) and
- extended care inpatients (excluded), but also
- outpatients treated in ambulatory settings (day surgery, medical clinics).

A key concern for an index measuring general hospital output is the shift of acute care from inpatient to ambulatory settings – for example, from inpatient to day surgery. For total surgical output defined as the sum of inpatient surgery plus day surgery, the shift from inpatient to day surgery reduces the cost of hospital production (for equal or better effectiveness); however, the average cost of inpatient acute care increases if the remaining surgical cases require more complicated surgery and/or are at greater risk of adverse events. Restricting the output basket to inpatient acute care may bias the measurement of real hospital acute care production.
The universe of acute inpatients:

Acute inpatients are grouped into one of the 4,746 APIx categories on the basis of
- case mix, which accounts for the diagnosis most responsible for length-of-stay during
  the inpatient episode of care (478 CMGs),
- case complexity overlay, which accounts for the presence of co-morbid diagnoses (4
  levels of Plx were used), and
- age-group adjustment (3 categories: paediatric, adult, older adult), which account for
  age related needed for resources (e.g., assistance with ambulation).
Overall, APIx categories are homogenous groupings of inpatients in terms of their clinical
and resource utilization characteristics.

Acute inpatients are recorded in DAD when they are discharged from hospital through
separation or death. The universe of inpatients consists of typical and atypical cases.
Atypical cases are defined as discharges due to death or separations occurring as
transfer to another hospital, sign-out, or long stay. Compared to typical discharges, the
RIW is calculated on a case-by-case basis (ref link to CIHI RIW web).

The validity of the set of discharged cases to approximate the universe of inpatients is
sensitive to changes in the characteristics of the cases admitted prior to the fiscal year
compared to those discharged in the following year. In excluding atypical case, the
output Price Index (CIHI 2003) assumed a stable relationship across the output series
between typical and atypical cases (see CIHI 2004).

The frame for measuring hospital production output:

For counting output (discharged cases, RIW-weighted cases), however, how inpatients
are grouped into the basket of APIx cells varies with changes to the case-mix grouper
methodology (e.g., new codes to account for evolving technology). The counting of
cases by APIx category is affected by several factors (see Table 2):
- The data series started in fiscal year 1997-98 with the implementation of the
  complexity overlay (Plx) and age adjustment.
- The replacement of the ICD-9/CM classification system with ICD-10/CA starting in
  fiscal year 2001-2002 limits the comparability of data trending after this period. The
  incomplete implementation of the new ICD-10 system across Canada has impaired
  comparability across the provinces and the trending of national data after fiscal year
- The redevelopment case grouping methodology (using ICD-10-CA/CCI) scheduled
  for implementation in all provinces starting fiscal year 2006-07 will create a new data
  series that is not comparable to earlier outputs on a year-to-year basis; however,
  regrouping the series using CMG/Plx2006 will develop a series back over time to the
  point where each province respectively adopted the ICD-10 classification (to fiscal
  year 2001-02 for Newfoundland, Prince Edward Island, Nova Scotia, British
  Columbia, Yukon Territory, and about 50% of Saskatchewan hospitals).
- Up coding of inpatient classification (especially Plx), especially in Ontario, may distort
  clinical data time series.

The case mix grouping methodology used to group inpatients to APIx cells is updated
periodically. This changes how acute typical and atypical inpatients are assigned to
APIx cells, with implications for the calibration of RIWs and the comparability of case
assignment over time. CIHI recommends performing trend analysis using data that has been retrospectively regrouped using the most recent grouper/RIW applied back over the series.

Finally, whereas RIWs, by definition, are valid weights for predicting relative need for hospital resources (expected utilization) across categories of inpatients, they should not be used to make comparisons over time (see CIHI 2004a, 2004b). This has obvious implications for using a price index to deflate the hospital inpatient acute care cost series for changes in shadow prices over time. For a specific fiscal year, however, RIWs are an appropriate approach for allocating resources (or funding) to inpatients grouped into homogenous (APIx) categories defined by demographic/clinical characteristics: CMG, Plx complexity overlay, and broad age-groups. As such, this approach ensures the fair allocation of resources (funding) across inpatient groupings in terms of the above attributes defining relative (comparative) need. The derived average total costs for these categories will approximate the actual cost of the hospital resources consumed by these inpatients.

Although RIWs have been recalibrated annually, the case-costing data, which is the basis of calibrating RIWs, is not derived from the fiscal year in question. Rather, the data set is derived from a mixture of prior time periods/ hospitals that changes annually as new years of data are added and older years of data are deleted. Moreover, the RIW calibration process, itself, evolves over time; indeed, CIHI is currently redeveloping the case mix/RIW methodology.

**Data available to measure hospital production using output indexes:**

Inspection of Table 2 finds that the duration of the shadow price and discharge data that can be applied to output indexes is limited for both Ontario and national series.

For discharge data:

- Ontario over the period of fiscal year 1997-1998 (introduction of Plx overlay with age adjustment) to fiscal year 2001-2002 (implementation of ICD-10/CA/CCI).
- National data is available for British Columbia, Alberta, some Saskatchewan hospital since 1997-98 while the series including Manitoba hospitals in the Winnipeg and Region Health Authority, Ontario, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, and the territories for the period of fiscal year 1997-98 to fiscal year 2000-2001 (implementation of ICD-10/CA/CCI).

Finally, the availability of CPWC values only for fiscal years 1999-20000 and 2000-2001 limits the duration of the shadow price series that can be estimated from CIHI financial data.

**Four questions ...**

**What could the CIHI hospital output index measure?**

The value index identity displayed in Figure 1 notes the duality in the specification of price and volume indexes. The calculation of index numbers need take only one of these two perspectives – either adjust for changes in price or changes in volume
(Brathaug 2003; Fisher and Shell 1998)— and one of several analytical formula, of which the Paasche and Laspeyres formulations are widely used fixed-weight indexes (see Diewert 1996, 1987). Hence, output in constant dollar can be estimated by deflating current year value with a price index, or alternatively, extrapolating base year value with a volume index.

**What are the alternative formulations of the output index?**

The formulation of an output index is determined by the definition of analytical perspective used (price versus volume) and specification of the fixed-weights (base year versus future year). Alternative output indexes are displayed in Table 1 by price versus volume perspective and base year (Laspeyres) versus future year (Pasche) fixed-weights:

- Paasche Price Index or Laspeyres Price Index,
- Paasche Volume Index or Laspeyres Volume Index.

Note: The cross product of the table cells equals the value index.

**What does the output Price Index measure?**

The *Hospital price index: Feasibility study* (CIHI 2003, pp 3 and 10) specified the output price index using the Paasche Price Index (PPI) formulation as,

\[
PPI = \frac{\sum (p_{1i} \times q_{1i})}{\sum (p_{0i} \times q_{1i})}.
\]

where

\[
\sum (p_{0i} \times q_{1i}) = \sum ([CPWC_{1} \times r_{1i}] \times q_{1i}),
\]

\[
\sum (p_{0i} \times q_{1i}) = CPWC_{0} \times \sum (r_{0i} \times q_{1i})
\]

The PPI was estimated using

- the measurement basket defined as APIX categories that have been in place since fiscal year 1997-1998 for which there are at least 200 cases.
- acute care inpatients assigned to the above subset of APIX categories using year-specific CMG/RIW grouping methodology;
- inpatients were defined as typical cases (output) for all provinces (i.e., excluding the territories) that reported jointly to the DAD (i.e., except for Quebec and Manitoba) and the CMDB.
- expected average total cost to impute the shadow price of outputs, where CPWC is calculated for the above (DAD) provinces using total cost (the direct cost of inpatient care adjusted for a share of indirect expenses) for acute hospitals – that is, total (typical and atypical) separations reported by the trimmed subset of hospitals (i.e., excluding hospitals that are outlier in terms of their CPWC). Data from the HS1/2 survey were used to extend the CPWC series back prior to fiscal year 1999-2000.

**The interrelationship between price and quantity for output indexes:**

It can be shown that for all acute inpatient separations in all APIX categories, the output price and volume indexes displayed in Figure 1 can be expressed as ratios of CPWC and WQ (see Table 3 for the formulas and CIHI 2004a for the calculations). These
formulas illustrate the key role that the RIW plays in calculating output indexes using CIHI data.

<table>
<thead>
<tr>
<th>Table 3: Simplified index formulations.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value</strong></td>
</tr>
<tr>
<td>$\sum (p_{1,i} \times q_{1,i})$</td>
</tr>
<tr>
<td>$\sum (p_{0,i} \times q_{0,i})$</td>
</tr>
</tbody>
</table>

What does theory and measurement say about using output indexes?

**Analytical perspective:** Adjust for change in volume or change in price?

Well-known factors present in health care markets affect the role of price in determining the quantity of health service produced (and consumed) (see Donaldson *et al.* 2004, Evans 1984, 2004, and Rice 2003). Brathaug (2003) concluded that constant dollar measurement of expenditure should be calculated as the direct volume measurement of the outputs produced. Direct volume measurement is recommended by the OECD for its member countries (Brathaug 2003), it has been suggested for Canada (Kitchen 1997) and implemented in Australia (Australian Bureau of Statistics 1999, 1998, 1997).

The methodology used by CIHI to calibrate the RIW does not support its use to calculate average total cost series that are meaningful over time (CIHI 2004b). This is a serious constraint that argues against using the price output index to measure the expenditure series in real dollars. In contrast, the quantity of health services produced is comprehensively measured. Moreover, the design of the RIW as relative values supports its use to estimate shadow prices as (base or future year) fixed-weights that are required for the volume output index.

The *Handbook on price and volume measures in national accounts* (Eurostat 2001; as cited by Brathaug 2003) specifies criteria for the first best method of measuring expenditure in constant dollars using direct volume measurement. The text in italics cites the Eurostat criteria stated by Brathaug (2003) and the subsequent text notes the implications for output measurement using administrative data available to CIHI:

- **Quantities should relate directly to output in that they should refer to complete products and not to contributory activities or to contributory intermediate or primary inputs.** To the extent that readmission for the same health condition is infrequent, inpatient separations are complete episodes of acute inpatient care.
- **Quantities should have sufficient stratification in that different quantities are available for all of the product groups comprising output.** By definition, CIHI case mix
classification systems assign acute inpatients uniquely to a single category. The APIx output measurement frame is both large and comprehensive.

- **Product groups should have sufficient homogeneity.** If there is more than one product within a product group, an additional requirement is that the composition of product group does not change over time. Whereas inpatient classification systems are homogenous in terms of clinical and resource usage characteristics, the CIHI grouping methodology has been revised over time, with dramatic changes for fiscal year 1993-2004 (addition of the complexity overlay) and with the implementation of ICD-10 over the period from fiscal years 2003-04 to 2005-2006. Ongoing redevelopment will substantially revise both the case mix grouping and RIW calibration methodology for fiscal 2006-2007, with updates to the methodology planned for every two years thereafter.

- **Quantities should be sufficiently representative for the product group.** Ideally, this requires an integral observation of the quantities of all items in the product group, but this may not be possible. Quantities may not be available for the product group; or the quantities do not cover all products of the group; or the quantities for the products are based on a sample. In these circumstances changes in the quantities that are observed should be representative of changes in the quantities that are not observed. CIHI case mix classification systems uniquely assign each inpatient in the universe of acute inpatients (typical and atypical cases) to an APIx category.

- **Quantities for a product group should account for changes in quality of products.** Changes in quality should be included in the volume component. Changes in quality cover two dimensions: changes in product mix and changes in physical characteristics. Change in inpatient case (product) mix is captured in the comprehensive APIx categories (case mix with complexity overlay and age adjustment) that are regularly revised to account for changes in clinical categories (e.g., introduction of the AIDS CMG) and diagnostic/therapeutic interventions (e.g., the pending change from the CCP to the CCI categories). Change in the outcomes experienced by the separated cases (output) is not explicitly accounted for by case mix classifications systems; however, to the extent that change across the APIx categories (e.g., the use of less invasive intervention, the shift from inpatient to day surgery) is associated with improvement in the quality (or outcome) of inpatient care, direct volume measurement will implicitly incorporate the dimension of product changes.

- **Quantities should be combined using base year total costs as weights for non-market output.** The Laspreyes volume index satisfies this criterion by using base year average total cost weights applied to the volumes measured by the APIx categories.

Brathaug (2003) concluded that the LVI applied to inpatient classification systems qualifies as a second best method for measuring expenditure in constant dollars – that is, satisfying all of the above Eurostat criteria, with the exception of not fully accounting for change in the quality dimension of the product’s characteristics. The LVI applied to clinical and accounting data series available to CIHI appears to satisfy these criteria.

**Price-weights:** Use average total cost to impute (shadow) price?

While price has limited meaning within the context of the economics of health care (or for public goods, in general), average total cost is a proxy for the price that competitive markets otherwise would have assigned to hospital output. As noted above, expected average total cost can be calculated for each APIx category using national RIWs,
provincial CPWC, and the count of acute inpatient discharges.

CIHI’s (2003) use of the expected average total cost to impute the (shadow) prices of the resources used by grouping of acute inpatients conforms to the strategy for estimating the value of public sector (non-traded) goods and services that was suggested by Hill (1993, p 402) and endorsed by Diewert (1996, p 267). The calculation of average total cost is sensitive to how RIWs are estimated as

- relative (cross-sectional) weights of inpatients’ expected (average) need for hospital resources across the APlx categories
- that are temporally (longitudinally) consistent over the duration of the output series.

Whereas RIWs are calibrated as relative measures of expected need for hospital resources, they do not lend themselves for trending analysis, in general, or, as here, for adjusting the hospital cost series for changes in the shadow prices of the inpatient outputs produced.

One concern of measuring the real cost of hospital production using the LVI applied to retrospectively regrouped data (i.e., the most recent grouper/RIW applied back over the nominal output series) is the requirement to annually recalculate the real expenditure series. Changes in the values of the series may confuse readers; policy-makers may elect to wait for future data in the hope that the series shifts to more favourable values.

Whereas the prospectively regrouped output series (the initial grouper/RIW for the series applied forward over the output series) is consistent with conventional LVI measurement, however, CIHI would be tasked with the burden of maintaining the base year grouper/RIW for the duration of the output series (likely four or five years).

What are the measurement issues in using CIHI’s administrative data to adjust hospital expenditure for changes in the volume of hospital output?

The review of the CIHI Hospital price index identified several measurement issues that may affect the calculation of output indexes, including the proposed LVI. For the calculation of a useable output index series based on the methodology presented here to proceed, the following issues would need to be addressed. Underlined text indicates the a priori choice for specifying the output index.

Which analytical formulation should be used: LVI versus PVI?

CIHI regularly updates its case mix/RIW methodology (annually since fiscal year 1997-98). For trend analysis, it will be necessary to retrospectively regroup the clinical data by applying the most recent grouper/RIW back over the series. This ensures the consistent grouping of cases to APlx categories.

The approach used to weight the hospital volume output index – future year versus base year shadow prices – should be consistent with the methodology used to measure the volume series: regrouped versus year-specific grouper/RIW. The LVI formulation, with the most recent year taken as the base year of the series and retrospective calculation of index values, fulfils this recommendation; however, the historic grouper/RIW methodology could be maintained to prospectively regroup the volume series from base year to the most recent year.
Future analyses could compare
• the LVI and PVI volume indexes for values calculated using the year-specific output series – that is, does volume index specification using base year versus future year price-weights matter?
• the LVI for values calculated using the output series retrospectively regrouped using the most recent grouper/RIW to those calculated using year-specific data – that is, does regrouping the output series matter?

Calculation of shadow price: actual average cost versus expected average cost?

Comparison of average total cost by CMG/Plx categories estimated
• as actual average cost calculated by the Ontario Case Costing Initiative (OCCI) from data reported by Ontario case-costing hospitals
• to expected average cost estimated by applying national RIWs to the Ontario CPWC would assess the validity and accuracy of estimating national shadow price-weights using the expected cost methodology available to CIHI.

Calculation of shadow price: full clinical population versus a well-defined subset?

Future analysis could assess the agreement between actual (OCCI) and estimated average total cost (CIHI) by fiscal year for
• the clinical population defined as typical discharges versus total discharges (= typical plus atypical) – that is, does it matter if measurement excludes atypical cases?
• the full clinical population versus the sub-set of CMG/Plx categories containing, say, at least 30 cases – that is, does it matter if measurement excludes APIx categories with small counts of cases?
• larger sets of OCCI hospitals versus the smaller sets reporting in earlier years – that is, is agreement sensitive to the number of hospitals that contribute case costing data?

Specification of the index measurement basket: all outputs in all hospital in all jurisdictions versus a well-defined subset?

The specification of the measurement basket should consider
• the universe of hospitals included,
• the set of acute inpatient outputs included, and
• the exclusion of day surgery outputs.

Should all jurisdictions versus selected provinces/territories be included in the measurement basket and, within these settings, should trimmed versus all institutions used to calculate CPWC? Future analysis could investigate the effect on LVI calculation of the universe of hospitals used by comparing
• all versus the subset of selected jurisdictions and
• all versus the subset of trimmed hospitals within each jurisdiction.

Should all outputs be included in the output basket: acute/extended inpatient care and day surgery/outpatient medical clinics ambulatory care versus inpatient acute care and day surgery versus inpatient acute only, all outpatient categories versus the subset with at least 30 cases, and total versus typical discharged cases? Future analysis could also
investigate the effect on LVI calculation of using

- alternative categories for grouping outputs: APIx (CMG/Plx/Age) versus CMG/Plx versus CMG.
- all APIx categories in this measurement frame versus only those with a sufficiently high count of cases (say, at least 30).
- typical cases versus total cases (= typical plus atypical discharges).

Finally, what is the effect of excluding day case surgery from measurement? As inpatient acute and day surgery outputs are measured using comparable methodology and scales, these two sets of outputs can be combined in a single index using national weights. Future analysis could compare LVI calculation for

- only inpatient acute output versus both inpatient acute and day surgery output – that is, is index calculation affected by the shift of acute care production from inpatient to day care surgery settings?
References


