DATA COMPATIBILITY IN PATIENT LEVEL CLINICAL COSTING

Terri Jackson, Jenny Watts, Lisa Lane, Robert Wilson

Hospital Services Research Group, Monash University Health Economics Unit, W. Heidelberg, Australia

Communications to: Terri Jackson, Hospital Services Research Group, Monash University Health Economics Unit, P O Box 477, W. Heidelberg VIC 3081 Australia

ABSTRACT

The costing of hospital output has long been bedeviled by problems such as vague product definition and inconsistent approaches to the problem of joint costs. The development of Diagnosis Related Groups has provided a major advance to the industry in terms of standardised product definitions, but many issues of costing remain unresolved. As activity based costing becomes more widespread in hospitals, the uses of data for comparative purposes will grow. Earlier approaches such as cost modeling rely on simplifying assumptions from which distortions may arise. These less data-intensive methods are giving way to more sophisticated systematic measurement of costs which rely on computerised patient or clinical costing systems (CCSs). CCSs are able to track how intermediate products (hours of nursing care, x-rays, pathology tests) are used in the care of individual patients. This approach supports better utilisation review within hospitals, and potentially between hospitals. Patient-level CCSs can differ widely, particularly in the degree of specificity with which they track both costs and patient utilisation. This paper reviews sources of potential distortion of cost estimates arising from system differences, and reports the development of a tool to standardise the description of the direct cost components of CCSs. Users of cross-hospital comparative cost data require a good understanding of source data issues in order to make valid comparisons.

KeyWords: Costs and cost analysis; cost allocation; decision support systems, management; product line management; accounting.

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BACKGROUND

Cost accounting has come to play an important role in modern management\(^1\). Cost accounting techniques have been developed which allow manufacturing firms to plan and cost production, and price their products. These systems allocate the direct labour and material costs of the manufacturing process to defined products. Overheads such as marketing may be assigned to individual products, whereas corporate services are generally allocated per unit of output. In assembly line production, with each unit a replica of each other unit, costs can be roughly averaged by way of ‘process’ costing. But when each unit of output is more specialised, ‘job costing’ is employed, whereby components are costed, with the cost of the components of each ‘job’ summed to determine the cost of the final assembled product\(^2\).

Until recently, hospitals had only local product definitions, or more usually, descriptors borrowed from medical billing protocols. Charges for hospital services were usually computed on a per diem basis, and insurers paid billed charges. Public hospitals in most countries received annual budgets which required little accounting for activity. When funders sought to compare institutions, they usually based comparisons on cost per bed day. When costing was undertaken in the industry, it was for purely internal use, and little attention was paid to comparability of costing approaches between institutions. With Fetter’s development of a set of standard product descriptors (Diagnosis Related Groups or DRGs)\(^3\), more extensive analysis and comparison of the efficiency of hospital production was made possible. By standardising for the mix of inpatient services each hospital produced, comparison of hospital costs across institutions was made more meaningful. Further, by defining the end product of hospital care as the treated patient rather than the bed day, Fetter drew management attention to the differing definitions of medical necessity implicit in different average lengths of stay for the same sort of care. Another of Fetter’s important conceptual breakthroughs was the identification of two levels of production in hospitals: intermediate products such as x-rays, pathology tests, days of care, and final products, the completed episode of a particular kind of care, e.g., appendicectomy\(^4\).

The adoption of DRGs as the basis of Medicare hospital funding in the US in 1983 ensured their currency for a range of uses in similar health systems. Today, hospitals in many jurisdictions are either subject to casemix-based funding, or under similar market type pressures to understand better their costs of production and relative
efficiency. The tools of casemix have in turn supported better estimation of hospital costs.

APPROACHES TO PATIENT COSTING

Considerable attention has been paid to issues of patient costing in Australia, with national support through Commonwealth Department of Health funding for the development of cost modeling capabilities in hospitals\(^5,6,7\). In the state of Victoria, by contrast, the Health Department supported early development and purchase of the more detailed and expensive clinical costing systems (CCSs)\(^8,9,10\). This differential investment has fostered lively policy discussion of the relative merits of each approach to hospital costing, with a third group in Australia arguing that the products of both approaches are intrinsically flawed for management and policy uses\(^11,12\). National cost weights for DRGs have been developed using the cost modeling approach\(^13,14\), whereas in Victoria, cost weights have been based on data from hospitals with CCSs\(^15,16\), an approach now followed in Western Australia\(^17\).

There is general agreement that the primary function of CCSs is as a decision support tool for internal hospital management\(^16,19\). For this purpose, most state health authorities have now allocated funding for large teaching hospitals to implement patient-level CCSs, with Western Australia, South Australia, and more recently, Queensland and NSW sponsoring CCS purchases for their major acute hospitals. External use for policy (e.g., setting relative resource weights) is seen as a byproduct rather than the primary function of these systems. Increasingly, however, hospitals’ desire to ‘benchmark’ their efficiency on a DRG basis has led to moves to standardise some elements of these systems so that valid comparisons can be made\(^20,21\).

Most participants in these debates acknowledge that hospital-costing processes can only provide estimates of patient costs. Large proportions of hospital expenditures relate to ‘joint costs’ of the many types of treatment provided. The nature of most overhead costs (the hospital chief executive’s salary, for example) mean that such costs will always be allocated to clinical care on the basis of simplifying assumptions\(^22\). There may be differences between systems in the specific allocation rules (some of which may have important consequences for estimates of patient costs, as discussed below), but the allocation by formula of overhead costs is common to all costing systems. Similarly, most approaches use such simplifying assumptions in the determination of the costs of ‘intermediate’ products of care. In the case of laboratory tests or imaging procedures, for example, the departmental budget is divided across the different products of the department based on a set of relativities. Some institutions conduct one-off studies of their costs of production for various tests and procedures from which they allocate costs to intermediate products. Others use relativities imported from outside the institution. What distinguishes the
two major approaches to clinical costing is whether this modelling is extended to the final products of the hospital: product lines and/or individual treated patients. The earlier approach, cost modelling, uses schedules of cost relativities for various clinical activities to allocate departmental budgets to the various DRGs. This is sometimes referred to as a ‘top down’ allocation of costs, and has been described in detail by a number of authors.\textsuperscript{5,6,7,23,24}

Clinical costing uses what is known as a ‘bottom up’ approach to costing, whereby the cost per patient is built up from recorded utilisation of each intermediate product.\textsuperscript{25} Relative values may be used in the estimation of the unit cost of these intermediate products (as in cost modelling) but these are modelled not on relativities amongst DRGs but amongst the products themselves. Thus pathology test costs are estimated not on the basis of DRG-shares of the pathology budget, but on some model of the relative resource intensity of the individual pathology tests. Records of the use of tests for a specific period are weighted by the relative value scale being used, with a cost per test estimated by dividing the department expenditure by the number of weighted tests. In order to do patient-level costing, most intermediate departments must be equipped with a means of recording individual patient utilisation, usually in computerised form (so-called ‘feeder’ systems). To estimate the costs of treatment of individual patient episodes, utilisation data on each costed intermediate product is attributed to the patient (through the use of data matching on medical record or episode number).

This ‘bottom up’ approach preserves information about the variability inherent in individualised medical treatment, while making possible estimates of average resource use at clinician, service and hospital levels. Both patient-level and DRG-level costs may be estimated, but with a CCS, the DRG-level cost always derives from the average of individual patients, whereas in cost modelling, the reverse is true, with the DRG average cost extrapolated to individual patients. A CCS can report the range and standard deviation of the mean cost in a DRG; a cost modelling system cannot. Refinement of the DRG (or other casemix) classification can be informed by the distribution of costs, where cost modelling can provide only an estimate of the group mean. Moreover, in top-down cost modelling, each patient within a DRG is estimated to use the same level of resources. No additional information is available to distinguish cost changes attributable to changes in input costs versus changes in the utilisation of intermediate products to treat patients. Cost modelling also assumes that relative utilisation of intermediate products is constant across hospitals. For comparisons of relative efficiency, any cost advantages specific to a product line (from economies of scale, for example, or more efficient care processes), are ‘washed out’ by the assumptions about resource use imbedded in the cost model. Real changes in clinical practice or cost inflation of certain components of care, cannot be identified from one period to the next, or between institutions.

The reliability of the estimates from a cost model relies on the extent to which the model is related to actual resource utilisation in the institution being costed. In the early days of cost modeling in Australia, the relativities (‘service weights’) used to distribute intermediate product costs (e.g., radiology) were based on relativities from
the US state of Maryland. Although this data source was one of the most accurate in terms of measured utilisation for its time,26 cost relativities inevitably reflected practice patterns in the US. These are likely to be affected by the higher rates of medical litigation and other cultural influences on practice patterns in that country, potentially inflating estimates, for example, of the use of investigational technologies relative to their use in a less litigious country like Australia. Subsequent work14 has been sponsored to define specific Australian service weights based on studies of DRG relativities in the use of intermediate products in samples of Australian hospitals.

The sophistication of the CCS approach, however, comes at a higher cost. Where they have not done so, hospitals must make the initial investment in information technology to track individual utilisation of services. These may already be present in the form of computerised nurse staffing/patient dependency systems or automated systems for test ordering and reporting of results. Those CCSs that do not require dedicated data sources can make use of such ‘feeder system’ data. In addition to hardware and software, there are significant ‘set up’ costs in implementing and documenting such systems, and ongoing costs for the salaries of suitably qualified information technology staff to maintain and extract useful reports from them.

**Figure 1. Matrix to characterise precision of intermediate product cost estimates in costing systems**

<table>
<thead>
<tr>
<th>Precision of Cost Identification</th>
<th>All (in)patients of hospital</th>
<th>All (in)patients within clinical unit</th>
<th>All (in)patients in a DRG</th>
<th>All (in)patients in a specific ward or receiving any pathology/imaging</th>
<th>All (in)patients receiving a specific therapeutic procedure</th>
<th>Specific patient</th>
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<td>Unweighted of total costs</td>
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The two approaches represent trade-offs. Hospitals and funders face high initial investments in patient level costing systems for continuing returns, versus the small initial investment required for cost modelling, with more limited capabilities. Downstream payoffs from benchmarking and utilisation review activities supported by CCSs, have the potential to repay these investments, but require sophisticated management and clinical leadership to be realised. The high internal validity of CCSs must be balanced against the increased external validity of sampling a wider range of hospitals, which the smaller initial investment required by cost modelling facilitates. For purposes of comparison, cost modelling, which confounds efficiency in production of intermediate products with efficiency in their use, may be more misleading for management than simple counts of resource use (e.g., days of stay).

**PRECISION:DICHOTOMY OR CONTINUUM?**

Wiley examines that cost modelling and clinical costing may be considered to lie on a continuum. One end of this spectrum is anchored by cost modelling, with its fairly crude estimation techniques, and the other end defined by CCSs. As new systems are developed, and hospitals implement them with a widening range of expertise and enthusiasm, the range of precision for each approach has become quite broad, with considerable overlap across the centre of the spectrum. Continuing refinement of service weights used in cost modelling systems results in closer emulation of clinical
costing precision. Because of the difficulties in directly collecting data on salaried and sessional doctors’ time costs, CCSs have generally relied on modelling approaches to the estimation of medical costs, and in those CCSs implemented with few computerised ‘feeder systems’, the precision of results resembles cost modelling.

In the course of a project to estimate DRG relative resource weights in a sample of hospitals in Victoria, Australia\textsuperscript{27}, the need for better ways of characterising and comparing CCSs was identified. The sample of hospitals comprised fifteen Melbourne and Victorian regional hospitals, all of which had some degree of patient costing. Figure 1 presents the general form of a matrix developed to document and compare these systems.

One matrix is used for each of a set of 14 intermediate products to characterise cost measurement in two dimensions: patient identification and cost identification. Movement to the right along the columns of the table indicates greater precision of identification of patients who receive hospital resources. Movement down the table documents increasing refinement of cost attribution. Hospitals may invest in achieving more precision in either dimension, with the most precise cost estimates characterised by the bottom right cell. While specific descriptors for the two axes were developed which differ for each major intermediate product, this generalised matrix provides an overview of the use of the grid to locate hospital systems. Generally, six levels of precision of patient identification are used. These involve averaging costs across:

- all inpatients (irrespective of whether or not they used the good or service)
- all inpatients in a particular medical specialty (e.g. cardiology)
- all patients in a particular DRG,
- all patients treated in a specific ward or department,
- all patients receiving a specific therapeutic procedure, or
- assigning costs only to the specific patients who receive the service.

DRG-level patient identification is generally more precise than medical specialty. For example, identifying patients in a DRG for acute myocardial infarction (AMI) is a more accurate way to attribute costs than to spread them across all patients treated in the specialist cardiology unit. In turn, identifying only those patients admitted to the coronary care unit (or ward) is a more precise means of allocating costs than spreading these costs across all patients in the AMI DRG. Distributing the costs of nursing care on the basis of a patient-dependency system which captures the care needs of the individual patient is more precise still. Similarly, movement down the table documents increasing refinement of cost attribution. For products dominated by labour costs, the crudest form of cost identification is to average across all admissions, and the most precise is to measure actual minutes of staff time for each care task, taking into account the salary grading of the particular staff member providing care, equivalent to ‘time and motion’ costing. Costing of units of utilisation can be refined at most levels by applying a relative value unit (RVU) scale, or by more carefully defining the type of episode or patient. Thus, an operation, say transurethral prostatectomy, can be costed on the basis of a specific theatre service weight for urology procedures (defining the episode type), or
measured operating theatre time can be weighted by an RVU which reflects average staffing of urology procedures (a refinement of cost identification). Often the two dimensions are interdependent, as it is unlikely that a hospital will cost very precise time units of a service unless individual patients can also be identified for assignment of those units in costing. But the byproduct nature of much of the data used in CCSs means that sometimes precision can be achieved relatively easily in one dimension without commensurate development of the other.

An example is in the use of payroll data to cost nursing activities. When nursing salaries are assigned to particular cost centres (e.g., each ward), per diem salary costs can be relatively easily computed for allocation and these will reflect the particular staffing mix of the unit or ward. For general medicine or general surgery wards, this allocation may be less precise than a DRG-specific ‘service weight’. But where ward care is even moderately specialised (e.g. a renal ward), a payroll-based allocation of nursing costs may provide more precise estimates of the real resources used in the care of patients in a particular DRG than, say, imported DRG nursing relativities.

Cost measurement will differ in nature depending on whether it is primarily staff time or consumable costs which dominate the intermediate product. Because of the labour-intensive nature of health care, most of the intermediate product matrices record the precision of staff time allocation. Where very high-cost consumables (implantable prostheses or very high-cost pharmaceuticals, for example) are as costly as staff time (or vary greatly between patients), separate intermediate products have been identified and/or the levels of precision have been modified to reflect this fact. Those products dominated by staff time often have some component of consumables cost (supplies for operating theatres, for example), but without creating a new matrix for these smaller intermediate products, the level of precision for these is not easily documented. Complete matrices and related definitions are available from the authors.

In using these matrices to compare systems across the 15-hospital sample, it became apparent that system-development is more consistent across intermediate product types than within hospitals. It emerged that some departments (imaging, lab and theatre, in particular), have implemented computerised ‘feeder systems’ earlier than other departments (especially those relating to direct care medical services). Theatre is an interesting example, where medico-legal concerns have driven hospitals to invest in systems to provide careful documentation of the timing and staffing for operative procedures. As a byproduct, these sub-systems provide the basis for very precise patient and cost identification. A clear pattern found in the study was for hospitals to cluster around a certain position in each matrix, with clear differences in the pattern for different intermediate products. This clustering probably also reflects investment decisions on the part of hospitals. It may not be rational to implement systems to provide very precise cost estimates for intermediate products which have a small impact on patient costs, which vary little from one patient type to another, or which pose significant challenges to the collection or use of such information, such as medical time recording systems.
OTHER ISSUES OF DATA VALIDITY

Precision of estimation is not the only issue of concern when evaluating or comparing the costs of hospital care, particularly when these comparisons are made below the level of the treated patient (the ‘final product’, in Fetter’s terms). Additional issues include consistency of cost centre definition, how indirect or overhead costs are allocated, and the way in which jointly produced hospital products (e.g., outpatient care, teaching and research) are identified and costed. This last is a particular weakness of most systems, as these non-inpatient products are less well classified and costed\(^{28,29}\). With support from the Victorian Department of Human Services, an industry group in Victoria has incorporated as the Clinical Costing Standards Association of Australia (CCSAA)\(^20\). Through collaborative work amongst Victorian hospitals, the Association has developed standards for use in hospital clinical costing. These cover:

- standardisation of the definition of direct and indirect costs,
- standardisation of the definition of fixed and variable costs,
- endorsement of a ‘roll up’ structure for cost centres to ‘Service Cost Groups’ to define 12 standard intermediate products,
- procedures for recording costs in clinical units or other cost centres which have been closed, and
- standard bases for allocation of indirect/overhead cost centres, and handling of various non-operating costs.

The CCSAA has proposed a refinement of the matrix approach to evaluate systems on the basis of a scoring system. This approach would weight various intermediate products by the proportion of a hospital’s total costs, so that increased precision in systems accounting for a greater proportion of costs would score more highly. In undertaking cross-hospital comparisons, however, it may be more important to evaluate the precision of specific subsystems than to rely on global assessments, and to look for greater precision in clinical systems where there is expected to be a high degree of variation between patients or providers (for example, operating theatre time or the use of high-cost implantable prostheses).

ALLOCATING INDIRECT OR OVERHEAD COSTS

Adherence to the CCSSA standards in Victoria is still variable, but generally high\(^{27}\). Victoria’s annual cost weights study provides a mechanism for documentation of system development and studies have progressively refined the tools available for assessing data quality\(^{15}\). In the course of the 97 Study\(^{27}\), additional investigation was made into what effects at the DRG level result from different approaches to the allocation of indirect or overhead costs. Preliminary investigation revealed that between 25% and 40% of the expenditures of participating hospitals were assigned
to indirect cost categories. There are a number of approaches to the allocation of these costs across treated patients. Clinical Costing Standard 5\(^{20}\) endorses the use of the simultaneous equations approach to problems in allocating indirect costs. This method recognises that while many indirect costs can be directly assigned to direct or patient care cost centres, some provide reciprocal services to other indirect departments (payroll department pays the wages of cleaners, who in turn provide cleaning services to the payroll office). Using matrix algebra, these reciprocal costs are allocated to each other, as well as to direct service cost centres\(^{30}\). Step-down approaches simplify the process by allocating indirect costs in a cascade, and ‘off the top’ approaches are further simplified, assigning indirect cost directly to direct cost centres on a single allocation basis (e.g., minutes of direct care).

The more sophisticated methods are quite resource intensive to implement, requiring an initial evaluation of the allocation bases to be used (e.g. floor space, percent of total budget)\(^{25}\), and computerisation of the general ledger to undertake the allocations. To determine whether the simple ‘off the top’ approach represents a reasonable, cost effective alternative, the simplified approach (allocation by minutes of direct care) used by a single hospital was simulated across the sample. The question of interest was whether this approach introduced any systematic distortion into the estimation of relative resource weights. Patient level indirect costs were available from 13 of the original sample of 15 hospitals. One hospital had no indirect costs recorded and the other was not included in the simulation due to data quality issues, but remained in the final recalculation of weights to ensure comparability with the original sample. Indirect costs (recorded in 12 of the 13 hospitals on the basis of either step-down or simultaneous equation allocations) were subtracted from total costs and these costs re-allocated at the patient level on the basis of length of stay (in days). In the absence of data on actual minutes of stay in these hospitals, days of stay was used as the closest proxy to the approach used in the thirteenth hospital.

Costs were then reaggregated at the DRG level, the three omitted hospitals added back into the sample, and the DRG level mean cost compared with the mean cost which had been calculated using the original overhead allocation methods in the 12 simulation hospitals. Including all original hospitals (that is, the 2 excluded because of data problems) eliminated any bias that might have arisen from using the smaller sub sample of only 13 hospitals, but would have the conservative effect of reducing the magnitude of differences between the two sets of mean costs.

SIMULATION RESULTS

The simulation (length-of-stay based allocation) apportioned more indirect costs to outlier cases, resulting in a redistribution of $16.6m (1.9%) from inlier to outlier cases. Figure 2 shows the differential effect on medical and surgical inlier cases. The
mean cost of surgical DRGs fell by $232 in the simulation, while the mean cost for medical DRGs rose by $42 (both significant at the 0.01 level).

Figure 2: ‘Surgical’ DRGs under-weighted by length-of-stay assignment of overhead costs

This result suggests that surgical DRGs normally incur higher measured overheads than medical DRGs, due to the resources used in the operating theatre, recovery room, etc, which are not recognised when a single time-based allocation is employed. When indirect costs are allocated on the basis of length-of-stay, proportionately more overheads are allocated to medical DRGs, reducing the measured differences in cost between medical and surgical DRGs.

This finding raises concerns that a less refined approach to indirect cost allocation can distort hospital decision making. Allocations of this sort may erroneously create pressure on clinicians to discharge medical patients prematurely because they appear to be more costly than they ‘really’ are. Hospitals may expand their capacity to undertake surgical work on the basis that these cases appear ‘cheaper’ to provide than they might appear if more precise overhead allocation techniques were used.

CONCLUSIONS

In her 1993 review of the European experience of hospital costing activities, Wiley noted that the majority of European countries could not provide data at the patient level for the utilisation of radiology, pathology, and pharmacy services [23]. While these systems are apparently more common in the United States, their potential for providing hospitals and funders with comparative cost information is constrained by the multi-payer nature of the US health care system. As noted, Australian states have sponsored progressive implementation of these systems, beginning in the larger
public teaching hospitals where payoffs are most likely to be realised. In the years ahead, pressures on health care budgets in most developed countries are unlikely to be eased, and both hospitals and funding authorities will look for tools to assist hospitals in evaluating their productive efficiency, particularly using comparisons across like hospitals. As information technologies become less costly, patient level costing systems using byproduct data from other computerised hospital functions are likely to replace earlier costing approaches.

Users of such systems require a good understanding of the issues involved in evaluating the validity and reliability of the costing information produced by the various systems and subsystems. By defining the dimensions and the levels of precision in costing techniques, the matrix approach proposed here provides hospital managers with tools to evaluate their own costing system and the comparability of data generated by others. Algorithms to distribute indirect or overhead costs can be chosen so as to reduce distortions in cost allocations. With an appreciation of the differing levels of precision in costing techniques, hospitals can determine in which areas they may wish to invest to refine their costing techniques, balancing up the costs and expected benefits of investing in a more accurate system. Clinicians concerned at the distortions to clinical practice which faulty cost information may engender [18] have a means of examining how costs are measured in clinically-sensitive subsystems of a CCS. Funders are able to evaluate the quality of data available for answering a range of policy questions.

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