Organ transplant AN-DRGs: Modifying the exceptions hierarchy in casemix classification

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Abstract

The study described in this article sought to develop AN-DRG Version 3 classification revisions for organ transplantation through statistical analyses of recommendations formulated by the Australian Casemix Clinical Committee. Two separate analyses of variance were undertaken for AN-DRG Version 2 and for the proposed Version 3 AN-DRGs, using average length of stay as the dependent variable. The committee made four key recommendations which were accepted and incorporated into AN-DRG Versions 3 and 3.1. This article focuses on the classification revisions for organ transplantation.

Introduction

The Australian Casemix Clinical Committee (ACCC) was established in 1990 by the Australian Health Ministers' Advisory Council to coordinate the clinical evaluation of Diagnosis Related Groups (DRGs). The development of the third version of Australian National Diagnosis Related Groups (AN-DRGs) commenced in April 1993, with the ACCC inviting 120 clinical organisations, health authorities and hospital associations to participate in its review. Seventeen clinical groups were established by the ACCC for the review process. The clinical groups related generally to the Major Diagnostic Categories (MDCs) of AN-DRGs such as ophthalmology, gastroenterology, obstetrics and gynaecology. Two groups were formed to deal specifically with paediatric, geriatric and rehabilitation casemix issues. Classification revisions to organ transplantation were considered by the pre-MDC Clinical Group, which carefully considered proposals by various organisations such as the Transplantation Society of Australia and New Zealand.

The ACCC completed its evaluation of the second version of AN-DRGs in December 1993 and presented its recommendations for Version 3 to the (then) Commonwealth Department of Human Services and Health. The recommendations were statistically analysed by the Department, with input from a Technical Reference Group. AN-DRGs should be suitable for a range of purposes, including hospital payment and management, quality assurance and utilisation review. This article focuses on classification revisions for organ transplantation, which was one of several high-cost/low-volume procedures considered by the ACCC.

The ACCC indicated that some high-cost/low-volume procedures, including single- and multiple-organ transplants, are cost outliers due to expensive consumables and prostheses. These procedures are normally performed in specialised units which may be disadvantaged unless their high costs are considered through either the funding or classification system. AN-DRG Version 2 included categories for liver transplants and automatic implantable cardioverter defibrillators. The ACCC recommended the creation of some new AN-DRGs for high-cost/low-volume categories. Transplants were only one type of high-cost/low-volume procedure considered. Extra corpeal membrane oxygenation, spinal implants and limb lengthening procedures were also considered.

This article covers the statistical analyses of the ACCC's recommendations for the inclusion of transplant AN-DRGs in the pre-MDC section of the classification system. This involves exceptions to using transplant patients' principal diagnosis as the initial classification variable for their allocation to an MDC and modifies the 'exceptions hierarchy' for AN-DRG formation. We also discuss international casemix classification systems and Commonwealth–State funding policies for transplants, given that, at the time, some organ transplants no longer had nationally-funded centre status, and would be placed on the Medical Benefits Schedule. Transplant costing and classification issues were considered important because in some States transplants would become part of the general casemix funding arrangements.

The ACCC's transplant recommendations for Version 3 were that:

- heart, heart–lung and lung transplants be transferred to the pre-MDC component of the classification
- the following classification of organ transplants and hierarchy be adopted:
  – multiple-organ transplants
  – liver transplants
  – heart transplants
  – lung transplants
- multiple-organ transplants be defined by two or more of the following procedures:
  – liver
  – heart
  – lung (including bilateral sequential single lung transplant)
  – kidney
  – pancreas

- a new ICD-9-CM code be created for bilateral sequential single lung transplant
- the cost weight for organ transplantation AN-DRGs include the cost of organ donation.

In AN-DRG Version 2, organ transplants (excluding liver) were classified in the MDC pertaining to the patient's principal diagnosis. There were three reasons for classifying organ transplants as pre-MDCs (which exclude the use of principal diagnosis as the basis for classification):

- multiple-organ transplants were occurring more frequently; selecting the principal diagnosis became problematic as it could relate to either organ
- single-organ transplants could be performed for diagnoses other than those pertaining to the MDC of the organ
- transplant patients who had a tracheostomy were classified to one of the tracheostomy categories instead of the transplant category.

A separate AN-DRG for multiple-organ transplants was required given that the costs differ markedly from single-organ transplants and they are often performed at different hospitals to the single-organ transplant procedure. A new ICD-9-CM code should be created for bilateral sequential single lung transplant for similar reasons.

A summary of the Version 2 and proposed Version 3 grouping changes is shown in Table 1.

Table 1: ACCC recommendations for transplant changes for AN-DRG Version 3 – A comparison with Version 2

Proposed Version 3		Version 2	
Transfer to pre-MDC	Procedure codes	AN-DRG	MDC
Multiple organ transplant (for example, heart–lung transplant)	336	220 Heart transplant	5
Liver transplant (no change)	5051; 5059	005 Liver transplant	pre-MDC
Heart transplant	375	220 Heart transplant	5
Lung transplant	335	160, 161, 162 Major chest procedures	4

The ACCC's recommendations were analysed from several perspectives by the Department of Human Services and Health and the Technical Reference Group. Statistical analyses of the ACCC's recommendations for transplants for AN-DRG Version 3 were undertaken along with analyses of the related Version 2 structure. International casemix classification systems and Commonwealth–State funding policy for transplants were also considered. The transfer of some transplant AN-DRGs to the pre-MDC represents a departure from using the principal diagnosis as the key classification variable. The implementation of these recommendations would change the

structure of some MDCs along with the exceptions hierarchy to the use of the principal diagnosis as the basis for AN-DRG assignment. The role of principal diagnosis and also the exceptions hierarchy in the formation of AN-DRGs is discussed below.

The role of principal diagnosis in the formation of DRGs

The first operational set of DRGs was developed in 1978 at Yale University. The formation of DRGs began by dividing all principal diagnoses into 23 mutually exclusive principal diagnosis categories, called MDCs. Diagnoses in each MDC correspond to a single organ system or etiology and are generally associated with a particular medical specialty. To maintain clinical coherence, no final DRG could contain patients in different MDCs. Diseases involving both a particular organ system and a particular etiology, such as malignant neoplasm of the kidney, were assigned to the MDC corresponding to the organ system involved. Most MDCs were initially divided into medical and surgical groups. The surgical groups were further defined based on precise surgical procedure, while medical patients were further defined on the precise principal diagnosis responsible for admission. Defining the surgical and medical classes in an MDC required that each class be based on some organising principle. In the urinary system MDC, a surgical group was formed for all patients with a procedure on the urethra. Here, the organising principle was based on anatomy. The surgical group was then divided based on whether the procedure was transurethral. Here, the organising principle was surgical approach. Once medical and surgical classes were formed, each class was evaluated to determine whether complications, co-morbidities or patient age would affect hospital resource consumption. Although the initial step in DRG determination was the assignment to an MDC based on the principal diagnosis, this general rule may not be appropriate for patients who have expensive procedures, as occurs for liver and bone marrow transplant patients, neonates, HIV, tracheostomy and multiple-trauma patients. Exceptions to using the principal diagnosis as the initial classification parameter to an MDC have resulted in the formation of an exceptions hierarchy to the general assignment rule and is discussed in more detail below (Commonwealth Department of Human Services and Health, 1995a).

The exceptions hierarchy and pre-MDC AN-DRGs

The exceptions hierarchy for assigning patients to an AN-DRG in Version 2 is shown in Table 2. Much of the structure was similar to Health Care Financing Administration DRGs (HCFA-DRGs) Version 10, with the notable exception of the MDC-level specification of paediatric and neonatal DRGs which more closely resemble All Patient DRGs (AP-DRGs).

The organisation of AN-DRGs following the implementation of the ACCC's recommendations are discussed in the final section of this article. This includes a brief discussion of the extent to which AN-DRGs have departed from standard assignment logic.

Table 2: AN-DRG Version 2 hierarchy

Exceptions hierarchy	MDC/AN-DRG assignment
Age less than 29 days	MDC 15
Principal diagnosis of HIV or secondary diagnosis of HIV and principal diagnosis of HIV-related condition	AN-DRGs 800–806 (MDC 18)
Liver transplant	AN-DRG 005 (pre-MDC)
Bone marrow transplant	AN-DRG 006 (pre-MDC)
Principal diagnosis of trauma and at least two significant traumas from different body sites	AN-DRGs 870–876 (MDC 21)
Tracheostomy	AN-DRG 001–004 (pre-MDC)
Principal diagnosis	MDCs 1–14, 16–23

Source: Commonwealth Department of Health, Housing, Local Government and Community Services (1993)

Method

National hospital morbidity data for all public hospitals held by the Department of Human Services and Health for 1991–92 were used to analyse the ACCC's recommendations. The statistical criteria used by the Department were as follows:

- *Improved homogeneity*
  Two- or three-level partition of a group leads to at least 5% reduction in variance and a large F-statistic, approximately 100 (see glossary). Also, the impact of the partition on the overall system meets a minimum threshold and statistical significance.
- *National group size*
  New groups that are created from an existing group contain at least 200 cases and at least 10% of the original group cases.
- *Difference in resources*
  New groups that are created from an existing group differ in average length of stay by at least two days or at least 100% (the group with higher average length of stay has at least twice the average length of stay of the smaller group). Additionally, the 90% confidence interval for the new groups should be distinct (intervals do not overlap).
- *New group homogeneity*
  New groups that are created from an existing group must have a coefficient of variation no higher than 1.3 times that of the original group (no more than 30% worse in internal variation).

These criteria were considered appropriate at the time of the study. The aim of applying the criteria is to facilitate the development of AN-DRGs so that each includes a homogeneous group of patients in terms of resource utilisation. The resource intensity

of patients in each AN-DRG must be similar in order to establish a relationship between the casemix of a hospital and the resources it consumes. However, some variation in resource intensity will remain among the patients in each AN-DRG. The definition of the AN-DRG will therefore not be so specific that every patient is identical but the level of variation is known and predictable. The average pattern of resource intensity of a group of patients in an AN-DRG can be accurately predicted. There has been some debate about the statistical criteria to develop AN-DRGs, particularly for Version 4. Some recent changes to the statistical criteria are covered in the discussion section of this article.

Results

The key results of statistical analyses of the ACCC's first three recommendations outlined above are summarised in Table 3.

Table 3: Analysis of variance results for transplant recommendations

Statistical results	Version 2	Proposed Version 3
Average length of stay	13.00	13.09
Weighted coefficient of variation	0.7749	0.7672
F-statistic	232.15	193.59
Alpha	<.0001	<.0001
Reduction in variance	25.95	27.23

Ideally, cost data should be used. However, such data were not available and average length of stay was used as the dependent variable. The one-way analysis of variance (eight levels or AN-DRGs) of the structure of AN-DRG Version 2 was undertaken for:

- liver transplant (AN-DRG 5)
- lung transplant (AN-DRG 160 – major chest procedures with major complications and co-morbidities; AN-DRG 161 – major chest procedures with non-major complications and co-morbidities; AN-DRG 162 – major chest procedures without complications and co-morbidities)
- heart transplant (AN-DRG 220),
- pancreas transplant (AN-DRG 360 – pancreas, liver and shunt procedures with complications and co-morbidities; AN-DRG 361 – pancreas, liver and shunt procedures without complications and co-morbidities), and
- kidney transplant (AN-DRG 550).

Here lung transplants were not included in an AN-DRG specifically for lung transplants; rather they were included in AN-DRGs 160, 161 and 162. Likewise, pancreas transplant was not a separate AN-DRG, rather patients undergoing pancreas

transplants were included in AN-DRGs 360 and 361. The results of this analysis of Version 2 are shown in Table 3. All AN-DRGs had a case count that exceeded 200, except for AN-DRG 5 (liver transplant) with a count of 102 cases and AN-DRG 220 (heart transplant) with 94 cases.

The proposed structure for Version 3 involved a one-way analysis of variance (10 levels or AN-DRGs) for each of the above AN-DRGs and also the new multiple-organ transplant and lung transplant. The analysis results are shown in Table 3. Note the F-statistic still exceeds the threshold of 100 and reduction in variance increased to 27.23, an increase of 4.93% over Version 2 results.

Group sizes, however, were very low for multiple transplants (22 cases), heart transplants (91) and lung transplants (20). The new AN-DRG for lung transplants had a longer average length of stay (23.3 days) relative to the AN-DRGs from which the procedure codes were drawn (AN-DRGs 160, 161 and 162; average length of stay ranging from 9.43 to 16.41 days). It did appear to represent a different sub-group. Likewise its 90% confidence intervals did not overlap with any of those from its original groups. Multiple organ transplants had one of the longest average lengths of stay (30.91 days) and appeared to be derived from a distinctly different group. Generally all transplant AN-DRGs had longer average lengths of stay relative to the other AN-DRGs (except AN-DRG 360 – pancreas, liver and shunt procedures with complications and co-morbidities). There was very little, if any, overlap of confidence intervals between the new groups, except for multi-organ transplants and liver transplants, which were clinically distinct groups anyway. Average length of stay for these AN-DRGs was also virtually the same.

Discussion

The ACCC's first four recommendations were endorsed by the Technical Reference Group on the basis of the statistical analyses, international developments and Commonwealth–State funding policy for nationally-funded centres undertaking transplants. These are discussed in more detail below. However, the Technical Reference Group noted caution about the small group size for AN-DRGs for multiple transplants, heart transplants and lung transplants. The recommendations have been incorporated into AN-DRG Version 3, which was available from July 1995.

Heart, heart–lung and lung transplants have been transferred to the pre-MDC. These transplant patients are assigned to the transplant AN-DRGs in the pre-MDC. The following classification of organ transplants and hierarchy was adopted: multiple organ (AN-DRG 7),liver (AN-DRG 5), heart (AN-DRG 8), lung (AN-DRG 9) and bone marrow (AN-DRG 6).

Multiple organs are now defined by two or more of the following procedures: liver, heart, lung (including bilateral sequential lung transplant), kidney, and pancreas. A new ICD-9-CM code was created for bilateral sequential single lung transplant (procedure code 3351) (Commonwealth Department of Human Services and Health 1995b).

Other key elements of the exceptions hierarchy are outlined below. All structural and design characteristics for these Version 3 AN-DRGs were retained for Version 3.1.

Organisation of AN-DRGs and the exceptions hierarchy

The departure from using the principal diagnosis as the initial variable in AN-DRG assignment has created the necessity to change the exceptions hierarchy. The AN-DRG Version 3 and 3.1 hierarchy for assigning patients is shown in Table 4. The new structure reflects the ACCC's recommendations for transplants.

Table 4: AN-DRG Versions 3 and 3.1 hierarchy

Exceptions hierarchy	MDC/AN-DRG assignment
Multiple organs, liver, heart, lung, bone marrow transplants	DRGs 005–009 (pre-MDC)
Extra corpeal membrane oxygenation (ECMO) without cardiac surgery	DRG 010 (pre-MDC)
Multiple trauma	DRGs 870–876 (MDC 21)
Age <29 days (or admission weight <2500 g + age 29 – 364 days)	DRGs 701–727 (MDC 15)
Principal/secondary diagnosis of HIV	DRGs 801–805 (MDC 18)
Tracheostomy procedure	DRGs 001–004 (pre-MDC)
Principal diagnosis	MDC 1–14, 16–23

Sources: Adapted from Figure 2, Commonwealth Department of Human Services and Health (1995a) and Commonwealth Department of Health and Family Services (1996)

In addition to transplants, there are other exceptions to the use of the principal diagnosis as the initial AN-DRG classification variable. These exceptions include tracheostomy, neonates, HIV and multiple trauma. There are also exceptions to the general AN-DRG structure wherein more than one procedure is used to define an AN-DRG. Further, endoscopy non-operating room (OR) procedures are classification parameters in MDCs 6 and 7. MDCs involving pregnancy, childbirth and neoplastic disorders also depart from the general classification structure (Commonwealth Department of Human Services and Health 1995a).

The ACCC, the Department of Human Services and Health and the Technical Reference Group considered international developments on transplant DRG classification systems in the United States (including AP-DRGs and HCFA-DRGs) and Canada during the development of Version 3. These are discussed below. There are also relevant transplant classifications in Korea and the United Kingdom. However, classification systems in these countries were not investigated during the development

phase of these AN-DRGs and are beyond the scope of this article. The basis of Commonwealth–State funding for National Transplant Centres was also considered during the developmental phase of the transplant AN-DRGs. The arrangements considered are covered below.

International developments on transplant DRGs

AP-DRGs (United States)

Departure in the AP-DRGs from using principal diagnosis as the initial variable in DRG assignment has necessitated the formation of an exceptions hierarchy. The hierarchy for assigning transplant and tracheostomy patients to an AP-DRG is shown in Table 5 and is based on AP-DRG Version 10, with Version 11 specifications added for lung transplants. The latter specifications involved the transfer of procedure codes 335 (lung transplant) from MDC 4 and 336 (heart and lung transplant) from MDC 5.

Table 5: Exception hierarchy for transplants and tracheostomy – AP-DRGs (United States)

Exception hierarchy	AP-DRG assignment
Liver transplant	Assign to liver transplant AP-DRG 480
Bone marrow transplant	Assign to bone marrow transplant AP-DRG 481
Lung transplant	Assign to lung transplant AP-DRG 795
Tracheostomy	Assign to tracheostomy AP-DRG 482 or 483

Sources: 3M Health Information System and New York Department of Health (1993, 1994)

HCFA-DRGs – lung transplants (United States)

The Health Care Financing Administration's (HCFA's) specification of transplants in the pre-MDC has not changed since Version 9. Liver and bone transplants are included in the pre-MDC. Most of the recent concerns of the HCFA have related to lung transplants. By comparison, the AN-DRG Version 2 in Australia allocated lung transplant to MDC 4 into DRGs 160 (major chest procedures with major complications and co-morbidities), 161 (major chest procedures with non-major complications and co-morbidities) and 162 (major chest procedures without complications and co-morbidities). AN-DRG Versions 3 and 3.1 have transferred all lung transplants from these AN-DRGs to form a new AN-DRG which is assigned to the pre-MDC category.

The HCFA also considered creating a new DRG for lung transplants. During 1992, it was approached about recognising single and double lung transplants as covered by Medicare services and creating one or more new DRGs specifically for these cases. Under the United States' DRG classification, ICD-9-CM procedure code 33.5 (lung

transplant) is assigned to DRG 75 (major chest procedures). This is the highest-weighted surgical DRG in MDC 4 (diseases and disorders of the respiratory system). Combined heart–lung transplants (procedure code 33.6) are allocated to MDC 5, DRG 103 (heart transplant). Under HCFA policy, United States Medicare contractors determine whether or not to cover and pay for claims associated with a lung transplant. Combined heart and lung transplants were not covered under Medicare in 1992.

During 1992 the HCFA began exploring the possibility of covering lung transplants on a national basis and the appropriateness of establishing a new DRG for these cases. It noted that any classification of lung transplants, and the resulting DRG relative weight, would be based on the cost of providing this service to Medicare beneficiaries.

A final decision to cover lung transplants on a national basis has still not been made. It is not the HCFA's practice to create a new DRG for an experimental procedure; rather it assigns the procedure to an existing DRG. There are three reasons for this approach.

- There are very few Medicare cases upon which to build a relative weight. Any weight used must be applied in recalibrating the weights of all other DRGs.
- Since the weight for lung transplants would be one of the highest, it would lower the weights of all the lower-weighted DRGs. The HCFA indicated that it is unfair for a procedure not yet approved for national coverage to have an effect on the payment for all other cases.
- The HCFA cannot predict which transplant cases will be approved for coverage, as this is a decision made by United States Medicare contractors on a case-by-case basis because there are no national coverage requirements.

Therefore, the HCFA does not have a basis for estimating the number of transplant cases for the coming Federal fiscal year as is required by their recalibration process. The HCFA therefore concluded that it should not create a DRG for lung transplants prior to the effective date of the national coverage decision (United States Department of Health and Human Services 1993, 1992).

HCFA – heart and liver transplant cost weights

The HCFA has established the relative weight for heart transplants (DRG 103) in a manner consistent with the methodology for all other DRGs except that the heart transplant cases that were used to establish the weight were limited to those Medicare-approved heart transplant centres that have cases in the 1992 financial year Medicare data files.

Similarly, the HCFA limited the liver transplant cases that were used to establish the weight for DRG 480 (liver transplant) to those hospitals that are Medicare-approved liver transplant centres (United States Department of Health and Human Services 1993). Acquisition costs for kidney, heart and liver transplants are paid on a reasonable cost basis. Unlike other excluded costs, the acquisition costs are concentrated in specific DRGs, including DRG 302 (kidney transplant), DRG 103 (heart transplant) and DRG 480 (liver transplant).

Because these costs are paid separately from the prospective payment rate, it is necessary to make an adjustment to prevent the relative weights for these DRGs from including the effect of the acquisition costs. Therefore, the HCFA subtracts the acquisition charges from the total charges on each transplant bill that showed acquisition charges prior to computing the average charge for the DRG and prior to eliminating statistical outliers (United States Department of Health and Human Services 1993). In the case of both heart and liver transplants, when a national coverage decision was made, enhanced payment under the newly-created DRGs for those procedures was made retroactive to the date of coverage. Once lung transplants are approved for coverage, the HCFA intends to follow the same policy.

In the United States, the cost weights exclude the acquisition costs for these transplants, which are paid on a reasonable cost basis and are paid separately to the prospective payment rate. In Australia, the ACCC recommended that the costs of organ donation be included in the cost weight. The Technical Reference Group and Commonwealth noted the United States' developments and the large variation in the acquisition costs in Australia, and deferred a decision on the ACCC's recommendation. At the time of the study, cost weights for organ transplantation in Australia did not include the cost of organ donation.

Canadian developments

Case Mix Groups (CMGs) are based on ICD-9 and the Canadian Classification of Diagnostic Therapeutic and Surgical Procedures. The Hospital Medical Records Institute, recently renamed the Canadian Institute for Health Information (CIHI), manages approximately 70% of hospital discharge data in Canada, which is grouped into CMGs (Antioch 1994). CMGs include 24 Major Clinical Categories (MCCs), which are the equivalent of MDCs found in DRG-derivative classifications. The CMG classification defines the principal diagnosis as the condition that accounts for the greatest proportion of resource usage and is referred to as the most responsible diagnosis.

In the Canadian situation there is no pre-MCC component but the (then) Hospital Medical Records Institute introduced features providing for the same classification outcome. For example, CMGs can be allocated across several MCCs. In the case of lung transplants (procedure code 455), the code is allocated to CMG 124 (lung transplant) and CMG 175 (heart and lung transplant), which is included in MCC 4 (diseases and disorders of the respiratory system), MCC 5 (diseases and disorders of the circulatory system), and MCC 10 (endocrine, nutritional and metabolic diseases and disorders).

This procedure code is also shown in MCC 98 (unrelated OR procedures) and is included in CMG 900 (extensive unrelated OR with complications and co-morbidities), and CMG 903 (extensive unrelated OR without complications and co-morbidities).

Likewise, the procedure code for heart transplant (495) is allocated to MCC 5 (CMG 176 – heart transplant, and CMG 175 – heart and lung transplant), MCC 4 (CMG 175 – heart and lung transplant), and MCC 98 (CMGs 900 and 903).

In Canada there are multiple organ transplants (such as heart–lung) and lung transplant CMGs. The allocation of CMGs across more than one MCC is generally in contrast to the situation in Australia (Antioch, Zhang & Brown 1994).

The research has identified large differences in international casemix classification systems. It is essential that any cross-national studies on hospital utilisation and costs should specify which version of the casemix grouping system was used and the various codes applied in the grouping process, such as diagnosis, procedures, complications and co-morbidities (Antioch, Selby Smith & Hailey 1995).

Australian Commonwealth funding/costing issues – Nationally-funded centres

At the June 1990 Australian Health Ministers' Conference, Ministers endorsed a national policy for the provision of new technologies and procedures. Certain services have been restricted to designated centres which have been accorded 'nationally-funded centre' status. The Commonwealth makes an annual contribution based on savings accrued from Medicare and Pharmaceutical Benefits. States and Territories are authorised by the Commonwealth to transfer funds from the Hospital Funding Grants to a trust fund. Each State contributes on a weighted population-share basis. Access to services is available free of charge to all eligible Australian residents, on the basis of medical need. No distinction is made between Medicare/public and privately-insured patients. All patients are treated as Medicare/public patients. Therefore no claims are lodged to private health insurance companies for any part of the service. Nationally-funded centre status is only granted by the Australian Health Ministers' Advisory Council.

Since its inception, the following specialties have been funded through the program: heart/heart–lung transplants, liver transplants, paediatric heart transplants, pancreas transplants and cerebrovascular embolisation. Liver transplants have not been included in the program since 1994–95. The Australian Health Ministers' Advisory Council agreed that adult cardiac transplantation units would no longer be granted nationally-funded centre status from 1 January 1995. Heart–lung transplantation continued to have nationally-funded centre status. The Council indicated that lung transplantation should be given nationally-funded centre status and expressions of interest should be called. The Australian Health Ministers' Advisory Council requested that the Australian Health Technology Advisory Committee develop guidelines on cardiac transplantation.

At the time of the research, the procedure price was based on costings provided by the centres and advice from the Australian Health Technology Advisory Committee. The costings covered operating costs including direct labour, clinical support, non-labour, donor collection, interstate patient transport and accommodation, overhead costs, depreciation and maintenance costs.

The nationally-funded centre budget was based on expected patient throughput. Centres providing the same type of procedure have received the same amount of funding per

patient receiving the procedure. The budget for the forthcoming year has been based on the expected patient throughput, escalated by the Medicare Index. Under Commonwealth policy, once a procedure ceases to have nationally-funded centre status it is included in the Medical Benefits Schedule. Since liver and cardiac transplantation would no longer be covered under the nationally-funded centre arrangements, costing and classification issues were considered to be especially important, given that several States had moved to casemix funding (Antioch, Zhang & Brown 1994).

Recent statistical criteria and design developments

After AN-DRG Versions 3 and 3.1 were released, the Commonwealth continued to refine the classification system (in consultation with key groups) to reflect new diagnosis and procedure codes, new medical technology, and to address problems with clinical and resource homogeneity. The Australian Refined Diagnosis Related Groups (AR-DRGs) Version 4, which use ICD-9-CM codes, have been developed. The new Version 4.1 uses ICD-10-AM codes. Version 4 now includes the following DRGs in the pre-MDC:

- AO1Z Liver transplant
- AO2Z Multiple organs transplant
- AO3Z Lung transplant
- AO4Z Bone marrow transplant
- AO5Z Heart transplant
- AO6Z Tracheostomy, any age, any condition
- A40Z Extra corpeal membrane oxygenation without cardiac surgery
- A41Z Intubation, age less than 16.

There are eight DRGs in the pre-MDC in Version 4, compared to ten in Versions 3 and 3.1 (Commonwealth Department of Human Services and Health 1998).

Statistical criteria

Most DRG classification systems assign patients into groups defined by low-level diagnosis codes and/or surgical codes which are based on clinical meaning resource coherence. Other patient features – such as secondary diagnosis (complications and co-morbidities), malignancy, severity procedures, age and health impairment – contribute to severity of illness. Australian clinicians refer to these factors as complicating clinical factors. These factors are used as classification variables to create more homogeneous DRGs within adjacent DRG clusters. Under Version 3, a hierarchical structure was followed which assumed that a patient's expected length of stay was estimated by the average of all patients in a DRG. The methodology involved splitting DRGs. This was done by sequentially identifying and assessing the most significant factors that added to resource usage. The factors included age, complications and co-morbidity level, and

malignancy as a principal diagnosis. For some DRG partitions, complicating principal diagnosis and certain procedures were also examined. The optimal age to use as a binary partition was determined though analysis of each age. The tree describing the split grew if there was a variable which produced branches, each with at least 200 cases, and explained 5% of the variance. Branches were subsequently collapsed where several terminal nodes had similar average length of stay. New methodology was used for AR-DRG Version 4. This involved splitting adjacent DRGs through multi-variable modelling of all factors that add significantly to resource usage. Therefore all combinations of variables were assessed to determine the most powerful. The combinations involved age range, complication and co-morbidity level, malignancy as a principal diagnosis, complicating principal diagnosis, and certain procedures indicating severity levels (Zhang et al. 1996).

Conclusion

The development of AN-DRGs by the Commonwealth was comprehensive and timely. We are seeing the ripening of a world leader in casemix classification systems in several clinical areas (Antioch et al. 1998). The improved classification characteristics for transplants designed by the ACCC and Technical Reference Group for Version 3 and 3.1 AN-DRGs have generally been carried over into the more recently developed AR-DRGs, which were made available to all States by the Commonwealth last year. Most States, excluding South Australia and Queensland, are still using Version 3.1 AN-DRGs, pending a full shift to ICD-10-AM coding and AR-DRGs.

Glossary

Analysis of variance: A statistical test for the equality of several population means using sample averages. Can be used to determine whether individual DRGs are homogeneous and significantly (statistically) different from other DRGs in terms of costs or average length of stay.

Confidence intervals: In determining the average length of stay of DRGs, the reliability of average length of stay estimates is important. The quest is for an interval estimate (that is, a range of values in which the estimated average length of stay lies). A confidence interval is a range of values that has some probability of including the true population. A 90% confidence interval means the probability is 0.90 that the interval determined on the sample could include the true population. When comparing two or more DRGs on average length of stay, if their 90% confidence intervals do not overlap, then it is very likely that these samples were drawn from distinct populations and hence are statistically different (Newbold 1991; Harnett & Murphy 1985).

Coefficient of variation: A measure of the variability in the data, with values typically in the range of 0.3–1.5. It can also be calculated as a percentage. It is calculated by dividing the sample standard deviation by the arithmetic mean.

F-statistic: The F-statistic is equal to the *between group* (or DRG) *mean square* divided by the *within group* (or DRG) *mean square*. Where the ratio is close to 1 we would not doubt the null hypothesis of equality of population means. We would suspect that there is a significant difference between average length of stay of DRGs if the variability of the *between groups* is large compared to the variability *within groups*. This would result in a figure much larger than 1. We would suspect that the null hypothesis is false. The null hypothesis is rejected for large values of this ratio (Newbold 1991).

Reduction in variance (RIV): A measure of the magnitude of variance reduction. It is equal to the *sum of squares between groups* (or DRGs) divided by the *total sum of squares*. The more distinct each group (or DRG) is from other DRGs and the overall mean, the larger is the *sum of squares between groups* and the higher the RIV value. An RIV of 1 (100%) implies that the classification has explained 100% of the variance, RIV values of 0 (0%) mean that no variance has been explained.

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