

Kathryn M. Antioch<sup>1,2</sup> · Michael K. Walsh<sup>1</sup>

<sup>1</sup> Bayside Health, The Alfred Hospital, Melbourne, Australia

<sup>2</sup> Department of Epidemiology and Preventive Medicine, Faculty of Medicine, Monash University, Melbourne, Australia

# The risk-adjusted vision beyond casemix (DRG) funding in Australia

## International lessons in high complexity and capitation

This contribution has two aims. The primary aim is to develop a risk-adjustment system for the casemix (diagnosis-related group, DRG) funding arrangements in Victoria, Australia, to enable funding to more adequately reflect patient severity for conditions relating to State-wide referral services. We discuss how the latest international developments in risk-adjustment methodologies in health financing are enabling the reform of casemix funding by improving equity in funding negotiation outcomes between hospital and State governments. A secondary aim is to identify how new risk-adjustment classification systems and methodologies can facilitate State and Federal government reform via new population based funding models that measure health need between and within States. The first section discusses the Australian health care system and reform context. An important element is casemix (DRG) funding issues and related price issues for base payments per case and the DRG price relativities. The averaging principle inherent in DRG cost weights has resulted in some high-intensity DRG weights being too low for a teaching hospital that is a key State-wide referral service for trauma, cystic fibrosis, heart and lung transplantation and

chronic heart failure. The second section outlines the costing allocation and regression methodology. We provide the results of efficiency benchmarking, DRG deficits and econometric methodologies used to develop the risk-adjusted specified grants (RASG) in the subsequent section. The conceptual framework for their calculation involving adjustments to the standard casemix funding formula, Consumer

Price Index (CPI) and technology change is explored along with the deliberations of a State-wide government-industry committee which has been established to develop risk-adjustment initiatives State-wide. Recent developments in Germany using the Australian AR-DRG classification system and the implications of the current work is explored. A Risk-Adjusted Capitation Funding Model (RACFM)

### Glossary

*Bed-day gap* is a measure used by the HRT. It is a measure of the inlier days beyond the 75th percentile plus the outlier days beyond the outlier trim point. It therefore measures the potential efficiencies that could be obtained if all stays were reduced to the 75th percentile LOS.

*Relative stay index* is the casemix adjusted LOS. Casemix adjustment is achieved by comparing each hospital's number of bed-days with an expected number of bed-days using the Health Round Table in the prior year as the benchmark.

*White heteroskedasticity test* examines whether the error variance is affected by any of the regressors, their squares or their cross-products. It tests whether any heteroskedasticity that is present causes the variance-covariance matrix of the ordinary least squares estimator to differ from its usual formula [25]. The output from the test is an  $F$  statistic and a statistic that has an asymptotic  $\chi^2$  distribution with a number of degrees of freedom equal to the number of regressors and squared regressors in the test regression. Each statistic provides a test of the hypotheses that the coefficients of the variables in the augmented regression are all zero. This is a general test for model misspecification since the null hypothesis underlying the test assumes that the errors are both homoskedastic and independent of the regression, and that the linear specification of the model is correct. Failure on any of these conditions could lead to a significant test statistic. Conversely, a non-significant test statistic is very reassuring since it implies that none of the three conditions is violated [28].

for chronic disease as a complementary modification to casemix funding is discussed. The model is a significant departure from the way in which Health Maintenance Organizations (HMOs) currently operate in the United States and represents an 'equity model' designed for Australia to ensure that Medicare aims are met. Developments in the United States regarding risk-adjusted capitation classification models involving Diagnostic Cost Groups (DCGs) are then considered for population-based funding models for State and national reforms.

## Australian health care system

### Reform context

The Australian health care system involves a federal structure of government, including Commonwealth (national), State and Local tiers. There is a dominant role of private practitioners providing care mainly on a fee-for-service basis but with governments increasingly influencing health service structures through financing arrangements. Australia has universal access to quality medical care via Commonwealth-State funding for Medicare and substantial private funding, especially through private health insurance, regulated and supported by the Federal government to ensure that the system offers some choice, especially for hospital care [34]. Under the National Health Act of 1953 private health insurance covers services not funded under the Medicare programme. Such insurance buys access to private hospitals and choice of medical specialists in private and public hospitals along with ancillary services such as physical therapy and dentistry. During 1995 the federal government passed legislation allowing health insurance plans to contract selectively with physicians and hospitals [48].

The Federal government funds universal benefit schemes for private medical services via the Medical Benefits Schedule and pharmaceuticals via the Pharmaceutical Benefits Scheme. State and Territory governments have the major responsibility for the financing and public provision of health services, including public and psychiatric hospitals under the Medicare, now called Australian Health Care

Agreements (AHCA) between Federal and State governments. Australia's health care system is complex, loosely organized and technically sophisticated. High standards of medical care prevail. Demand-side measures include the introduction of co-payments by consumers for gaps not covered by the government subsidy for health care. Various supply side approaches to containing government outlays include limiting the range of items attracting subsidies under the Medical Benefits Schedule and Pharmaceutical Benefits Scheme, encouraging best practice and budgeting a fixed amount for each person (capitation) as is undertaken by HMOs in the United States and by the United Kingdom [34]. The Federal government has analysed income and expenditure components of the coordinated care trials to assess the expenditure level required to sustain them. It is also considering alternatives to the economic benchmark for the proposed fund pool [24], which was originally determined from historic use, not health need or risk [33]. Governments have promoted competition, emphasized evidence-based medicine, separate purchasers, providers and regulatory functions, primary care and prevention and better systems integration [34]. Advances in risk adjustment are currently being explored as a key mechanism to aid funding reform in Australia at all levels of government from Federal through to initiatives at the State government and health service level. An important element of health care reform in Victoria, one of Australia's largest States, is casemix funding issues impacting on major teaching hospitals.

### Casemix funding arrangements in Victoria

Since 1 July 1993, Victorian public hospitals have been funded on their casemix, which was initially limited to in-patient services. It has since been extended to include subacute and non-in-patient services [5, 31]. The casemix funding formula is updated annually. Hospital separations are coded using the *International Classification of Diseases*, tenth revision. In-patient separations are allocated to DRGs for funding using a modified form of AR-DRG version 4.1, the VIC-DRG4 [31]. Victorian

modifications are only slight and involve changes to grouping criteria for only a few AR-DRGs. Initially, Victorian in-patient casemix funding was based on a variable and fixed model. Since 2000–2001 casemix payments are presented in a single payment rate with allowances for rural areas and differential claw-backs for different levels of under performance. The payment unit is the weighted inlier equivalent separation (WIES). Most separations are classed as 'inliers', meaning that their length of stay (LOS) falls between lower and upper trim points. 'Outlier' separations, with LOS falling outside the lower and upper trim points, are converted into inlier equivalents. The cost weights and LOS trim points are updated annually, which then alters the WIES value for a given LOS in a particular DRG [31].

The WIES value for a separation is derived by converting each separation into an 'inlier equivalent' and multiplying that by a cost weight. The cost weight is also multiplied by the standard (WIES) payment per inlier equivalent and the payment of the separation is claimed from the Department of Human Services (DHS). The additional payment per diem for a high outlier in a specific DRG is based on the cost weight applicable for that year, excluding the costs of operating theatres and prostheses. An outlier is converted into an inlier equivalent by adding a per diem payment for high outlier days (i.e. those above the boundary point) to the inlier payment. The per diem payment for the high outlier is further adjusted by 0.7 for surgical and 0.8 for medical DRGs. A final adjustment for high outlier weight payments may be made to distinguish rural and urban hospitals [47].

During 2001–2002 hospital in-patient funding was capped by setting WIES targets. Each hospital was allocated a quantum of WIES known as target A. The hospital received full funding for in-patient activity up to the levels of target A and funding at a marginal rate up to WIES target B. Target B was set at 5% of the total WIES allocation for metropolitan hospitals and 3% for rural hospitals [31]. Recently, during 2002–2003, target calculation was revised so that there are now no separate targets A and B. WIES targets were paid at the standard rate of \$2,515.

The public WIES rate varies in accordance with the size and nature of the provider between \$2,515 and \$2,788. The latter rate relates to the rurally adjusted rate for smaller hospitals [47].

Other features of in-patient casemix funding include adjustments for mechanical ventilation, Aboriginal and Torres Strait Islander (ATSI) patients; new technologies and specified grant payments for services that are highly specialized and not easily funded on a casemix basis. During 2002–2003 several co-payment adjustments were incorporated into WIES calculations. The formula for calculating WIES during 2002–2003 was:

$WIES_{10} = \text{base\_WIES} + \text{mv\_copay} + \text{th\_copay} + \text{AAA\_copay} + \text{ASD\_copay} + \text{colonocopy} + \text{ATSI\_WIES}$   
where: base\_WIES=determined by

DRG, LOS and related category (same day, one day or multiday), inlier equivalence (inlier, low outlier or high outlier) and number of mechanical ventilation days; mv\_copay=mechanical ventilation co-payment; th\_copay=thalesaemia co-payment for code D56.x or D57.2; AAA\_copay=stent co-payment: endoluminal repair of an aortic aneurysm (AAA stent); ASD\_copay=payment for use of an atrial septal defect (ASD) closure device; colonocopy=colonoscopy co-payment: gastroscopy patients also receiving colonoscopy; ATSI\_WIES=Aboriginal and Torres Strait Islander loading [47].

Victorian government hospital funding policy also embraces non-admitted patients, sub-acute and non-acute care, purchasing arrangements with the private sector, teaching, research and capital funding, performance bonuses and coding audits [31]. The Victorian government is examining alternative funding models, consistent with integrated and coordinated care to develop a comprehensive purchasing model [46]. A risk-adjusted capitation funding model has been developed for cystic fibrosis patients treated by an Australian HMO to facilitate greater efficiency and equity in Victoria's health system [1, 3]. The integration of cost-effective best practice evidence into clinical practice guidelines and protocols for conditions such as cystic fibrosis further

reinforces the move towards greater efficiency [8, 9] and can facilitate cost-effectiveness when used with the capitation funding model.

### Price issues: base payments per case and AR-DRG price relativities

If casemix policy is to maintain credibility, the funding arrangements must respond to changes in the cost structure of hospitals and meet increases in demand [2]. The Prospective Payment Assessment Commission in the United States advises on 'update factors' to incorporate changes in inflation and technology [14]. The Victorian DHS has forecast State level hospital expenditure, providing important input into funding negotiations with the State Treasury about State-wide hospital funding [2]. One of these models developed by Antioch et al. [7] for the Acute Health Division of DHS found that Victorian State Gross Product, population under 4 years, mix of public and private patients in public hospitals, introduction of casemix funding and funding cuts, State-wide proportion of public beds to total beds and technology significantly impacted on expenditure. These results, along with projections of population and Consumer Price Index (CPI), were used by DHS to forecast Victorian hospital expenditure for 1997–1998 to 2000–2001. They were also used for internal budget allocation within DHS [7].

Duckett [14] emphasizes that a critical element is the level of the absolute dollar amount that is paid for the average cost. For a system of case payment to be acceptable to a hospital this base amount must be accepted as being set at an appropriate, achievable standard. As casemix funding was introduced in Victoria in the context of severe budget restrictions, with subsequent reductions, this aspect of casemix funding requires careful monitoring. Although the price relativities for casemix funding (the weights) are set using data for Victorian hospitals, the actual base payment per case is essentially determined on a normative or policy basis rather than benchmarking. There is a risk that the price may not be set at an achievable level consistent with quality standards [14]. Threat of malpractice, physician prac-

## Abstract

Eur J Health Econ 2004 · 5:95–109  
DOI 10.1007/s10198-003-0208-z  
© Springer-Verlag 2003

Kathryn M. Antioch · Michael K. Walsh

### The risk-adjusted vision beyond casemix (DRG) funding in Australia. International lessons in high complexity and capitation

#### Abstract

Hospitals throughout the world using funding based on diagnosis-related groups (DRG) have incurred substantial budgetary deficits, despite high efficiency. We identify the limitations of DRG funding that lack risk (severity) adjustment for State-wide referral services. Methods to risk adjust DRGs are instructive. The average price in casemix funding in the Australian State of Victoria is policy based, not benchmarked. Average cost weights are too low for high-complexity DRGs relating to State-wide referral services such as heart and lung transplantation and trauma. Risk-adjusted specified grants (RASG) are required for five high-complexity respiratory, cardiology and stroke DRGs incurring annual deficits of \$3.6 million due to high casemix complexity and government under-funding despite high efficiency. Five stepwise linear regressions for each DRG excluded non-significant variables and assessed heteroskedasticity and multicollinearity. Cost per patient was the dependent variable. Significant independent variables were age, length-of-stay outliers, number of disease types, diagnoses, procedures and emergency status. Diagnosis and procedure severity markers were identified. The methodology and the work of the State-wide Risk Adjustment Working Group can facilitate risk adjustment of DRGs State-wide and for Treasury negotiations for expenditure growth. The Alfred Hospital previously negotiated RASG of \$14 million over 5 years for three trauma and chronic DRGs. Some chronic diseases require risk-adjusted capitation funding models for Australian Health Maintenance Organizations as an alternative to casemix funding. The use of Diagnostic Cost Groups can facilitate State and Federal government reform via new population-based risk adjusted funding models that measure health need.

#### Keywords

Hospital funding · Risk adjustment ·  
Diagnosis-Related Groups ·  
Diagnostic Cost Groups · Casemix funding

tice patterns and patient expectations constrain the elasticity of supply in the short run [20]. How quickly this inertia is overcome depends in part on the strength of the control structures of the health care system and the size of the budget cuts [14].

The averaging principle inherent in cost weights in Victoria has resulted in some Australian DRG weights being too low for The Alfred Hospital, which is a State-wide provider of services for trauma, cystic fibrosis, heart and lung transplantation and chronic heart failure. Such high complexity patients can be treated under Australian DRGs for conditions relating to these services, with procedure and diagnosis severity markers rendering the patients more costly to treat relative to other hospitals' patients in the same DRG. This results in inappropriate underfunding from the State government, which can be addressed by RASG. Antioch and Walsh [2] highlighted the case for high severity/complexity flow-on effect for State-wide referral services for trauma, impacting on AN-DRG 23 (craniotomy with complications and co-morbidities) and AN-DRG 3 (tracheostomy except for mouth, larynx or pharynx disorders with age over 15 years). The Alfred Hospital had successfully negotiated RASG totalling around \$14 million since 1998–1999 for these DRGs and also cystic fibrosis (AN-DRG 173) [2, 3].

For casemix payments to be acceptable the average price and cost weights must be set at an appropriate standard; otherwise inappropriate under-funding in the face of cost effective service provision can reduce distributional justice. The general pursuit by economic rationalists of efficiency as the only 'policy' relevant value and the consequential neglect of altruism and other moral behaviours is a short-sighted strategy with long-term negative consequences [23]. From the perspective of a large teaching hospital the pursuit of equity in addition to efficiency would involve the principle of a fair price that would cover the costs of the efficient provider plus allow 'normal profit'. It would also enable a sustainable provider industry, avoid the need for cross-subsidization between hospital services and avoid the need for additional specified grants [2]. The DRG formula attempts to

include adjustments for complexity, age, sex and outliers. However, the underfunding that has occurred can potentially impact on quality of care. If a hospital's key aim is to maintain the highest quality of care, RASG may be the best solution.

The need to craft a payment mechanism for hospitals that provides for the legitimate operating needs of efficient institutions is an enduring health policy dilemma also facing the United States [12, 27]. Problems have emerged with the prospective payment system used by Medicare and other US payers which have been criticized for not adjusting for differences in severity within DRGs. Many studies have examined the relationship between profitability and illness severity at the hospital level (for review see [12]). Carpenter et al. [12] found that two measures of severity, i.e. the number of unrelated diseases and disease stage, are significant predictors of cost per case and often have better predictive power than DRGs. In the majority of instances payers did not compensate adequately for severity, and higher values for the severity variable therefore resulted in financial losses for the hospital. We turn now to the case developed for high complexity respiratory, cardiology and stroke DRGs related to State-wide referral services.

### Risk-adjusted specified grants: high-complexity DRGs

#### Methodology

#### Selection of deficit DRGs and links to State-wide referral services

An analysis of all DRGs across the hospital during 1999–2000 and 2000–2001 was undertaken to determine the entity profit/loss. This incorporated all costs incurred and revenue from WIES-funded activity and allocation of all fixed, variable, specified and Traffic Accident Commission (TAC) grants. Rationale for "DRG choice" is the substantial deficit in the earlier benchmarking/cost weight year and the subsequent year, inadequate compensation through 2001–2002 casemix formula changes, with links to State-wide referral services of transplantation, heart failure and trauma. Five DRGs were selected relating to respiratory, cardiology and

stroke, with total deficits of \$3.6 million. Two significant trauma (orthopaedic) DRGs were also identified at a total deficit of \$0.7 million; and are beyond the scope of the current contribution.

#### Cost allocation methodology

The general method of cost allocation to derive the cost bucket data was developed by the Health Round Table (HRT), Australian and New Zealand Chapters, involving over 20 major teaching hospitals. For The Alfred Hospital, full costs were attributed to in-patient care, and no reduction was made for reimbursement of teaching and hospital costs. The overhead costs are support services attributed to a patient care service where there is no direct charging by the support units. These include hospital management, finance, human resources, sterile services, information technology, engineering, building services, cleaning, fuel, light and power. Direct costs include all costs of performing the service and managing the service, such as department heads and administrative staff. There is provision for depreciation to be included as a separate bucket, but it is not used by many hospitals, including The Alfred Hospital. Capital charges, buildings and interest costs were also excluded. Superannuation, workers' compensation and other on-costs were included within buckets. Costs per patient were included in the cost buckets outlined in **Table 1**, which were split into direct and overhead costs. The costs for 13 cost buckets were summed to derive a total bucket calculation. The cost allocation method specifying components of cost buckets and application of resource intensity weighting factors to total operating costs in the general ledger for each service is outlined in **Table 1**.

#### Design: multiple regression analyses for risk adjustment

An excellent overview of methodological issues relating to risk adjusted funding for competitive health plans such as HMOs is provided by Van de Ven and Ellis [45] and have guided developmental work relating to Australian HMOs [1, 3]. Van de Ven and Ellis' [45] presentation of econometric techniques and statistical design for risk adjustment is relevant to the cur-

Table 1

Cost allocation method	
Cost bucket components	Resource intensity weighting
<i>Allied health</i> : allied health staff providing in-patient care and associated consumables and supplies	Minutes of care
<i>Operating room management</i> : theatre staff, infusion/bypass and operation consumables	Minutes of care
<i>Specialized procedural services</i> : procedure area staff, consumables for operations used in day surgery, hyperbaric, cardiac catheter laboratories, endoscopy, lithotripsy, radiotherapy sleep laboratories	Weighted procedure treatment types; fractional bed-days
<i>Anaesthetics</i> : Supply and staffing costs.	Theatre minutes
<i>Implantable prostheses</i> : artificial joints and limbs, pacemakers and hearing aids	Weighted prosthetic items, purchase costs
<i>High-dependency costs</i> : coronary care unit, high-dependency unit and intensive care unit services	Length of stay in intensive care unit and coronary care unit
<i>Ward</i> : nurses and other ward staff, ward consumables and high dependency services	Length of stay in ward
<i>Imaging</i> : medical, scientific, nursing, administrative staff, and supplies involved in providing this in-patient service	Weighted procedure type
<i>Pathology</i> : as above	Weighted pathology type
<i>Pharmacy</i> : as above	Stock price of prescription drugs–Imprest pharmacy; ward bed-days
<i>Medical and surgical services</i> : medical, surgical consultants, visiting staff, registrars, resident medical officers and associated staff, supplies and consumables	Bed-days
<i>Emergency</i> : medical, nursing, administrative and other staff assigned to the emergency department, consumables and observation ward costs in the emergency department	Triage category minutes
<i>Other services</i> : other staff involved in patient care where the hospital assigns catering, housekeeping, admissions, medical records and in-patient related portering	Bed-days (foodservices); admissions, discharges, appointments

rent work and was also applied by Antioch and Walsh [2] to successfully develop high complexity RASG for trauma and cystic fibrosis AN-DRGs. The RASG are determined by minimizing the prediction error of hospital expenditure. Shen and Ellis [44] identify three functional forms commonly applied to predict health care expenditure. The simplest is a linear model estimated by ordinary least squares regression analysis.

Other functional forms deal with health expenditure skewness: non-linear (e.g. log) transformations of dependent variables [30], and two-part models of health spending by Duan et al. [13]. Shen and Ellis [44] emphasize that both non-linear approaches lead to biased estimation under heteroskedasticity [32] and Manning [29]. As sample size becomes

large, the simple linear model may perform as well as the other two (Ellis and Azzone, unpublished, 1998). Linear models are close to the cell based approach used in practice to calculate average expenditure per risk group. Shen and Ellis [44] used linear model and the ordinary least squares regression for their large sample sizes. Ellis and Azzone (unpublished, 1998) also prefer simple linear regression models, and most risk adjustment models have used them and adjusted for heteroskedasticity using the Huber-White formula [45]. In the current study linear regression was used, and heteroskedasticity was adjusted using the White formula [25, 28].

Five separate multiple regression analyses were undertaken for AR-DRGs F42A (circulatory disorders without acute myo-

cardial infarction (AMI) with invasive procedures complicating diagnosis/procedures), F42B (circulatory disorder without AMI with invasive procedures without complicating diagnosis/procedures), B70A (stroke with severe or complicating diagnosis/procedures), E62A (respiratory infections/inflammation with catastrophic complications and comorbidities), E65A (chronic obstructive airways disease with catastrophic/severe complications and comorbidities). Cost per patient was the dependent variable. Independent variables for the five multiple regressions were sex, age, emergency, LOS outlier, number of diagnoses, procedures and disease types (body systems) and complexity. Step-wise linear regression excluded nonsignificant variables. Data were assessed for heteroskedasticity, multicollinearity, structure stability and functional form. The equations generally took the following form, which are defined in **Table 2**:  $\text{CostPP} = \beta_0 + \beta_1(\text{Age}) + \beta_2(\text{Emergency}) + \beta_3(\text{Outlier}) + \beta_4(\text{Complexity}) + \beta_5(\text{Diagnoses}) + \beta_6(\text{Procedures}) + \beta_7(\text{Sex}) + \beta_8(\text{Disease types}) + e$ .

The costing data used in the study, including cost per patient and the independent variables to assess cost drivers, was based on Health Round Table (HRT) data (see Tables 1, 2). The HRT data for The Alfred Hospital is based on costing data routinely provided by the hospitals to the Victorian Department of Human Services for its annual cost weight study.

The measure for the complexity variable involves the Patient Clinical Complexity Level (PCCL) which is used for grouping AR-DRGs in Australia. It is based on the cumulative effect of a patient's complications and comorbidities and is calculated for each episode. The complexity variable was excluded from the specification for DRG E62A as all patients were high-complexity cases. The emergency variable was excluded from DRG B70A specification as virtually all were coded as emergency cases. Diagnostic tests were checked for heteroskedasticity, multicollinearity, structural stability, normality and functional form. A general specification was used. The model was chosen because it was considered the best fit of the data after the process of excluding all nonsignificant independent variables. This

Table 2

**Definition of all variables**

Variable	Definition
CostPP	Cost per patient
Age	Patient age
Emergency	Dummy variable: '1' if patient admitted through emergency department, otherwise '0'
Outlier	Dummy variable: '1' if patient an outlier on length of stay, otherwise '0'
Complexity	Dummy variable: '1' if patient classified as high-complexity case (PCCL), level 3 or 4, otherwise '0' for DRGs F42A F42B, B70A; '1' if 4, '0' if 3 on DRG E65A
Diagnoses	Number of diagnoses
Procedures	Number of procedures
Disease types	Number of body systems
Sex	Dummy variable: '1' if male, otherwise '0'; gender of patient

Table 3

**Multiple regression results. All analyses were adjusted for heteroskedasticity except for AR-DRG E62A**

DRG B70A: stroke with severe or complicating diagnosis/procedure	CostPP=5610 ( $\beta_0$ ) +23390 (outlier) +970 (disease types) +e Adj. $R^2$ =0.64, $SE_{reg}$ =7240.04, $F$ =71.40, $P$ <0.001 ( $n$ =81)
E62A: respiratory infections, inflammation with catastrophic complications and comorbidities	CostPP=6950 ( $\beta_0$ ) -70 (age) +14070 (outlier) +1440 (procedures) +e Adj. $R^2$ =0.5185, $SE_{reg}$ =5690.59, $F$ =50.90, $P$ <0.001 ( $n$ =140)
E65A: chronic obstructive airways disease with catastrophic or severe complications and comorbidities	CostPP=1030 ( $\beta_0$ ) +7190 (outlier) +1350 (procedures) +380 (disease types) +e Adj. $R^2$ =0.51, $SE_{reg}$ =3386.09, $F$ =82.69, $P$ <0.001 ( $n$ =235)
DRGs F42A: circulatory disorder without acute myocardial infarction with invasive procedures with complicating diagnosis/procedure	CostPP=3660 ( $\beta_0$ ) +5140 (outlier) +620 (disease types) +e Adj. $R^2$ =0.20, $SE_{reg}$ =2896.53, $F$ =27.20, $P$ <0.001 ( $n$ =216)
F42B: circulatory disorders without acute myocardial infarction with invasive procedures without complicating diagnosis/procedure	CostPP=5460 ( $\beta_0$ ) -20 (age) -1820 (emergency) +250 (diagnoses) +e Adj. $R^2$ =0.06, $SE_{reg}$ =2800.017, $F$ =11.30, $P$ <0.001 ( $n$ =517)

method was based on the 'top down' approach where nonsignificant independent variables are gradually excluded on a step-by-step basis, that is, by stepwise linear regression. Each exclusion step involves running a number of regressions with different variable combinations to identify variables that are nonsignificant in all circumstances. When a variable was found to be nonsignificant across a wide range of model specifications, it was excluded. The  $t$  statistic was used to decipher which variables were nonsignificant at 95% level of

confidence (that is,  $t > 1.65$ ). The overall significance of the model was also considered in view of the  $F$  and  $R^2$  statistics for the various combinations of explanatory variables. Benchmarking analyses were also undertaken to analyse the inter-relationship between the hospital's efficiency and casemix complexity vis-à-vis other major teaching hospitals in Australia and New Zealand. The results of these analyses were considered in light of the size of the funding deficits experienced by the hospital. Benchmarking compar-

isons were made between 11 hospitals of the HRT in Australia and New Zealand.

**Severity marker data**

Severity markers were identified for the 15 most expensive patients in each DRG. The severity marker data were obtained from DRG attestation reports produced by the Medical Records Department of The Alfred Hospital. These reports document for each patient during a specified episode of care all principal and secondary diagnosis and procedure codes and their definition. The complete lists of patient-specific codes were discussed with the medical opinion leaders who identified the severity marker codes associated with the hospital's State-wide referral services and which would be unlikely to occur in patients in the same DRG in other hospitals in the State. This assists in identifying the relative cost disadvantage of Alfred Hospital vis-à-vis other major teaching hospitals.

**Results****Multiple regression**

The results of the analysis are presented in Tables 3 and 4. The model for DRG B70A (stroke with severe or complicating diagnosis/procedure) explained 64% of the variance in per patient costs, with the number of disease types and LOS outliers being significant cost drivers. The financing gap of \$435,542 was attributable mainly to the state-wide service for trauma and neurosurgery. The expensive patients had severity markers of intracerebral and subarachnoid haemorrhages and ventilatory support for 24–96 h. Alfred Hospital attracts very complex haemorrhage strokes due to its helicopter availability for State-wide trauma services. High complexity was also reflected in the hospital having the highest proportion of emergency admissions (99%) and an average cost higher by \$6,636 than the benchmarking group. Only 19% of separations accounted for an astounding 45% of total costs, and the bed-day gap for the DRG was higher than all HRT at 23% given the patient complexity. Higher costs were due mainly to medical, ward and allied health.

For DRG E62A (respiratory infections/inflammation with catastrophic

Table 4

### Benchmarking and severity markers

	Benchmarking	High cost patients: severity markers, 15 most expensive patients
DRGB70A: stroke with severe or complicating diagnoses or procedures	The financing gap for 2001–2002 was \$435,542. State-wide referral service for trauma and neurosurgery. Highest proportion of patients with high-complexity score (PCCL 4), 60%. Emergency admissions (99%) 2 percentage points higher than for all HRT. Average cost of \$14,860 was \$6,636 higher than for all HRT. Length of stay 23.3 days, longer by 7.4 days than HRT. Bed-day gap of 23% was higher than all HRT (13%).	19% of the separations accounted for 45% of total costs. Severity markers: <i>Principal diagnoses</i> : intracerebral, subarachnoid haemorrhages. <i>Procedure</i> : continuous ventilatory support for 24–96 h. Complex haemorrhage strokes treated due to helicopter availability, transporting patients State-wide for trauma and high level ICU and neurosurgery. Length of stay 29–95 days; 6–12 procedures; 4–12 diagnoses; 80% had PCCL 4; 80% were outliers on length of stay; 93% were emergency cases.
E62A: respiratory infections, inflammation with catastrophic complications and comorbidities	Financing gap for 2001–2002 was \$334,948. State-wide referral service for lung transplantation, chronic heart failure, and cystic fibrosis. 74% of episodes with a principal diagnosis of pneumonia, higher than HRT (52%). Much higher proportion of cases with a secondary diagnosis of chronic heart failure (36% vs. 32%). Highest average cost of \$7,503 higher by \$1,457 than HRT. Much higher same-day caseload (10%) than HRT (3%). Much lower relative stay index (85% vs. 97% for HRT), i.e. casemix adjusted length of stay. Bed-day gap was equal to the HRT (12%).	11% of the separations accounted for 37% of total costs. Severity markers: <i>Principal diagnoses</i> of pneumonia due to either staphylococcus or pseudomonas; legionnaires disease. <i>Principal procedure</i> : injection of gamma globulin, computed tomography of brain and chest, bronchoscopy and therapeutic thoracentesis. <i>Co-morbidities</i> : left ventricular failure and congestive heart failure, primary pulmonary hypertension, acute respiratory failure and bronchectasis. Selective deficiency in immunoglobulin G subclass with bronchectasis and legionnaires with end-stage renal disease. Length of stay 8–88 days; up to 12 procedures and 12 diagnoses; all had PCCL 4; 40% were outliers on length of stay; 87% were emergency cases.
E65A: chronic obstructive airways disease with catastrophic or severe complications and comorbidities	Funding gap for 2001–2002 was \$520,265. Linked to State-wide referral service for: lung, heart and bone marrow transplantation, immunology and chronic heart failure clinic. Casemix complexity (PCCL) higher at 3.45 than 3.44 for HRT. Second highest proportion of cases with principal diagnosis of bronchiectasis (11%) vs. 8% for HRT. Bronchiectasis is linked to State-wide referral service for cystic fibrosis, transplantation and immunology. Ranked 4th on percentage of patients with chronic heart failure as a secondary diagnosis (28%) vs. 25% for HRT. This co-morbidity, when occurring with chronic obstructive airways disease, is often associated with pre-lung transplantation patients. High average costs of \$5,862 relative to \$4,331 across HRT. Same-day cases: 15% vs. 4% for HRT. Length of stay was lower (6.8 vs. 7.8 for HRT.) Bed-day gap only 2% vs. 11% for HRT. Relative stay index was 81% vs. 97% for HRT.	6% of the separations accounted for 20% of the costs. Severity markers: <i>Principal procedures</i> : insertion of intercostal catheter for drain; percutaneous central vein catheterization; bilevel positive airway pressure; percutaneous biopsy of bone marrow and computed tomography of chest. <i>Principal diagnosis</i> : bronchiectasis. <i>Co-morbidities and complicating procedures</i> : State-wide referral services for lung, heart, and bone marrow transplantation and chronic heart failure. <i>Pseudomonas</i> , acquired absence of part of lung, congestive heart failure, unstable angina, left ventricular failure, angina pectoris, heart and lung transplant status, pneumonia in mycoses, failure and rejection of lung, surgical operation with transplant of whole organ, lung transplant status, pneumonia due to <i>Pseudomonas</i> or <i>Staphylococcus</i> acute myocardial infarction, bilevel positive airway pressure, non-familial hypogammaglobulinaemia which require the allergy/asthma clinic and can lead to bronchiectasis. This requires the expertise in cystic fibrosis and lung transplantation physicians. Some patients with bilevel positive airway pressure are on the waiting list for lung transplantation. Length of stay: 12.5–30 days; they had up to 8 procedures and 11 diagnoses; 9 had PCCL 4, and another 6 had PCCL 3; 20% were outliers on length of stay; 60% were emergency cases.

complications and comorbidities) the independent variables of age, LOS outliers and number of procedures were variables significantly impacting on costs. The model explained 52% of the variance. The financing gap of \$334,948 was attributable mainly to the State-wide services for lung transplantation, chronic heart failure and

cystic fibrosis. Only 11% of separations accounted for 37% of costs. Of these high cost cases, severity markers linked to these State-wide referral services were principal diagnosis of pneumonia due to either *Staphylococcus* or *Pseudomonas* infection and Legionnaires' disease. Principal procedure markers were injection of gamma

globulin, computed tomography of brain and chest, bronchoscopy and therapeutic thoracentesis. Severity co-morbidities were left ventricular failure and congestive heart failure, primary pulmonary hypertension, acute respiratory failure and bronchectasis. Selective deficiency in immunoglobulin G subclass with bronchec-

Table 4 (Continued)

## Benchmarking and severity markers

	Benchmarking	High cost patients: severity markers, 15 most expensive patients
F42A: circulatory disorder without acute myocardial infarction with invasive procedures with complicating diagnoses or procedures	Financing gap for 2001–2002 was \$508,544. State-wide referral service for heart failure and heart transplantation. 54% of its caseload high complexity (PCCL 2, 3, 4) which was 8 percentage points higher than for all HRT. Average PCCL was 1.47 vs. 1.21 for HRT. Second highest proportion of congestive heart failure patients (6% vs. 3%) and a lower proportion of angina patients relative to all HRT (56% vs. 63%). High average costs of \$5,380 vs. \$3,815 for all HRT. Length of stay was 3.6 days vs. 4 across HRT. Much lower bed-day gap at 6% being 9 percentage points lower than HRT. Much higher proportion of same-day cases (45%), higher by 16 percentage points relative to HRT.	7% of separations accounted for 16% of costs. Severity markers: <i>Procedures</i> : coronary angiography with left and right heart catheter; Bx myocardium by cardiac catheterization; right heart catheterization; bone densitometry dual-energy radiography at least two sites. <i>Diagnosis severity markers</i> : congestive heart failure, dilated cardiomyopathy, left ventricular failure, cardiomyopathy unspecified and ischaemic cardiomyopathy. <i>Co-morbidities and complications</i> : ischaemic cardiomyopathy, left ventricular failure, primary pulmonary hypertension, endocarditis valve unspecified, ventricular tachycardia and dilated cardiomyopathy. Length of stay ranged from 0.5 to 34 days; up to 11 procedures and 12 diagnoses; 80% had PCCL 3 or 4; 47% were outliers on length of stay; 73% were emergency cases.
F42B: circulatory disorders without acute myocardial infarction with invasive procedures without complicating diagnoses or procedures	Financing gap for 2001–2002 is \$1,772,557. State-wide referral service for heart transplantation and chronic heart failure. Four of Alfred Hospital's high cost patients had heart transplantation status; three had already been transplanted, the other subsequently had a heart transplant but suffered failure and rejection. 32% of cases with a principal diagnosis of angina pectoris unspecified, much higher than HRT at 23%. Highest proportion of cases 91% with conditions requiring coronary angiography with left heart catheterization vs. only 80% for HRT. High average costs of \$4,836 which was higher by \$2,546 relative to HRT. Very high proportion of same-day cases (80% vs. 55% for HRT). Performed significantly better on relative stay index, length of stay and bed-day gap. Length of stay was 0.9 vs. 1.4 for HRT. Relative stay index was 73% for Alfred Hospital vs. 99% for all HRT. The bed-day gap was only 25% vs. 33% for HRT.	3% of the separations accounted for 7% of the costs. Severity markers: <i>Principal diagnosis</i> : ischaemic cardiomyopathy. <i>Principal procedures</i> : Coronary angiography with left and right heart catheterization and also right heart catheterization which can be very expensive. 27% of these high cost patients had heart transplantation status. Length of stay: 0.2–12 days; 2–11 diagnoses; 1–12 procedures; 67% were PCCL 2 or higher; 27% were outliers on length of stay; 13% were emergency patients.

tasis and Legionnaires' disease with end-stage renal disease also impacted. In 74% of cases there was a principal diagnosis of pneumonia much higher than the group, by 22 percentage points. Although the average cost across the DRG was higher than the average by \$1,457, The Alfred Hospital had very high efficiency, with same-day cases being 7 percentage points higher and a Relative Stay Index lower than the group by 12 percentage points. Higher costs were attributable mainly to drug costs.

For DRG 65A (chronic obstructive airways disease with catastrophic or severe complications and comorbidities), LOS outliers, number of procedures and disease types were significant cost drivers. The model explained 51% of the variance in costs. The funding gap of \$520,265 was attributable mainly to the State-wide refer-

ral service for lung, heart and bone marrow transplantation, immunology and chronic heart failure clinic. Six percent of cases contributed to 20% of costs. Of these high cost cases some with the severity marker bilevel positive airway pressure were on the Hospital's waiting list for a lung transplant. Other severity markers included principal procedure of percutaneous biopsy of bone marrow and principal diagnosis of bronchiectasis. Severity co-morbidities were *Pseudomonas*, acquired absence of part of lung, congestive heart failure, unstable angina, left ventricular failure, angina pectoris, heart and lung transplant status, pneumonia in mycoses, failure and rejection of lung, surgical operation with transplant of whole organ, lung transplant status, pneumonia due to *Pseudomonas* or *Staphylococcus*, AMI and nonfamilial hypogammaglobu-

linaemia. Although the average cost for the DRG was higher by \$1,531, the Hospital was relatively more efficient with the same-day cases being 11 percentage points higher than the group, LOS lower by 1 day, bed-day gap lower by 9 percentage points and Relative Stay Index lower by 16 percentage points. Higher costs were mainly attributable to medical, wards, allied health, pathology, imaging and pharmacy.

The model for DRG F42A (circulatory disorders without AMI with invasive procedures with complicating diagnosis/procedure) explained 20% of the variance in costs, with number of disease types and LOS outliers significant cost drivers. The funding gap of \$508,544 was attributable mainly to the State-wide referral service for heart failure and heart transplantation. Seven percent of cases accounted for 16% of costs. These high cost cases had



related severity procedure markers including coronary angiography with left and right heart catheter, Bx myocardium by cardiac catheterization, right heart catheterization, and bone densitometry dual-energy radiography of two or more sites. Diagnosis severity markers were congestive heart failure, dilated cardiomyopathy, left ventricular failure, cardiomyopathy unspecified and ischaemic cardiomyopathy. Severity co-morbidities and complications were ischaemic cardiomyopathy, left ventricular failure, primary pulmonary hypertension, endocarditis valve unspecified, ventricular tachycardia and dilated cardiomyopathy. Although the average cost in the DRG was higher by \$1,565, the Hospital was highly efficient, with the bed-day gap being 9 percentage points lower than the group and same-day cases being 16 percentage points higher. This was astounding considering that 54% of the hospital's casemix was rated as high complexity (PCCL levels 2–4), being 8 percentage points higher than the group. Higher costs were mainly attributable to special procedures used in the operating suite.

The model for DRG F42B (circulatory disorders without AMI with invasive procedures without complicating Diagnosis/procedures) explained 6% of the variance. Clearly key factors unable to be captured by the multiple regression frameworks, such as linkage to transplantation requirements impact on the model and major co-morbidities such as cardiomyopathy. Perhaps further models can include the presence of various severity markers as dummy variables to determine their explanatory capacity. The negative coefficient for emergency (lower cost) related to only 67 cases (i.e. 13% of the entire caseload). Many of these patients were admitted through the emergency department with a principal diagnosis of unspecified chest pain and had a coronary angiography with left heart catheter undertaken. Further regression analyses were undertaken on this DRG, indicating that this DRG may require revised grouper criteria. The financing gap of \$1,772,557 was attributable mainly to the State-wide referral service for heart transplantation and chronic heart failure. Four of the high cost patients had heart transplantation status.

Three had already been transplanted. The other subsequently had a heart transplant but suffered failure and rejection. Three percent of the cases in the DRG accounted for 7% of the costs. In these high-cost patients the severity markers included principal diagnoses of ischaemic cardiomyopathy and principal procedures of coronary angiography with left and right heart catheterization and right heart catheterization, which can be very expensive. Of these high-cost patients 27% had heart transplantation status. Although the average cost in the DRG was higher by \$2,546, the relative efficiency was very high, with same-day cases being 25 percentage points higher than the group. The Relative Stay Index was lower by 26 percentage points, with the bed-day gap being lower by 8 percentage points. Higher costs were attributable mainly to the direct costs of special procedures in the operating room.

## Discussion

The results of the multiple regression analyses presented above can be used for risk adjustment of high-complexity DRGs and provides supporting evidence about high casemix complexity and efficiency. Outlined below is the method of calculating the RASG for the five DRGs based on the regression results and implications of the findings for Australia and Germany. We then briefly discuss complementary modifications to casemix funding for chronic diseases such as cystic fibrosis via State-wide disease-specific Risk Adjusted Capitation Funding Models (RACFM). The secondary aim of the contribution is to consider broader risk adjustment arrangements for State and Federal government reform, including population-based funding models. In this regard we consider how State-wide disease-specific Risk Adjusted Capitation Funding Models might be further enhanced by using the United States' system of DCGs. DCGs use multi-site diagnostic profiles, medical history over time and patient demographics to predict costs. They are associated with risk-severity scores that can better estimate disease burden and can be extended beyond in-patient care to include community services and pharmaceuticals. DCGs can fur-

ther enable risk-adjustment reform in Australian States such as Victoria and New South Wales through new population-based fund-holding models for area health services. Finally, initiatives to risk adjust Federal funding processes using DCGs could be applied to the coordinated care trials and also to measure health need and disease burden for the growth index of the AHCA. All States and Territories have called for the federal government to improve this growth index in the context of the current renegotiation of the AHCA. This could assist allocation of funds between and within States over time. We turn first to the method of calculating the RASG for the five high complexity DRGs analysed in the study.

## Risk-adjusted specified grant calculations

The final size of the net RASG payable by DHS to The Alfred Hospital for each of the five DRGs would be based, in part, on a payment level determined for each patient from the risk adjustment formulas identified above and summed across all patients for the previous year within each AR-DRG to arrive at a total payment called the Full Risk-Adjusted Payment (FRAP). The difference between this AR-DRG calculation for FRAP and the amount that would be payable through the standard casemix funding formula would comprise the final net actual level of the final RASG for the AR-DRG. For example, for a patient admitted under AR-DRG E65A (chronic obstructive airways disease with catastrophic or severe complications and comorbidities) the amount calculated for the FRAP for that admission would be based on the following formula:

$$FRAP_e = \sum_{i=1}^n [\$1030(\beta_o) + \$7190(Outlier_{ie}) + (\$1350 * Procedures_{ie}) + (\$380 * DiseaseTypes_{ie})]$$

where:  $FRAP_e$  = FRAP in DRG<sub>e</sub>;  $n$  = total number of patients;  $\beta_o$  = constant,  $y$  intercept-base rate payment for DRG<sub>e</sub>;  $Outlier_{ie}$  = LOS outlier status for patient<sub>i</sub>, DRG<sub>e</sub>;  $Procedures_{ie}$  = number of procedures for

## Infobox

$$\begin{aligned}
 Y = & \beta_0 + \beta_{11} * D_1 BR + \beta_{12} * D_1 LPA + \beta_{13} * D_1 HLT + \beta_{14} * D_1 LT + \beta_{15} * D_1 BIBAP + \beta_{16} * D_1 AGE + \beta_{18} * D_1 SEX \\
 & + \beta_{19} * D_1 PROC + \beta_{110} * D_1 DIAG + \beta_{111} * D_1 DISEASE + \beta_{112} * D_1 LVF + \beta_{17} * D_1 AGE + \beta_{18} * D_1 SEX \\
 & + \beta_{19} * D_1 PROC + \beta_{110} * D_1 DIAG + \beta_{111} * D_1 DISEASE TYPES + \beta_{112} * D_1 COMPLEX + \beta_{113} * D_1 OUTLIER \\
 & + \beta_{114} * D_1 EMERG + \beta_{21} * D_2 BR + \beta_{22} * D_2 LPA + \beta_{23} * D_2 SEX + \beta_{29} * D_2 PROC + \beta_{210} * D_2 DIAG \\
 & + \beta_{211} * D_2 DISEASE + \beta_{24} * D_2 HLT + \beta_{25} * D_2 LT + \beta_{25} * D_2 BIPAP + \beta_{26} * D_2 LVF + \beta_{27} * D_2 AGE \\
 & + \beta_{28} * D_2 SEX + \beta_{29} * D_2 N BIPAP + \beta_{N6} * D_2 N LVF + \beta_{N7} * D_2 N AGE + \beta_{N8} * D_2 N SEX + \beta_{N9} * D_2 N PROC \\
 & + \beta_{N10} * D_2 N DIAG + \beta_{N11} * D_2 N DISEASE + \beta_{N12} * D_2 N PROC + \beta_{N10} * D_2 N DIAG + \beta_{N11} * D_2 N DISEASE TYPES \\
 & + \beta_{N12} * D_2 N COMPLEX + \beta_{N13} * D_2 N OUTLIER + \beta_{N14} * D_2 N EMERG + \dots + \beta_{N1} * D_1 BR + \beta_{N2} * D_1 LPA \\
 & + \beta_{N3} * D_1 HLT + \beta_{N4} * D_1 LT + \beta_{N5} * D_1 BIPAP + \beta_{N6} * D_1 LVF + \beta_{N7} * D_1 AGE + \beta_{N8} * D_1 SEX \\
 & + \beta_{N9} * D_1 PROC + \beta_{N10} * D_1 DIAG + \beta_{N11} * D_1 DISEASE TYPES + \beta_{N12} * D_1 COMPLEX \\
 & + \beta_{N13} * D_1 OUTLIER + \beta_{N14} * D_1 EMERG + D
 \end{aligned}$$

## Where

Y	=Per patient costs
$\beta_0$	=Y intercept
$\beta_{ij}$	=array of coefficients, one set for each of j hospitals
$D_1 BR$	=Dummy variable bronchiectasis teaching hospital $D_1=1$ , other=0.
$D_1 LPA$	=Dummy variable lung part absence teaching hospital $D_1=1$ , other=0
$D_1 HLT$	=Dummy variable heart and lung transplantation teaching hospital $D_1=1$ , other=0
$D_1 LT$	=Dummy variable lung transplantation teaching hospital $D_1=1$ , other=0.
$D_1 BIPAP$	=Dummy variable Bilevel Positive Airway pressure (BIPAP) teaching hospital $D_1=1$ , other=0.
$D_1 LVF$	=Dummy variable Left Ventricular Failure teaching hospital $D_1=1$ , other=0.
$D_1 AGE$	=Patient age, teaching hospital $D_1=1$ .
$D_1 SEX$	=Dummy variable 1 if male, other=0 (gender of patient), teaching hospital $D_1$
$D_1 PROC$	=Number of procedures at teaching hospital $D_1$
$D_1 DIAG$	=Number of diagnoses at teaching hospital $D_1$
$D_1 DISEASE TYPES$	=Number of body systems at teaching hospital $D_1$
$D_1 COMPLEX$	=Dummy variable at teaching hospital $D_1$ , 1 of patient classified as high complexity case (PCCL) level 1 if 4. 0 if 3.
$D_1 OUTLIER$	=Dummy variable at teaching hospital $D_1$ , 1 if patient an outlier on length of stay, otherwise 0
$D_1 EMERG$	=Dummy variable at teaching hospital $D_1$ , 1 if patient admitted through emergency department, otherwise 0

patient  $i$  in DRG<sub>e</sub>; Disease Types<sub>ie</sub>=number of disease types for patient  $i$  in DRG<sub>e</sub>.

The FRAP would be determined as follows if the patient were an outlier on LOS and had five procedures undertaken along with three disease types. The base rate (or constant) would equal \$1,030. To this amount would be added \$7,190 for LOS outlier status, plus \$1,350 for each of five procedures (totaling \$6,750), and \$380 for each of three disease types (total of \$1,140). The grand total for this admission for this patient is \$16,110. The standard casemix funding formula would be calculated based on the total amount payable for that DRG under standard casemix funding arrangements. The standard casemix funding formula would be subtracted from the FRAP

to determine the size of the final RASG payable to Hospital. The standard casemix funding formula level would implicitly embrace changes in the CPI, technology and wages given the total funding amounts from the Treasury to the Victorian DHS incorporates such adjustments. However, there would also need to be an adjustment to the FRAP for CPI, technology change and wages. Previous experience by the State government (DHS) in calculating the net final RASG for DRGs 3, 23 and 173 did involve other additional grants to other major teaching hospitals, given the size of the 'relative disadvantage' of The Alfred Hospital vis-à-vis the other hospitals. Further consideration would therefore also need to be given to the extent of relative

disadvantage of The Alfred Hospital. This would enable improved distributional justice across the State.<sup>1</sup> Calculation of the FRAP could also include some adjustments for the new co-payments where relevant to the DRG. Those relevant to the cardiology DRGs could involve the stent co-payment and payment for use of an atrial septal defect (ASD) closure device. Trauma and respiratory DRGs might include the mechanical ventilation co-payment. Future research could include the co-payments in the regression models as dummy variables to calculate payment rates for FRAP. The regression equations could be formally re-estimated. Further severity markers identified in the current research might also be included in future regression specification, for example, bronchiectasis and cardiomyopathy for lung and heart transplant related services, respectively. We turn now to the implications of the research for casemix classification and funding developments in Germany.

### Developments in Germany

Section 17b of the Hospital Financing Law (KHG) of May 2000 specified that the German Self-Administration Board must select a classification system to reimburse all hospital in-patient care from January 2003. The board comprises representatives of insurers and hospitals. The classification is a variant of DRGs in use in at least one country for funding purposes. This is challenging since in all other countries DRGs are only one of several factors determining a budget or are used for only partial reimbursement. The German Hospital Association (DKG), the German Society for Thoracic and Cardiovascular Surgery (DGTHG) and the University of Münster aided the selection process

<sup>1</sup> Consideration of the relative disadvantage of The Alfred vis-à-vis other teaching hospitals and the size of any other Risk Adjusted Specified Grants for other teaching hospitals can be further explored using the following formulae in the case of COPD, where severity markers are included into the equation, along with teaching hospital dummy variables for each teaching hospital and all other variables. This specification can be used both to predict why certain hospitals are more expensive than others, as well as to understand whether some factors systematically vary or are the same across all hospitals. (see infobox)

through a project that analysed cardiac surgery data of 18 different German hospitals from 1999 to evaluate eight variants of DRGs. This included Health Care Financing Administration DRGs, version 17.0 INTERNOVA (HCFA-DRGs); All-Patient DRGs, version 12.0 3 M (AP-DRG); Group homogenes de malades, France (GHM), refined DRGs, INTERNOVA (R-DRGs); All-Patient Refined DRG, version 15.0 3 M (APR-DRGs); Australian Refined DRGs, version 4.1, Australia (AR-DRGs); International All-Patient DRGs 3M (IAP-DRGs); and Leistungsgerechte Diagnosefallgruppen, Austria (LDF) [42].

They established 12 evaluation criteria. Those particularly relevant to the current research concern the adequacy of the classification system including co-morbidities, complications, expensive and/or modern procedures, sensitivity to extreme cases and their relative size, cost homogeneity of the residual group, resistance of the system to gaming and cost homogeneity. An excellent detailed comparison of the underlying theories and constructions of the eight variants are provided by Rochell and Roeder [41] and Roeder et al. [42]. They found that the French GHM-DRG and Australian AR-DRG variants had the best medical logic. The Australian system was outstanding regarding its explanation of its design and operation, and its statistical performance in resource use homogeneity. An added advantage was the PCCL logic involving five levels of severity for every adjacent DRG based on additional diagnoses. Roeder et al. [42] concluded that it could be recommended from the evidence on cardiac surgery, given its suitability for quality assurance, payment system, benchmarking and performance control. Another attraction was the open nature of its classification design, software implementation and the high level consideration of clinical logic over many years of refinement. The GHM variant, as with the AP-DRG, had a disadvantage regarding very heterogeneous groups and would require additional development to take account of variations such as the PCCL. The HCFA variant did not adequately account for variations in severity and would require extension. R-DRG had virtually the same grouping results as HCFA-DRGs, although the more elabo-

rate differentiation of complexity levels matches multiple morbidity more effectively [42]. The AR-DRG version 4.1 has been chosen as the basis for future German costing system for hospitals [26].

Methodologies and statistical criteria used to develop the grouper for Australian DRGs have been described elsewhere and have also been deemed to 'world leading' [4, 6]. The methodologies are considered rigorous, valid and sound. However, DRG development processes are unable to capture, or adjust for, the effects of a small group of very expensive patients related to State-wide referral services that likely occur in only a few hospitals nationally. At The Alfred Hospital this relates to services such as major trauma, heart and lung transplantation, chronic heart failure and cystic fibrosis. There might be similar effects for a small group of DRGs for other major teaching hospitals, in view of their State-wide referral services. Extremely high outliers are excluded from final statistical analyses during DRG development phases, which use LOS as the dependent variable rather than per patient costs. Attempts simply to split DRGs further to capture this effect are generally difficult, since the statistical criteria requires at least 200 cases in any new DRG split.

Further, attempts to use the standard cost weight 'averaging' system in the standard casemix funding formula have proven inadequate to compensate for the small number of high-cost and very severely ill patients linked to these State-wide services. Further application of routine severity adjustment systems may not solve the problem either. The AR-DRG already attempts high-level severity adjustment via the PCCL. Perhaps the limitations found reflect the limitations of using LOS as the dependent variable during grouper development, rather than per patient costs, although AR-DRGs version 5 uses patient costs. Higher level analytical approaches developed in the current research are required to resolve the problem adequately and to articulate sound arguments to the State Treasury to identify the true level of current inappropriate underfunding and hence expenditure growth requirements. Only a few DRGs generate a significant proportion of hospital-wide deficits. These issues beset oth-

er countries, including the United States, and need careful analyses to determine adequate mechanisms for solving them beyond traditional solutions.

The current research has identified the stroke DRG as requiring severity (or risk) adjustment. Research in Germany on AR-DRGs version 4.1 for stroke also identified a need for severity-adjustment of the grouper. Kugler et al. [26] applied a stroke-severity measure called the Barthel Index, involving additional diagnoses. When grouping using their own stroke data base, 36.8% ( $n=177$ ) of cases were assigned to the DRG with the highest cost weight. Of these patients 53.7% had a serious stroke. Grouping on the basis of standard hospital information systems led only to 2.8% assigned to the DRG with the highest cost weight. The authors concluded that the type and extent of additional diagnoses are crucial for DRG grouping. Disability and impairment measures should also be assigned to the grouping process to improve homogeneity. Procedures must be included in the definition of medical DRGs. They also concluded that DRGs covering overlapping health care sectors should be developed for patients with post-stroke rehabilitation [26].

A State-wide Risk Adjustment Committee established by the Victorian DHS is leading State-wide reform on risk adjustment for both high-complexity RASG and complementary modifications to casemix funding arrangements such as risk-adjusted capitation funding models. These may also be of interest in Europe.

### State-wide risk adjustment government and industry committee

A State-wide Risk Adjusted Working Group (RAWG) was established in 2002 by the Victorian DHS in collaboration with Bayside Health and the major teaching hospitals to explore the potential for RASG across the entire hospital industry in Victoria. RAWG, chaired by Kathryn Antioch, will advise the government on the need for risk-adjusted funding arrangements for high-complexity and chronic-care patients of State-wide specialty services via RASG and will consider establishing a risk management insurance pool. It will provide hospital industry evidence for use in

budget deliberations between the Victorian DHS and the State Treasury, in negotiations about the size of the entire funding pool to more appropriately reflect health need. It will identify and evaluate Risk Adjusted Capitation Funding Models (RACFM) for State-wide referral services for Chronic Diseases and also for extended episode of care arrangements in Victoria. These models are discussed below.

### Risk-adjusted capitation funding models (RACFMs)

The need to explore RACFMs in Australia arose in part from previous negotiations undertaken by Bayside Health in which The Alfred Hospital argued that the cost weights used in casemix (DRG) funding in Victoria have also been shown to be too low for some State-wide chronic disease services. The Alfred Hospital requested RASG in 1998–1999 for cystic fibrosis given an annual deficit of \$0.5 million and lower cost weights implicit in the new funding formula. It argued it had higher casemix complexity with 28% emergency and higher PCCL but efficiency on LOS and costs, having a \$3,000 lower average cost relative to that at the highest cost hospital. The Alfred Hospital successfully obtained RASG since 1998–1999 and the cost weight increased in 1999–2000. The Alfred Hospital argued that RACFMs are feasible alternatives to casemix funding arrangements. Under capitation arrangements managed care organizations are paid a fixed amount of money for each enrollee regardless of the amount of services actually provided. A RACFM for cystic fibrosis public patients treated by an Australian HMO, The Alfred Hospital, was developed. This health 'plan' refers to a risk-bearing entity that performs some insurance function, that is, it bears some or all of the financial risk associated with the random variation in health expenditure across individuals. Health plans may also manage or provide health care. Adverse selection is of limited concern since patients pay solidarity contributions via Medicare levy with no premium contributions to the Australian HMO. Sponsors paying premium subsidies to the Australian HMO are the Victorian and Federal governments. There are no premium contributions by patients to the Australian HMO.

Regression analyses for DRG 173 (cystic fibrosis) found significant variables impacting on per patient costs were emergency status (1276.9), outlier on LOS (6377.1), patient complexity (3043.5), number of procedures (317.4) and the constant (or base payment rate; 4492.7). This related to the in-patient premium subsidies by the Victorian Government sponsors. Regression results were  $R^2=0.21$ ,  $SE=3598.3$ ,  $F=14.39$ ,  $P<0.001$ . Regression coefficients represent the additional per patient costs summed to the base payment (constant). The regression explained 21% of the variance in cost per patient.

The payment rate is adjusted by a best practice annual admission rate of 2.5 per registered patient. This would result in an increase in the funding pool as only 100 of the 200 patients who were registered with The Alfred Hospital were admitted over the study year period. There should be flexibility in redistribution of funding from the above in-patient pool to link to the hospital in the home program. The model is a blended RACFM for in-patient, out-patient, hospital in the home, fee for service federal payments for drugs and medical services, lump-sum lung transplant payments and risk sharing through cost (loss) outlier payments. Home and palliative services funded by the State and Federal governments are 'carved out'. Current development of cost effective clinical practice guidelines, protocols and pathways by The Alfred Hospital for cystic fibrosis can be used with the capitation funding models. The model reflects distributive justice approaches by Rice [39] and Reinhardt [38], whereby we commence with principles of fairness and then proceed to efficiency. This supplementary alternative to casemix funding may be instructive for Germany as they are using AR-DRG funding models in Europe [3]. This work has led to consideration of the DCG risk-adjustment classification system that could be used in Australia for capitation.

### United States' Center for Medicare and Medicaid: risk-adjustment classification models – capitation lessons for Australia

The approach proposed for Australia, involving risk adjusted capitation and *risk*

*scores* for patients reflects recent developments in the United States that took effect in 2000. HMOs previously received a fixed payment for each beneficiary, adjusted only for such factors as age, sex and county but not medical history. Medicare paid an average of \$5,800 a year for each beneficiary. Since 2000 HMOs receive additional payments for beneficiaries hospitalized in the prior year for specific conditions. The bonus runs from \$1,910 a year for breast cancer to \$26,464 for AIDS (*New York Times*, 16 Jan. 1999). The HCFA in the United States, recently renamed Center for Medicare and Medicaid, uses a DCG-based model to set capitation rates for Medicare plus choice health plans [18]. This model uses principal in-patient DCGs [36] and is transitional to full-encounter risk adjustment by HCFA in 2004, which has supported research on DCGs [19, 21, 22, 35]. The DCG hierarchical condition category (HCC), using multiple conditions over full encounters has been recently chosen by the Centre for Medicare and Medicaid.

The DCG-HCC classification system uses diagnoses generated during patient encounters to infer medical problems. Diagnostic profiles and patient demographics predict costs. The system of Condition Categories (CC) hierarchies captures both chronic and serious acute disease manifestations and expected costs. Each CC coefficient reflects the increment to expected costs that is independently associated with the condition [10]. The DCG-HCC classification system has been selected by the Medicare program for 2004 and is being trailed in Canada and Germany, with Columbia and Israel trailing various versions of DCGs. DCGs identify the person's full range of medical conditions over time from in-patient, ambulatory and multi-sites. For health plans that lack reliable all-encounter claims data a risk model using both pharmacy (called Rx groups) and in-patient diagnoses may be best [49]. Whilst our Australian DRG classification system has proven very useful to date in the context of developing disease-specific risk-adjusted capitation funding models, the DCG-HCCs could also be applied to such models for State-wide referral services offered by the Victorian DHS, area health boards in New South Wales and po-

tentially area health services in Victoria. Specifically, the DCG-HCC model which has been widely validated internationally and in the United States and an extension using pharmacy information called Rx groups hold particular promise. A model that uses drug information is now implemented in The Netherlands, and models using this information are being quickly adopted because of the ready availability of pharmacy information. Pharmacy models are of particular interest in Australia because they are useful when there is limited all-encounter diagnostic data.

### Risk adjustment and DCG applications in Victoria

There are several ways that these DCG systems could be used in Victoria and potentially in Europe. Firstly, DCG-HCCs with Rx groups could be used to develop a needs based target allocation formula for government programs such as casemix funding, with actual work being paid by casemix activity. DCGs are associated with risk scores which can measure disease burden. DCG calibration could be compared with analyses of needs based funding based on age-/sex-adjusted weighted separations. The advantages of exploring the DCG concept is the burden of disease can be assessed by factors beyond just inpatient care to potentially include community services and drugs. This application may also be of considerable interest to Germany given its implementation of casemix funding arrangements. The second application could be in further developmental work of a disease-specific risk adjusted capitation funding model for cystic fibrosis, HIV-AIDs, chronic heart failure or cancer for an Australian HMO. This could replicate the model developed by Antioch and Walsh [3] but applied to cystic fibrosis and other diseases using DCG-HCC and compared to analyses using DRGs applying regression techniques and predictive ratios (expected expenditure/actual expenditure). The third application could be to develop a DCG-HCC Risk-Adjusted Integrated Budget-Holding (DRAIB) model for area health services in Victoria, which is population-based, incorporating State funding. Budgets could be defined by a resource dis-

tribution formula developed by the Victorian DHS. Fundholding and health services planning could occur at the regional level, covering a broad range of services such as hospital in-patient and out-patient services, community-based primary care and public health and health-promotion services. Private medical services and private pharmacy would be excluded. Data from mortality ratios, rurality and socio-economic index could also be incorporated. Current casemix funding via DRGs could be potentially maintained, with actual payments based on activity, but with targets determined by DCG-HCC. A fourth initiative, recommended by Dwyer [17], calls on designers of the next AHCA to consider pooling federal and State funds, to be held by area health services.

### Risk adjustment and DCG applications in New South Wales

We now consider the application of DCGs in New South Wales. The New South Wales area health authority service model has been described as a non-competitive (partial) fundholding model which is population based. New South Wales uses geographic capitation resource allocation methods. The resource distribution formula allocates funds to 17 area health services and monitors equity. A global annual budget is allocated between nine programmes – population and oral health, primary and community, out-patients, emergency, acute in-patient, mental health, rehabilitation, extended care, teaching and research. Expenditure related to population size is allocated using capitation methodology and summed for total area allocation, which is adjusted for cross boundary flows. Capitation formula includes age-/sex-weighted population, aboriginality, homelessness, private hospital care and rurality. The generic needs index includes a standardized mortality ratio, education and occupational status and a rurality index [40]. Although by 2001, expenditure within each region was within 5% of that determined by the formula, the efficiency and other implications of the model have not been assessed [43].

Risk selection is a potential problem throughout Australian health systems, giv-

en inadequate funding levels and implicit incentives to 'cream skim', 'cherry pick' and 'dump to cope'. This contrasts with assumptions (in the absence of hard evidence) made by Segal et al. [43] that risk selection is virtually non-existent in New South Wales under a 'non-competitive (partial) funding holding model which is population based'. However, their theoretical model should be evaluated in light of industry evidence of selection. Furthermore, one questions whether any market is purely a 'non-competitive model'. Most markets would be somewhere on a continuum between 'non-competitive' and 'competitive'. The work by Segal et al. [43] is a welcome and important contribution in providing an initial framework to facilitate further debate about the strengths and limitations of competitive vs. non-competitive models of integrated capitation funding holding. Selection may be better avoided with possible improved predictive costs under a DCG-type system in that health need can be better measured and built into total cost structures. The relative allocative efficiency between regions can also be enhanced with better measures of disease burden. This formulation could be evaluated by calibrating data using the DCG-HCC and the Rx groups drug classifications for predicting and comparing allocations under the current formula. An early study of New South Wales data used only in-patient hospital data for a version of DCGs [37] but could be substantially improved by using the DCG-HCC system combined with the drug classifications system (Rx groups). The Productivity Commission [37] in considering managed competition proposals has highlighted the merits of giving regionally based, public non-competing budget holders the responsibility for purchasing the full range of health services for their residents and other opportunities for reforming existing financing and delivery arrangements for public hospitals. These are consistent with the foregoing recommendations.

### Risk-adjustment applications for coordinated care trials

The coordinated care trials were established in the late 1990s in Australia to test whether multi-disciplinary care planning

and service coordination leads to improved health and well-being for persons with chronic health conditions. Funds pooling between Federal and State/Territory programmes for each trial participant were trialed as a means of providing funding flexibility to support this coordinated approach. Duckett and Agius [15] carried out an excellent analysis of the coordinated care trials using Adjusted Clinical Groups (ACG), Ambulatory Diagnostic Groups (ADG) and DCGs. They found that age, gender, and diagnosis-based risk adjustment measures explain around 40–45% of variation in costs of service use in the current year for untrimmed data compared to approximately 15% for age and sex alone. Prediction of subsequent use is lower at 20%. Using more information to assign persons to risk categories generally improves prediction. Use of DCGs was marginally better at explaining or predicting the variation in costs of service use for those who use the service, whereas the use of Adjusted Clinical Groups or Ambulatory Diagnostic Groups was better at predicting any service use. They concluded that low predictive power carries policy risk of ‘cream skimming’.

Another important evaluation measure is the predictive ratio (expected expenditure/actual expenditure) which has shown DCGs to perform extremely well internationally. The closer this ratio is to 1, the better the performance. Further analyses of Australian data to investigate this measure are important. Analyses of  $R^2$  values across entire classification systems can be somewhat limited in their capacity to reveal the real value of a total classification system. In developing Australian DRGs the  $R^2$  statistic was explored for the major diagnostic category, including medical and surgical partitioning [6]. Further, explanatory variables are also considered at the level of two or three partitions of a group [4] or new DRG splits for chemotherapy [16]. There may be great value in further analysing the explanatory power of DCGs at more refined levels of the classification system itself, for example, perhaps at the level of the Aggregated Clinical Conditions, its sub-components of CCs, or for patient sub-groups such as cystic fibrosis patients using Australian data. Potential uses of DCGs for

risk adjustment at the national level are feasible for the AHCA re-negotiations and also the reinsurance pool arrangements.

### Medicare agreements: Federal-State funding

The system of AHCA has been in place for almost 20 years, establishing the level of Federal grants given to the States and Territories for funding public hospitals. In a recent publication Australian States and Territories [11] emphasize that the system is under extreme pressure. During April 2002 health ministers convened nine expert reference groups, who advised that ‘funding should follow the patient, wherever they are treated’. Once a sustainable funding base has been established, the States argue that the total 2003–2008 ACHA grants should be *properly indexed* to reflect growth in demand and escalation in costs. The index should comprise prices, wages and measures to identify need such as demographic effect and population growth and aging and factors unrelated to demography such as technology. They estimate a total index of 7.96% in the first year. However, this is likely to increase as estimates are updated to reflect changed conditions [11]. It is in relation to this index for growth, related to health need and ‘changed conditions’ across the system, that the use of DCG-HCCs with Rx groups has a good, potential application nationally. Risk adjusted capitation of the reinsurance pool for national health insurance arrangements could be facilitated by DCGs also.

### Conclusion

If casemix policy in Australia and internationally is to maintain credibility and equity, the arrangements must respond to changes in the cost structures of hospitals and meet demand increases. Problems have emerged from applying the averaging principle inherent in cost weights. The actual base payment per case is a political decision, not based on public benchmarking. We have detailed specifications of the RASG formula and its relationship to the standard casemix funding arrangements for high-deficit DRGs in teaching hospitals that are linked to State-wide referral services.

Aggregation of RASG calculated for all teaching hospitals can identify the level of current inappropriate underfunding across the entire State. The potential application of risk adjustment in Victorian government negotiations with the Treasury about the size of the entire hospital funding pool can then expand the role of risk adjustment to achieve greater allocative efficiency and distributional justice on a State-wide basis. Achieving a funds pool to more accurately reflect health need may enable the upward adjustment of funding for some high cost hospitals *without* inappropriate clawback from other hospitals via an inequitable downward adjustment.

A Victorian government committee on risk adjustment involving State and hospital industry collaboration holds great potential to improve equity for State allocation of funds and negotiations with the Treasury. Its deliberations and those of The Alfred Hospital are instructive for other jurisdictions using casemix (DRG) funding. Similar problems of DRG funding have arisen in the United States and risk-adjusted grants may hold particular appeal there and in European countries using DRG funding.

Importantly, we have identified the potential for future research, which can explore re-specifications to the funding formula. This might include the integration, as dummy variables, of the recent co-payment variables such as ASD closure device and stent co-payments for cardiology patients. Severity markers such as bronchiectasis and cardiomyopathy can likewise be integrated as dummy variables for DRGs related to lung and heart transplants, respectively.

Risk adjustment can also improve equity in the broader context of health care reform in Australian States, and federally via improved capitation, area health funding, casemix target formulation, the coordinated care trials and the re-negotiations of AHCA. The use of DCGs or an extension using pharmacy data called Rx groups holds excellent potential for risk adjustment in Australia as they effectively measure health need on a population basis. DCGs can be used to calculate casemix targets for hospitals based on health need, within the current Victorian casemix funding arrangements. They can be used for disease-specific RACFMs and also risk-

adjusted integrated budget holding in Victoria. Likewise in New South Wales, they can better measure health need and be integrated into the resource distribution formula. Federally they hold significant promise in potentially improving resource allocation between States through their application in the growth factor to measure changes in health status over time for Australian States in the AHCA.

## Corresponding author

**Kathryn M. Antioch**

Bayside Health, The Alfred Hospital, Commercial Rd Prahran, 3181 Melbourne, Victoria, Australia  
e-mail: K.Antioch@alfred.org.au

## Acknowledgements

K.A., Chair of the State-wide Risk Adjustment Working Group (RAWG), would like to thank Profs. Randall P. Ellis and Wynand PMM Van de Ven for excellent tuition in risk-adjustment methodologies during the 1999 International Health Economists Association Conference, The Netherlands, and for subsequent assistance. We also thank the reviewers of the *European Journal of Health Economics* for excellent comments. Earlier versions of this contribution were presented at the Fourth European Conference on Health Economics, Paris, 2002, the Financial Review Conferences: the Fifth Health Congress: Australia's Leading Health Industry Event, Sydney 2003, the International Health Economists Association Conference, 2003, United States and the Australian and New Zealand Health Services Research Conference, 2003, Melbourne.

**Conflict of interest:** No information supplied.

## References

- Antioch KM (2002) Book review on the social economics of health care. *Aust N Z J Public Health* 26(3):288–289
- Antioch KM, Walsh MK (2000) Funding issues for Victorian hospitals: the risk-adjusted vision beyond casemix funding. *Aust Health Rev* 23(3):145–53
- Antioch KM, Walsh MK (2002) Risk-adjusted capitation funding models for chronic disease in Australia: alternatives to casemix funding. *Eur J Health Econ* 3:83–93
- Antioch KM, Zhang X (2000) Organ transplant AN-DRGs: modifying the exceptions hierarchy in casemix classification. *Aust Health Rev* 23(1):137–152
- Antioch KM, Walsh MK, Anderson D et al (1998) A new ambulatory classification and funding model for radiation oncology: non-admitted patients in Victorian hospitals. *Aust Health Rev* 21(1):62–76
- Antioch KM, Zhang X, Raw J (1998) Using endoscopic procedures for AN-DRG assignment: Australia leads the way. *Aust Health Rev* 21(4):80–95
- Antioch KM, Walsh MK, Anderson D et al (1999) Forecasting hospital expenditure in Victoria: lessons from Europe and Canada. *Aust Health Rev* 22(1):133–155
- Antioch KM, Chapman R, Elliot B et al (2001) Cost-effective clinical pathways at the Alfred Hospital: international lessons from Bayside Health. *Aust Health Rev* 24(4):21–29
- Antioch KM, Jennings G, Botti M et al (2002) Integrating cost-effectiveness evidence into clinical practice guidelines in Australia for acute myocardial infarction. *Eur J Health Econ* 3(1):26–39
- Ash AS, Ellis RP, Pope GC et al (2000) Using diagnoses to describe populations and predict costs. *Health Care Financ Rev* 21(3):7–28
- Australian States and Territories (2002) Facing the future: opportunities for better health services.
- Carpenter CE, Rosko MD, Louis DZ et al (1999) Severity of illness and profitability: a patient level analysis. *Health Services Manage Res* 12(4):217–226
- Duan N et al (1983) Smearing estimate: a non-parametric retransformation method. *J Am Stat Assoc* 78:605–690
- Duckett SJ (1995) Hospital payment arrangements to encourage efficiency: the case of Victoria, Australia. *Health Policy* 34:113–134
- Duckett SJ, Agius PA (2002) Performance of diagnosis-based risk adjustment measures in a population of sick Australians. *Aust N Z J Public Health* 26(6):500–507
- Duckett SJ, Stow S (2001) Payment policy for chemotherapy in public hospitals: a case for splitting DRGs 780/R63Z. *Aust N Z J Public Health* 25(6):552–525
- Dwyer JM (2002) The next Australian Health Care Agreements: what clinicians want. *Aust Health Rev* 25(6):17–23
- Ellis R (1999) Diagnostic cost group (DCG) risk adjustment models. *DxCG, Waltham*
- Ellis RP, Ash A (1995) Refinements to the diagnostic cost group model. *Inquiry* 32(4):1–12
- Ellis RP, McGuire TG (1986) Providers behavior under prospective reimbursement: cost sharing and supply. *J Health Econ* 5:129–51
- Ellis RP, Pope GC, Iezzoni LI, Ayanian JZ, Bates DW, Burstin H, Ash AS (1996) Diagnosis-based risk adjustment for Medicare capitation payments. *Health Care Financ Rev* 12(3):101–28
- Ellis RP, Pope GC, Iezzoni LI et al (1996) Diagnostic cost group (DCG) and hierarchical coexisting condition and procedures (HCCP) models for Medicare risk adjustment. Final report. *Health Care Financing Administration: Baltimore*
- Etzioni A (1988) *The moral dimension: towards a new economics*. Free Press: New York
- Federal Department of Health and Aged Care (1999) *The Australian coordinated care trials. interim technical national evaluation report*. Federal Department of Health and Aged Care: Australia
- Kennedy P (1992) *A guide to econometrics*. Basil Blackwell, Oxford
- Kugler C, Freytag S, Stillger R, Bauer P, Ferbert A (2000) *Australian refined diagnosis related groups. Formal and inherent problems of grouping with the example of stroke care*. *Dtsch Med Wochenschr* 125(51–52):1554–1559
- Leary RS, Johantgen ME, Farley D et al (1997) All-payer severity – adjusted diagnosis-related groups: a uniform method to severity adjust discharge data. *Top Health Inf Manage* 17(3):60–71
- Lilien DM, Startz R, Ellsworth S, Noh J, Engle R (1995) E views users guide econometric view: micro TSP for Windows and the Macintosh. *Quantitative Micro Software: Irvine*
- Manning WG (1998) The logged dependent variable, heteroskedasticity and the retransformation problem. *J Health Econ* 17(3):283–295
- Manning WG et al (1987) *Health Insurance and the demand for medical care: evidence from a randomised experiment*. *Am Econ Rev* 77:251–277
- McNair P, Duckett S (2002) Funding Victoria's public hospitals: the casemix policy of 2000–2001. *Aust Health Rev* 25(1):72–98
- Mullahy J (1998) Much ado about two: reconsidering retransformation and the two-part model in health econometrics. *J Health Econ* 17(3):247–282
- Peacock S, Segal L (2000) Capitation funding in Australia: imperatives and impediments. *Health Care Manage Sci* 3:77–88
- Podger A, Hagan P (1999) *Reforming the Australian health care system: the role of government*. Occasional papers. New series no 1. Commonwealth Department of Health and Aged Care
- Pope CG, Ellis RP, Liu CF et al (1998) Revised diagnostic cost group (DCG)/hierarchical coexisting conditions (HCC) models for Medicare risk adjustment. Final report. *Health Care Financing Administration. Health Econ Res: February*
- Pope, GC, Ellis, RP, Ash, AS et al (2000) Principal inpatient diagnostic cost group model for Medicare risk adjustment. *Health Care Financ Rev* 21(3):93–118
- Productivity Commission (2002) *Managed Competition in Health Care Workshop proceedings: Canberra 23 August, 2002*. Productivity Commission: Australia
- Reinhardt UE (1992) Reflections on the meaning of efficiency: can efficiency be separated from equity? *Yale Law Policy Rev* 10:302–315
- Rice T (1998) *The economics of health reconsidered*. Health Administration: Chicago
- Rice N, Smith R (1999) Approaches to capitation and risk adjustment in health care: an international survey. *Centre for Health Economics, University of York: York*
- Rochell B, Roeder N (2000) *Vergleichende Betrachtung und Auswahl eines Patienten-klassifikationssystems auf der Grundlage von Diagnosis Related Groups*. *Krankenhaus nos 4, 5*
- Roeder N, Rochell B, Juhra C et al (2001) Empirical comparison of DRG variants using cardiovascular surgery data: initial results of a project at 18 German hospitals. *Aust Health Rev* 24(4):57–80
- Segal L, Donato, R, Richardson J, Peacock S (2002) Strengths and limitations of competitive versus non-competitive models of integrated capitated fundholding. *J Health Serv Res Policy* 17 [Suppl 1]:56–64
- Shen Y, Ellis RP (2002) How profitable is risk selection: a comparison of four risk adjustment models. *Health Econ* 11(2):165–174
- Van de Ven WPMM, Ellis R (2000) Risk adjustment in competitive health plan markets. In: Newhouse JP, Culyer AJ (eds) *Handbook of health economics*. Elsevier: Amsterdam, pp 755–845
- Victorian Department of Human Services (2000) *Victorian public hospitals policy and funding guidelines 2000–2001*. Acute Health Division, Victorian Government: Melbourne
- Victorian Department of Human Services (2002) *Victorian public hospitals policy and funding guidelines 2002–2003*. Metropolitan Health and Aged Care Division Victorian Government: Melbourne
- Willcox S (2001) Promoting private health insurance in Australia: a policy in search of evidence? *Health Aff (Millwood)* 20(3):152–161
- Zhao Y, Ellis RP, Ash AS et al (2001) Measuring population health risks using inpatient diagnoses and outpatient pharmacy data. *Health Services Res* 26(6):180–193