Submission to the Independent Hospital Pricing Authority (IHPA):
Consultation Paper on the 2013-14 Pricing Framework
by Dr Kathryn Antioch

The Victorian Government (2012) [1] has provided excellent recommendations in response to the IHPA's Consultation Paper on the 2013-14 Pricing Framework. I previously led the risk adjustment reform of Activity Based Funding (ABF) in Victoria as Chair of the Victorian Government's Risk Adjustment Working Group (RAWG) and as Principal Adviser, Evidence Based Medicine and Funding Reforms reporting to the CEO of Alfred Health (then called Bayside Health). This reform work has been published in three editions of the *European Journal of Health Economics* and in the *Australian Health Review*. Based on the findings of this work, which is hereby provided to the IHPA as attachments to this submission, I fully endorse the following recommendations by the Victorian Government (2012) [1] in their submission to the IHPA and view their implementation as essential:

- The IHPA's proposal to examine price adjustments for specialised services should not be confined to 'isolated' sites.
- The IHPA should consider appropriate block funding to supplement ABF payments for highly specialised low volume services such as:
    - Transplant services such as heart, lung and liver; and
    - Other state wide services such as burns, spinal, specialised respiratory support, integrated cancer programs, HIV/AIDs programs, the Paediatric Emergency Transport Service, the Newborn Emergency Transport Service and the Perinatal Emergency Referral Service (Victorian Government, 2012)[1]

In support of these recommendation I hereby attach the evidence from the Victorian experience, which is published in the *European Journal of Health Economics*. My co-authors on the RAWG findings include senior members of the Victorian Government at the time and an international world leader in risk adjustment from the USA (Professor Randall Ellis). The effects of State-wide referral services across a range of DRGs can be complex and if the high intensity service requirements of these specialised services are not adequately resourced through the risk adjustment of funding arrangements, they can lead to unacceptable underfunding and major funding deficits in teaching hospitals. The evidence supporting this view are attached and referenced as follows:

- Antioch KM, Ellis RP, Gillett S et al (2007) "Risk adjustment Policy Options for Casemix Funding: International Lessons in Financing Reforms" *European Journal of Health Economics*, 8:195-212[2].
- Antioch KM and Walsh MK (2004) 'Risk adjusted Vision Beyond Casemix (DRG) Funding in Australia: International Lessons in High Complexity and Capitation' *European Journal of Health Economics*.5: 95- 109 and Erratum EJHE (2004) 5:115.
- Antioch KM and Walsh MK (2002*)* 'Risk adjusted capitation funding models for chronic diseases in Australia: Alternatives to Casemix Funding', *European Journal of Health Economics* 3:83-93

I also raised the urgent need for risk adjustment for ABF in my submission to the recent Senate Finance and Public Administration Legislation Committee Inquiry into the National Health Reform Amendment (Independent Hospital Pricing Authority) Bill 2011. The final report of that Senate Inquiry cited the issues I raised about the need for risk adjustment in several sections. My submission to that Inquiry and the Final report of the Senate Committee are attached for your consideration and are referenced as follows:

- Antioch KM (2011) 'Submission to the Senate Finance and Public Administration Legislation Committee Inquiry into the National Health Reform Amendment (Independent Hospital Pricing Authority) Bill 2011' Submission Number 14. (Published by Parliament)[3]

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[1] Victorian Government (2012) IHPA Consultation Paper on the 2013-14 Pricing Framework
http://www.ihpa.gov.au/internet/ihpa/publishing.nsf/Content/F7F044CD6146FF45CA257A7F0003F03B/$File/Victoria.pdf

[2] http://people.bu.edu/ellisrp/EllisPapers/2007_AntiochEllisGillett_EJHE_RiskAdj.pdf

[3] http://www.aph.gov.au/Parliamentary_Business/Committees/Senate_Committees?url=fapa_ctte/ind_hospital_pricing_authority/submissions.htm
Submission no 14

- Commonwealth of Australia (2011) The Senate: Finance and Public Administration Legislation Committee National Health Reform Amendment (Independent Hospital Pricing Authority) Bill 2011 (Provisions). Final Report [4]

These matters are extremely important to enable equity in funding and to ensure the provision of quality health care. I would be pleased to further assist the IHPA in this matter.

Yours sincerely,

Dr Kathryn Antioch
BA (Hons) MSc (UBC) AFCHSM CHE PhD (Health Economics)
Principal Management Consultant
Health Economics and Funding Reforms
Deputy Chair, Guidelines and Economists Network International (GENI) Board
Adjunct Senior Lecturer, Department of Epidemiology and Preventive Medicine Monash University
Advisory Board, Cost Effectiveness and Resource Allocation Journal
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Dr Kathryn Antioch holds appointments to Government Expert Panels (Federal and State) relating to Activity Based Funding and Casemix Reforms. She previously led the risk adjustment reform of Activity Based Funding (ABF) for the Victorian Government as Chair of the Risk Adjustment Working Group (RAWG) and worked in the Senior Management of Hospital Networks on this issue. Since 2010, she has been involved in 11 Senate Parliamentary Inquiries involving national health reforms, following her briefings to the Council of Australian Governments (COAG) on risk adjustment of ABF from 2008 to 2010. Kathryn addressed the need for risk adjustment for ABF and also for analyses of hospital efficiency and quality performance data in several of the Parliamentary inquiries. She previously worked in Australian Federal and State Governments on ABF classification systems and funding models. Kathryn worked with the Australian Casemix Clinical Committee (ACCC) and the Technical Reference Group (TRG) in developing Australian DRGs when working in the Federal Department of Health and Ageing. She held two Ministerial appointments to the Principal Committees of the National Health and Medical Research Council (NHMRC) for six years to 2009. These were the Health Advisory Committee and National Health Committee. She was an appointed member of the NHMRC's Privacy Working Committee and Lead Committee. Kathryn was previously appointed by the Victorian Governor in Council to a Victorian Health Practitioners Registration Board and worked on a Canadian (British Columbia) Royal Commission on Health Care and Costs on hospital and aged care reform.

[4] http://www.aph.gov.au/Parliamentary_Business/Committees/Senate_Committees?url=fapa_ctte/ind_hospital_pricing_authority/report/index.htm

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ORIGINAL PAPER

Risk adjustment policy options for casemix funding: international lessons in financing reform

Kathryn M. Antioch · Randall P. Ellis · Steve Gillett · Daniel Borovnicar · Ric P. Marshall

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Abstract This paper explores modified hospital casemix payment formulae that would refine the diagnosis-related group (DRG) system in Victoria, Australia, which already makes adjustments for teaching, severity and demographics. We estimate alternative casemix funding methods using multiple regressions for individual hospital episodes from 2001 to 2003 on 70 high-deficit DRGs, focussing on teaching hospitals where the largest deficits have occurred. Our casemix variables are diagnosis- and procedure-based severity markers, counts of diagnoses and procedures, disease types, complexity, day outliers, emergency admission and ''transfers in.'' The results are presented for four policy options that vary according to whether all of the dollars or only some are reallocated, whether all or some hospitals are used and whether the alternatives augment or replace existing payments. While our approach identifies variables that help explain patient cost variations, hospital-level simulations suggest that the approaches explored would only reduce teaching hospital underpayment by about 10%. The implications of various policy options are discussed.

Keywords Risk adjustment · Casemix funding · Diagnosis-related groups · Hospital costs

K. M. Antioch (✉)
Health Economics and Funding Reforms,
27 Monaro Road, Kooyong, Melbourne,
VIC 3144, Australia
e-mail: kantioch@yahoo.com.au

K. M. Antioch
Department of Epidemiology and Preventive Medicine,
Monash University, Melbourne, VIC, Australia

K. M. Antioch
National Health Committee, National Health and Medical Research Council, Canberra, ACT, Australia

R. P. Ellis
Department of Economics, Boston University,
Boston, MA, USA

S. Gillett · D. Borovnicar · R. P. Marshall
Metropolitan and Aged Care Division,
Victorian Department of Human Services,
Melbourne, VIC, Australia

R. P. Marshall
University of Melbourne, Melbourne, VIC, Australia

R. P. Marshall
Australian National University, Canberra, ACT, Australia

Introduction

This paper examines alternatives for improving the payment systems used by government funding agencies to fund hospitals using prospective payment formulae while appropriately reflecting variations in costs and severity across hospitals and patients. While hospitals in Australia and elsewhere have been switching to the use of diagnosis-related groups (DRG) payment formulae to reimburse hospitals, DRG classification systems around the world have been found to be limited in their ability to predict the differences in costs between teaching and non-teaching hospitals. Part of this issue may relate to the role of state-wide referral services of some teaching hospitals, which impact on the higher complexity of patients that are treated there for Australian-refined diagnosis-related groups (AR-DRG) related to such

services. Data from the Victorian Department of Human Services, Australia, were analysed to investigate this issue.

This analysis was undertaken because of concerns that existing mechanisms for paying hospitals may be leading to systematic underpayment of some teaching hospitals, due to the averaging principle inherent in the use of AR-DRG cost weights and the funding policy that all centres should be paid the same for the same AR-DRG episode. The Victorian government established a committee called the Risk Adjustment Working Group (RAWG) in 2002 involving both government (Victorian Department of Human Services) and hospital industry representatives to examine this issue in consultation with international experts. The RAWG's key Terms of Reference are to advise the government on the need for risk-adjusted funding arrangements for, inter alia, high-complexity patients of state-wide specialty services via risk-adjusted specified grants (RASG). In this paper, we examine several alternative approaches for changing payment systems for hospitals in Victoria through risk adjustment and consider the implications for hospital payment in an international context. Our analysis builds on the initial work undertaken by Antioch and Walsh [1] in the area.

A 2004 review of hospital prices and resource allocation by the Victorian Department of Human Services (DHS), Premier, Cabinet and Treasury and Finance identified non-salary cost escalation and variable management performance as key determinants of declining hospital financial performance. For 2004–2005, it recommended a financial sustainability framework linked to the demand management, strategic planning, accountability and performance reporting to eliminate deficits and control costs. Hospitals were asked to manage productivity targets of at least 0.5% over two years to contribute to deficit elimination. Hospital cost control mechanisms are to be strengthened through the development of guidelines for medical and surgical supplies and pharmaceutical cost control, following the recommendation of two independent consultancies on best practice in these areas (DHS, 2004;[14]). Arguments advanced by the hospital industry include pricing reform as an important strategy impacting on hospital deficits. These should be considered within the recommended broader assessment of the role of variable hospital management performance and non-salary cost escalation. Whilst the issues are complex, the risk adjustment analyses can, potentially, shed some light on new mechanisms to further assist the funding processes.

Australian health care system and the reform context

The Australian health care system is managed within the country's federal structure of government, which includes Commonwealth (national), State and Local tiers. State and Territory governments have the major responsibility for the financing and public provision of health services, including public and psychiatric hospitals under what are now called Australian Health Care Agreements (AHCA) between the Federal and State governments. The Federal government funds a universal benefit scheme for private medical services called the Medical Benefits Schedule and pharmaceuticals via the Pharmaceutical Benefits Scheme. In addition to this universal public insurance program, many individuals also purchase private insurance that covers additional benefits, such as access to private hospitals, a choice of medical specialists in public and private hospitals, dentistry and certain ancillary services, such as physiotherapy (see [12, 17] for discussion).

Australia relies upon both demand-side and supply-side incentives to try to control costs. Demand-side measures include co-payments by consumers, while supply-side approaches to containing government outlays include limiting the range of items covered by the Medical Benefits Schedule and the Pharmaceutical Benefits Scheme. In recent years, governments have promoted competition and emphasised evidence-based medicine. They have also separated purchaser, provider and regulatory functions and improved primary care, prevention and systems integration functions [12]. Advances in risk adjustment are currently being explored as a key mechanism to aid funding reform in Australia at the Federal and State levels of government. An important element of health care reform in Victoria, one of Australia's largest states, is improving the casemix funding system, particularly as it affects major teaching hospitals.

Since 1 July 1993, Victorian public hospitals have been funded based on customised AR-DRG casemix systems, which are updated annually. Initially limited to the AR-DRG funding of inpatient services, this system has since been extended to include virtually all episode-based funding of sub-acute and non-inpatient services [4, 11]. Hospital separations (elsewhere called discharges or visits) are coded using the International Classification of Diseases, 10th revision, Australian modification. Inpatient separations in Victoria are allocated to AR-DRGs using a modified form of AR-DRGs [11]. Victorian modifications are relatively slight and involve changes to the grouping criteria for only a few AR-DRGs.

Prior to 2000, Victorian inpatient casemix funding reimbursed variable and fixed costs separately. 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 underperformance. The primary payment unit for each separation is its weighted inlier equivalent separation or WIES. Most separations are classed as ''inliers,'' meaning that their length of stay (LOS) falls between lower and upper trim points. ''Outlier'' separations, which are those with LOS falling outside the lower and upper trim points, receive a variable payment based in part on LOS and in part on their inlier equivalent [11].

The WIES value for a separation is determined by converting each separation into an ''inlier equivalent'' and multiplying that value by a cost weight. The calculated WIES value for the separation is then multiplied by the standard (WIES) payment per inlier equivalent and the payment for the separation is claimed from the Victorian Department of Human Services. The WIES value for a low LOS outlier is derived by conversion into a partial episode value, again described as an ''inlier equivalent,'' which is multiplied by a cost weight in the same way as an inlier payment. For example, in 2004, the 3-day treatment for a major small and large bowel repair (AR-DRG G02A) with a 5-day low boundary point had an outlier equivalence of 0.6 (3 days stay/5-day low boundary), an inlier cost weight of 5.2949 and a WIES value of 3.1769 (0.6×5.2940). Similar to the US and other countries, high LOS outliers received additional payments for each day above the high outlier threshold. This payment was calculated at 70% or 80% of the AR-DRG average inlier cost per day (excluding operating theatres and prostheses costs). Final adjustments for high outlier weight payments sometimes distinguish rural and urban hospitals (DHS, 2002, 2004; [14, 16]).

Since 2001–2002, the total hospital inpatient budget has been capped by setting maximum WIES targets for each hospital. Until a hospital reaches this expenditure cap, the standard WIES payment rate for 2001–2002 was set at $2,515, while for 2004–2005, this rate was $2,919 for major providers, with rural, acute care hospital rates ranging from $3,055 to $3,235 (DHS, 2004; [14]). In addition to DRG-based WIES payments, additional WIES payments, called ''co-payments,'' are paid to hospitals by the state government for mechanical ventilation, thalassaemia, certain stents, atrial septal defect and Aboriginal and Torres Strait Islander loading (DHS, 2004; [14]). Victorian government hospital funding policy also embraces separate funding for 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 [11].

In addition to the WIES-based casemix payments, other facility payments are made by the state government. Specified grants are provided for specific services not covered by casemix, general patient bed day funding or training and development. These include a mixture of historically paid service grants, specific one-time grants and financial payment grants that have not been put into the general WIES price. A few specified grants were rolled into WIES for 2004–2005, including the complexity component of the Training and Development grant, an outpatient base grant and a small rural services grant (DHS, 2004; [14]). The Victorian government continues to explore alternative funding models to facilitate integrated and coordinated care.

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

Every casemix payment system needs to calculate both the base payment and a set of relative values. In Victoria, the calculation of the base payment amount is made jointly by the Department of Human Services and the Department of Treasury and Finance. Antioch et al. [5] found hospital expenditure to be associated with Victorian State Gross Product, the proportion of the population under 4 years of age, the mix of public and private patients in public hospitals, the introduction of casemix funding and subsequent funding cuts, the state-wide proportion of public beds to total beds and technology. These same factors continue to influence annual increases in base payments. However, concerns persist that the base payments have increased too slowly [1, 8]. Setting relative values correctly takes on increased importance when hospitals are facing deficits which may jeopardise their performance.

AR-DRGs and teaching hospitals

This paper builds upon the earlier analysis by Antioch and Walsh [1–3], which documented that hospitals such as the Alfred hospital, which is a state-wide provider of services for trauma, cystic fibrosis, heart and lung transplantation and chronic heart failure, treat patients that are more complex and, hence, more expensive than what the AR-DRG casemix arrangements would indicate. Antioch and Walsh [1] explored the potential for RASGs to reduce the budget shortfall facing hospitals such as the Alfred. They analysed five high-complexity AR-DRGs, encompassing respiratory, cardiology and stroke AR-DRGs. Collectively, these

five AR-DRGs were responsible for annual deficits of $3.6 m at the Alfred. Five stepwise linear regressions found that age, LOS outliers, number of disease types, diagnoses, procedures and emergency status were all significant predictors of patient-imputed costs. They also identified diagnosis- and procedure-based severity markers related to the state-wide referral services. The R^2 value explained 64% of the patient-level variance for the stroke AR-DRG, and 52% and 51% for severe respiratory infections and severe chronic obstructive pulmonary disease (COPD), respectively. The proportion of variance explained for some circulatory disorders without acute myocardial infarction (AMI) was lower, at between 6% and 20% of variance explained [1].

Previously, 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 negotiated increases in RASGs, which totalled around $14 million over the period from 1998 to 2004 for these DRGs and also cystic fibrosis [1, 3].

For casemix payments to be acceptable, the base price and the relative cost weights must be set appropriately; otherwise underfunding problems will emerge. 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 appropriate costs of an efficient provider. It would also enable a sustainable provider industry, avoid the need for cross-subsidisation between hospital services and avoid the need for additional specified grants. Antioch and Walsh [1] argued that the AR-DRG formula adjustments for complexity, age, sex and outliers do not go far enough, and argue that RASG may be a very helpful solution.

The Victorian experience is relevant for many other countries. Crafting a fair and efficient payment mechanism for hospitals is an enduring health policy challenge facing every country [7, 10]. Problems have emerged with the prospective payment system used by US Medicare and other US payers, which are criticised for not adequately capturing differences in severity within DRGs. Many studies have examined the relationship between profitability and illness severity at the hospital level (for a review, see Carpenter et al. [7]). Carpenter et al. [7] 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, DRG payments did not compensate adequately for severity, and higher values for the severity variable resulted in financial losses for the hospital.

Training and development grants

Equitable payment of teaching costs is a particular challenge for every country. The costs of clinical care and teaching are closely interwoven and costs are not easily allocated between these two functions. This problem is further compounded by the fact that teaching and other speciality hospitals tend to attract more complex patients. In Victoria, funding to recognise special teaching hospital costs has been provided through Training and Development (T&D) grants. Following the 2001–2002 review of T&D grants, funding was divided between funding for complexity and funding for training and teaching, with the latter based on the actual numbers of staff. In 2004, the complexity component of the T&D grant was aimed at compensating teaching hospitals for treating more complex patients within selected AR-DRGs. Patient complexity was measured by identifying complex AR-DRGs and the most expensive conditions within them based on the highest cost patients and related ICD-10 procedure and diagnosis codes that accounted for 30% of the workload. Each hospital's proportion of WIES associated with ''complex'' patients in ''complex'' AR-DRGs was then estimated and the complexity grant was allocated based on the share of WIES (DHS, 2003, 2004; [14, 15]).

In summary, the setting for our analysis is one in which payments to health care facilities are based on AR-DRGs, but subject to numerous adjustments. Fixed AR-DRG payments are adjusted upwards and downwards for high and low LOS outliers. Further specified grants are made for certain services, and T&D grants are made to pay for complexity and teaching costs.

Methodology

Risk adjustment alternatives for hospital casemix funding

The starting point for our analysis was to identify the AR-DRGs for 2002–2003 that contributed the most to losses by major teaching hospitals in Victoria. The teaching hospitals participating in RAWG provided data on the ten AR-DRGs that contributed the most to their deficits. These deficit calculations were based on

all costs incurred and revenue for WIES-funded activity, which allocated all fixed, variable and specified grants. Each hospital was requested to identify severity markers (particularly, diagnosis and procedure codes) related to the 15 most expensive patients in each deficit AR-DRG. This methodology, along with initial formulations of how to calculate the net RASGs were based on that outlined in Antioch and Walsh [1]. The analysis was influenced by the international literature on risk adjustment by Van de Ven and Ellis [13].

Preliminary analysis

The initial regression models tested were based on variables identified by Antioch and Walsh [1], including:

- Severity markers (selected diagnosis and procedure codes identified by leading clinicians as specifically relating to the state-wide referral service in each hospital)
- Age
- Sex
- Number of diagnoses
- Number of disease types (i.e. body systems)
- Complexity as measured by the patient clinical and complexity level (PCCL, four different levels, created by the AR-DRG grouper)
- Flag for high outlier on the length of stay
- Emergency department admission
- Number of procedures.

The dependant variable was per patient cost for the hospital stay. Severity marker procedure and diagnosis code data related to state-wide referral services were identified for three hospitals using clinical input and were applied to those AR-DRGs across all hospitals in the data set.

A linear model was specified with explanatory variables that capture the above variables and is discussed further below:

$$\begin{aligned} Y = {} & \beta_0 + \beta_1(\text{SEVERITY MARKERS}) + \beta_2(\text{AGE}) \\ & + \beta_3(\text{SEX}) + \beta_4(\text{DIAG}) + \beta_5(\text{DISEASE TYPES}) \\ & + \beta_6(\text{COMPLEX1}) + \beta_7(\text{COMPLEX2}) \\ & + \beta_8(\text{COMPLEX3}) + \beta_9(\text{COMPLEX4}) \\ & + \beta_{10}(\text{OUTLIER}) + \beta_{11}(\text{EMERG}) \\ & + \beta_{12}(\text{PROCEDURES}) + \varepsilon \end{aligned} \quad (1)$$

Some analyses excluded the number of procedures (PROCEDURES), which improved the stability of the model. The above specification in Eq. 1 was, therefore, further analysed excluding procedures and utilising data for financial years 2001–2002 and 2002–2003 for our sample of 23 hospitals, including some teaching and large rural hospitals. Such analyses found R^2 values ranging from 0.0181 for AR-DRG L61Z (Admit for renal dialysis) to 0.6463 for AR-DRG L62A (Kidney and Urinary Tract Neoplasms w Catastrophic or Severe CC). Of the AR-DRGs analysed, approximately 31 (or 53%) had R^2 values over 0.400, indicating that over 40% of the variance was explained by the specification. However, there were often negative or insignificant coefficients for the four PCCL complexity variables (COMPLEX1–4), based on the complexity measure created by the AR-DRG grouper. This reinforced previous analyses reported in the Victorian Department of Human Services 2003–2004 Policy and Funding Guidelines (DHS, 2004; [14]), which indicated that the PCCL was not a significant severity adjustment variable once other predictors, such as outlier status, were included in the equation. Hence, refined models were conceptualised and tested below, excluding the PCCL variables, procedures and also the number of diagnoses (DIAG), given that the number of body systems (DISEASE TYPES), was already captured.

Four funding models

Further analysis was undertaken using variations of Eq. 1 above. Four further funding policy models to risk-adjust casemix funding in Victoria were conceptualised.

Independent variables

All regression models excluded the number of procedures, PCCL level and the number of diagnoses as independent variables. A new variable, called ''transfers in,'' was also included, which detected whether the admission was the result of a transfer from another facility. Hence, the independent variables explored included:

- Severity markers (aggregated or disaggregated)
- Age
- Sex
- Number of disease types (i.e. body systems)
- Outlier on length of stay
- Emergency admission
- Transfers in.

These variables were used in Models 2, 3 and 4 below. Model 1 used only the severity markers as an independent variable.

Dependent variables

For most of our analysis, the dependant variable was per patient costs. In the case of Model 1 below, another dependent variable was also used (cost minus WIES payment). This variable is of interest because it is an empirical approximation of the degree of underpayment (overpayment if negative) under the 2002–2004 WIES-based payment formula. Hence, this regression model is trying to explain costs not already being predicted by the WIES-based payment formula. This variable represents only a proportion of the underpayment (i.e. the difference between cost and revenue), as other revenue sources are payable to hospitals in addition to the WIES price, such as specified grants. We also varied the explanatory variables used as severity markers, using both aggregated and disaggregated versions.

Severity markers

For all analyses, AR-DRG-specific severity marker variables were constructed using diagnoses and procedure codes identified as potential signals of higher costs and clinical complexity that were related to the statewide referral services of the hospital with the AR-DRG deficit. Severity marker codes had been provided by clinicians at five teaching hospitals and were included in the analyses. Two variations were used. The first approach was to *aggregate* all severity markers into a single binary variable for the specific AR-DRG that simply distinguished whether a given hospitalisation had ANY of the relevant diagnoses or procedures. The other approach was to create separate (or *disaggregated*) severity flags for each of the diagnosis or procedure codes for the specific AR-DRG. Severity markers relating to only three hospitals were included in the *disaggregated* severity marker analyses. Only results for the *aggregated* severity flags are reported here for Models 2, 3 and 4. Results for Model 1 using both *aggregated* and *disaggregated* severity flags are reported below.

Payment models

The general specification for Models 2, 3 and 4 as defined above was as follows:

$$Y = \beta_0 + \beta_1(\text{SEVERITY MARKERS}) + \beta_2(\text{AGE}) + \beta_3(\text{SEX}) + \beta_4(\text{DISEASE TYPES}) + \beta_5(\text{OUTLIER}) + \beta_6(\text{EMERG}) + \beta_7(\text{TRANSFERS IN}) + \varepsilon \quad (2)$$

Specifications for Model 1 were:

$$Y = \beta_0 + \beta_1(\text{Severity Markers Aggregated}) + \varepsilon \quad (3)$$

$$Y_1 = \beta_0 + \beta_1(\text{Severity Marker Aggregated}) + \varepsilon \quad (4)$$

$$Y = \beta_0 + \beta_1(\text{Severity Marker 1}) + \beta_2(\text{Severity Marker 2}) + \beta_n(\text{Severity Marker } n) + \varepsilon \quad (5)$$

The dependent variable for Eqs. 2, 3 and 5 above was ''cost per patient.'' The dependent variable for Eq. 4 above was ''cost per patient minus WIES payment.''

Model 1: severity marker co-payment model Using this framework, all hospitals would receive extra money based on selected severity marker variables. The amount provided would be based on coefficients from regressions that only include severity marker flags. This approach is analogous to what is currently called the ''co-payment'' concept by the Victorian DHS, used to pay for selected services such as stents. Three variations are considered, as shown by Eqs. 3, 4 and 5.

Model 2: expanded risk-adjusted specified grant (RASG) Under this system, the predicted cost of each patient would be calculated by new payment formulae based on multivariate regression models estimated for selected AR-DRGs. The explanatory variables using this framework might include not only the AR-DRG, but demographics, severity, number of disease types, day outlier, emergency and ''transfers in.'' Each hospital could be paid *one* RASG based on the *summation* of the net RASGs (gross RASG minus current casemix revenue) for each of the selected AR-DRGs. The gross RASG would be based on the significant coefficients for each regression for each AR-DRG. It is called an ''expanded'' RASG because each hospital is paid only *one* ''expanded'' RASG based on the summation of all of the RASGs that would have been payable for each AR-DRG identified. Hence, all grants are rolled into one aggregated RASG, not a series of AR-DRG-specific RASG payments. As is the case for all of the models articulated here, adjustments would need to be made for consumer price index (CPI), wages and technology, given that the calculations would be based on the year prior to the introduction of the new funding policy.

Model 3: training and development grant Under this system, we would calculate the expanded RASG using a similar methodology as specified in Model 2, but using data only for hospitals that receive T&D grants (i.e. RAWG hospitals). The percentage allocation by hospital of the summation of the expanded RASGs across all of the teaching hospitals

would be determined. This model would only be used to determine the percentage allocation by hospital of the additional funds available to be distributed across the teaching hospitals for the T&D grants. The percentages of cost burdens would be used to multiply by available funds to determine the T&D grant for each hospital. For example, the RASG calculations could imply that $15 million is justified for reallocation, while only $10 million is available from the Treasury. Each hospital's percentage share of the summation of RASGs ($15 m) could be used to calculate the desired level of funding for each hospital and the available funds ($10 m) could be divided up among eligible hospitals based on these proportions. The evidence of the difference between *required* (i.e. risk-adjusted) and *available* funds could be used in the funding negotiations by the DHS with central agencies. An advantage of this option is that it measures the entire pool of funds to enable appropriate risk-adjusted funds. Whilst this amount may not be available in the Treasury funding, which is a political decision, then the relative distribution of funds between hospitals can be estimated and applied to the available funds. This approach would logically build on the current methodology used in the complexity component of the T&D grant.

A key difference of this new option is that the new model is based, as a starting point, only on the deficit DRGs for the hospitals currently running at a deficit and in receipt of the T&D grant. It applies risk adjusters to identify the drivers of costs for those DRGs and uses them to allocate funds in an equitable way among all of the teaching hospitals. It, therefore, limits the regression analyses to data from the RAWG hospitals that would be in receipt of the T&D grant. This option is similar to Model 2 in its choice of predictive variables, differing primarily in how the predictions from the regression model would be used. However, the regression data sets are different, given that the coefficients in Model 2 uses data from all hospitals (including some rural hospitals), whereas Model 3 only uses data for the RAWG hospitals which are the major teaching hospitals.

Model 4: risk adjustment replacement formulae New risk adjustment formulae for a few AR-DRGs that are high deficit for teaching hospitals. It would replace the current formulae (WIES and grants).

A summary of these options and the variables included in the regressions are outlined below in Table 1.

Models 1, 2 and 4 were analysed using data for the teaching and rural hospitals for which patient-level cost information was available, while Model 3 was based on teaching hospital data only.

Results

Model 1: severity marker co-payment

The three variations of Model 1 use only severity markers as independent variables. Equations 3 and 4 use a single aggregated severity marker. Equation 5 uses disaggregated severity markers. For the disaggregated severity markers, separate indicators were identified for each diagnosis or procedure identified by clinicians as appropriate predictors of increased spending. Up to 13 markers were identified for each AR-DRG considered. The three different models varied depending on the level of aggregation of the severity marker and two different dependent variables, i.e. either ''cost per patient'' (Eqs. 3, 5) or ''cost per patient minus the WIES revenue'' (Eq. 4).

Overall, very low R^2 values were obtained for Eqs. 3 and 4, ranging from 0.0032 for AR-DRG R63Z (Chemotherapy) to 0.2665 for AR-DRG A04A (Allogenic bone marrow transplantation) for Eq. 3. Negative coefficients were found for the single severity markers for AR-DRG E62B (Respiratory infections/inflammation). The R^2 values for various AR-DRGs increased modestly for Eq. 5 when the disaggregated severity markers were used in place of the single aggregated measure in Eq. 3. This approach holds promise, since the higher proportion of variance is explained. The R^2 values varied from 0.00316 for R63Z (Chemotherapy) to 0.48196 for B76B (Seizure age >2 w/o catastrophic), which included up to ten severity markers. Negative coefficients persist for some severity markers, which are difficult to rationalise.

Models 2 and 4

Models 2 and 4 utilised the same regression specification (Eq. 2) and the same data set. Hence, they are discussed together in this section. Model 2 involved the ''expanded RASG,'' whereby each hospital could be paid one RASG based on the summation of the net RASGs. The net RASGs would be calculated based on the gross RASG minus the current casemix revenue for each AR-DRG. The gross RASG would be based on the significant coefficients for each regression for each AR-DRG. As in other models, adjustments would be required for CPI, wages and technology. Model 4 involved a risk-adjusted replacement formulae for a few AR-DRGs that were high deficit across a range of hospitals. The formulation for Model 4 could be incorporated into the current formulae (WIES and specified grants etc.) to make payments more accurately reflect severity.

Table 1 Models and variables for current analyses

Model	Policy option addressed	Sample	AR-DRGs	Dependent variables	Core demographic variables	Emergency department	Severity variables	Transfers	Outliers
1	Model 1: severity marker co-payments	All hospitals	70	Cost or cost-(WIES × average payment)			Single or multiple severity markers		
2	Model 2: expanded RASG	All hospitals	70	Cost	Age, sex, no. of body systems	Emergency department admission	Severity marker	Patient transferred in	High LOS outlier
3	Model 3: Training &Dev grant	RAWG hospitals	70	Cost	Age, sex, no. of body systems	Emergency department admission	Severity marker	Patient transferred in	High LOS outlier
4	Model 4: Replacement formulae	All hospitals	70	Cost	Age, sex, no. of body systems	Emerg. dept. admission	Severity marker	Patient transferred in	High LOS outlier

Table 2 provides results for Models 2 and 4. The data analysed are for all hospitals using cost per patient as the dependent variable. The R^2 values were relatively high for these options and ranged from 0.00426 for L61Z (admit for renal dialysis) to 0.65536 for C01Z (Proc for penetrating eye injury). Of the AR-DRGs analysed, approximately 32 (or 46%) had an R^2 value over 0.400, indicating that, for these AR-DRGs, over 40% of the variance was explained by the specification, which is a very good outcome. A relatively large number of negative coefficients remain on selected severity markers, perhaps explained by collinearity. Any effort to include these coefficients in a payment model would need to be carefully considered.

Model 2 is the expanded RAWG where each hospital is paid one RASG based on the summation of the net RASG (gross RASG minus current casemix formulae/revenue) for each AR-DRG. This option implicitly requires calculation of the revenue under the current arrangements. This extends beyond just WIES revenue to also include T&D grants, specified grants etc. A major survey of revenue modelling was underway with RAWG representatives during 2004. Further consideration is required of this modelling to enable a consistency of approach between hospitals and higher validity of revenue modelling approaches. Further details of the survey results are discussed below. Hence, the feasibility of this funding option will depend on the further development of this revenue modelling framework state-wide. The regression modelling undertaken to date is very promising, discovering that a high proportion of the variance is explained by the variables included. Like the other options explored, the work could be further advanced via a wider incorporation of severity markers from more hospitals and, hence, more AR-DRGs. In general, the R^2 value is higher where the severity marker variable has been included.

Model 4 involves the replacement formulae for a few AR-DRGs that have ''deficit'' status across several hospitals. It would simply replace the current formulae (WIES plus various grants). This option has some appeal, given that it is easier to develop and implement compared to Model 2. It uses the same set of coefficients and data set as for Model 2, but is a simple ''replacement formulae'' that does not require the calculation of any net RASGs nor the gross RASG. Hence, the need for extensive revenue modelling in the calculation of the price is not a key requirement. When using the data from each AR-DRG, it would be important to identify the sub-group of AR-DRGs that were ''deficit status'' across a broad range of hospitals. This could involve the following DRGs identified to date via the RAWG data processes, including:

Table 2 Model 2 (expanded risk adjusted specified grant (RASG)) and Model 4 (risk adjustment replacement formulae)

Obs.	Victorian DRG (W10)	DRG label	*N*	R^2	Dependent mean	Number of Parms.	Intercept	Age	Sex	No. of body systems	Emerg. dept. admission	Patient transferred in	High LOS outlier	Severity marker
1	901Z	Exten O.R. Proc Unrel to Prin Diag	1,139	0.5890	10,984	6	896	–23	–	1,879	3,405	3,822	16,928	–
2	A04A	Allogenic Bone Marrow Transplant	120	0.6243	42,004	5	2,2005	–369	–	3,473	–	–	82,178	16,961
3	A06Z	Tracheo Any Age, Any Condi	1,775	0.3952	64,512	4	11,476	–	–	5,122	–	–	73,612	15,690
4	B02C	Craniotomy W/O CC	857	0.1343	11,243	6	10,041	–50	–	900	1,196	–	14,041	1,448
5	B70A	Stroke W Severe or Compl Diag/Proc	1,840	0.3444	11,554	4	1,309	–	–	1,823	–	–	24,119	954
6	B76B	Seizure Age >2 W/O Cat or Sev CC	3,923	0.3142	1,588	6	1,167	–	–	276	–491	1,520	7,386	3,162
7	B81B	Other Disord of Nerv Sys W/O Cat or Sev CC	1,789	0.4646	1,988	5	1,013	–7	–	355	–	1,499	7,900	–
8	C01Z	Proc for Pen Eye Inj	153	0.6554	4,847	4	2,720	–	–	–	1,766	3,261	26,237	–
9	C03Z	Retinal Proc	1,253	0.1296	2,883	4	2,657	–	–	87	–	2,923	3,914	–
10	C05Z	Dacryocrystorhinostomy	371	0.0638	2,373	3	1,928	–	–	311	1,280	–	–	–
11	C08Z	Major Lens Proc	9,749	0.0483	1,790	4	1,410	3	–	75	–	–	4,812	–
12	C10Z	Strabismus Proc	591	0.3190	1,696	3	1,555	8	–	–	11,096	–	–	–
13	C11Z	Eyelid Proc	941	0.3165	1,798	3	1,270	–	–	264	–	–	9,165	–
14	C12Z	Other Corneal, Scleral & Conjunctival Proc	495	0.4310	1,417	3	819	–	–	311	–	–	4,005	–
15	D06Z	Sinus, Mastoid & Comp Mid Ear Proc	1,368	0.3401	3,721	6	3,161	–18	–	698	1,445	2,246	6,405	–
16	D09Z	Misc Ear, Nose, Mouth & Throat Proc	2,109	0.2690	2,623	5	1,756	12	–	240	–	2,453	7,127	–
17	D10Z	Rhinoplasty (W or W/O Turbinectomy)	1,315	0.1408	2,632	5	2,428	–6	–	242	1,097	–	6,442	–
18	D11Z	Tonsillectomy or Adenoidectomy	4,181	0.2354	1,799	6	1,383	8	–	207	–310	–453	4,595	–
19	D13Z	Myringotomy W Tube Insertion	2,620	0.4354	936	5	536	–	–	315	1,146	16,749	3,493	–
20	D40Z	Dental Extractions and Restorations	2,907	0.2936	1,706	7	1,406	–8	–125	322	401	2,191	5,810	–
21	D66B	Other Ear, Nose, Mouth & Throat Diag W/O CC	1,991	0.2030	1,320	3	1,135	–	–	72	–	–	5,653	–
22	E02C	Other Respir Sys O.R. Proc W/O Cat or Sev CC	2,318	0.5358	2,469	5	1,526	–	–	394	1,408	–	6,860	–539
23	E62B	Respir Infect/Inflam W Sev or Mod CC	3,199	0.3542	4,543	5	4,983	–11	–	443	–	–	10,900	–1,823
24	E65A	COAD W Cat or Sev CC	3,827	0.3600	5,545	8	3,058	–24	308	633	1,028	1,557	13,045	1,226
25	E71A	Resp Neoplasms W CC	1,440	0.4558	4,322	5	142	–	–	655	1,202	994	9,291	–
26	F06A	Cor Bypass W/O Invas Cardiac Inves Proc W Cat/Sev CC	1,441	0.4069	21,269	7	7,212	84	–	1,742	3,781	–1,609	31,330	2,252
27	F10Z	Percutaneous Coronary Angioplasty W AMI	1,385	0.2810	9,091	5	2,406	34	–	998	1,719	–	14,180	–
28	F12Z	Cardiac Pacemaker Implantation	1,261	0.2806	11,073	6	12,456	–72	–	950	1,717	–1,687	9,717	–
29	F15Z	Percutaneous Cor Angioplasty W/O AMI W Stent Imp	2,243	0.3266	5,804	5	1,938	17	–	857	1,427	–	6,536	–
30	F42A	Circ Diso W/O AMI W Inv Card Inves Proc W ComDX/Pr	2,192	0.3832	5,083	5	3,748	–31	–	665	2,081	–	11,250	–
31	F42B	Circ Dis W/O AMI W Inva Card Inves Proc W/O ComDX/Pr	3,003	0.2371	2,617	5	1,527	–	284	215	1,505	–	4,789	–
32	G02A	Major Small & Large Bowel Proc W Cat CC	936	0.4877	20,733	5	3,209	–	–	2,173	2,804	6,865	51,370	–
33	G03A	Stomach, Oesophageal & Duodenal Proc W Malig	226	0.4405	22,167	3	8,026	–	–	2,317	–	–	66,671	–

Table 2 continued

Obs.	Victorian DRG (W10)	DRG label	*N*	R^2	Dependent mean	Number of Parms.	Intercept	Age	Sex	No. of body systems	Emerg. dept. admission	Patient transferred in	High LOS outlier	Severity marker
34	G07B	Appendicetomy W/O Cat or Sev CC	2,807	0.1475	4,144	6	2,413	9	142	347	977	–	6,762	–
35	G44C	Other Colonoscopy, Sameday	8,991	0.0098	1,138	6	1,095	–2	32	60	–259	276	–	–
36	G45B	Other Gastroscopy for Non-Major Digestive Dis, Sameday	9,505	0.0822	847	4	869	–1	–	–	381	–	–	475
37	H04B	Cholecystectomy W/O Closed CDE W/O Cat or Sev CC	3,321	0.4016	4,479	6	3,120	11	–170	257	2,017	–	5,496	–
38	I08A	Other Hip & Femur Proc W Cat or Sev CC	1,281	0.4076	14,545	4	10,097	–64	–	1,375	–	–	25,694	–
39	I13C	Humerus, Tibia, Fibula & Ankle Proc Age <60 W/O Cat or Sev CC	1,924	0.3660	5,749	5	2,162	28	–	824	556	–	10,396	–
40	I18Z	Knee Procedures	2,969	0.3258	2,886	6	2,802	–23	–	490	1,356	–2,399	8,416	–
41	I68A	Non-Surg Neck+Back C W/O Pain Man/ Myelo (Age <75 W CC)/Age >74	1,556	0.4862	3,519	5	1,633	–12	–	573	–	–	10,070	7,884
42	I68B	Non-Surg Neck+Back C W/O Pain Man/ Myelogram Age <75 W/O CC	3,411	0.4319	1,412	7	470	–5	–	316	206	830	5,695	6,375
43	J06A	Major Proc for Malig Breast Condi	1,056	0.4133	6,306	4	3,159	–	–	1,033	2,706	–	11,359	–
44	J64B	Cellulitis (Age >59 W/O Cat or Sev CC) or Age <60	4,650	0.3337	2,587	6	794	3	–	394	525	905	5,224	–
45	K60B	Diabetes W/O Cat or Sev CC	2,945	0.4004	2,577	8	1,776	–30	219	351	839	2,307	7,333	515
46	K62C	Misc Metabolic Disord W/O Cat or Severe CC Age <75	3,147	0.4840	1,112	5	290	–	–	305	334	1,920	6,781	–
47	L61Z	Admit for Renal Dialysis	138,707	0.0043	384	4	478	–1	–	–22	–	100	–	–
48	L62A	Kidney & Urinary Tract Neoplasms W Cat or Sev CC	189	0.6060	4,680	5	1,806	–54	–	996	1,741	–	17,267	–
49	M06A	Other Male Reproductive Sys O.R. Proc For Malig	193	0.4407	9,295	4	–1,135	71	–	–	–	–	21,549	6,306
50	N09Z	Conistation, Vagina, Cervix & Vulva Proc	4,820	0.4058	1,498	7	369	9	–	276	612	1,543	6,798	5,105
51	O01A	Caesarean Delivery W Multiple Comp Diag, At Least One Sev	1,509	0.5878	10,829	4	4,207	–	–	1,661	–	4,580	31,768	–
52	O01D	Caesarean Delivery W/O Complic Diag	4,457	0.0748	5,102	4	4,683	–15	–	380	–	–	9,382	–
53	O60D	Vaginal Delivery W/O Complic Diag	16,909	0.0536	2,387	5	1,816	–6	–	339	503	–	8,030	–
54	O65A	Other Antenatal Adm W Sev Complic Diag	5,262	0.4474	1,152	6	6	11	–	427	357	960	8,884	–
55	O65B	Other Antenatal Adm W Mod or No Complic Diag	8,112	0.3329	963	6	195	9	–	211	288	1,154	5,348	–
56	P67B	Neonate, AdmWt >2499 G W/O Sign O.R. Proc W Major Prob	1,006	0.5444	6,496	4	2,046	–	–	908	–	2,586	20,485	–
57	P67C	Neonate, AdmWt >2499 G W/O Sign O.R. Proc W Other Pro	3,036	0.3390	3,024	6	1,266	–	–	725	524	1,805	8,633	1,842
58	Q02A	Other O.R. Proc of Blood & Blood Forming Organs W Cat or Sev CC	150	0.5377	20,313	3	–2,573	–	–	2,653	–	–	106,362	–
59	Q60A	Reticuloendothelial & Immunity Dis W Cat or Sev CC	863	0.5504	7,604	5	–1,405	–54	–	1,860	–	–2,384	25,095	–

Table 2 continued

Obs.	Victorian DRG (W10)	DRG label	*N*	R^2	Dependent mean	Number of Parms.	Intercept	Age	Sex	No. of body systems	Emerg. dept. admission	Patient transferred in	High LOS outlier	Severity marker
60	R04B	Other Neoplastic Dis W Other O.R. Proc W/O Cat or Sev CC	551	0.3915	3,419	5	4,027	–13	–1,278	–	–	–	14,151	1,396
61	R61A	Lymphoma & Non-Acute Leukaemia W Cat CC	409	0.5385	13,716	4	4,455	–125	–	2,144	–	–	24,722	–
62	R61B	Lymphoma & Non-Acute Leukaemia W/O Cat CC	2,075	0.4021	4,835	5	4,679	–55	–	805	–	1,973	10,337	–
63	R63Z	Chemotherapy	39,171	0.0118	723	6	849	–3	83	–	554	–	2,980	1,122
64	R64Z	Radiotherapy	2,179	0.4022	8,477	7	–2,772	25	–	1,599	1,615	3,812	19,747	1,033
65	T01A	O.R. Proc for Infect & Parasitic DisW Cat CC	407	0.3710	21,897	4	2,649	–112	–	3,596	–	–	39,747	–
66	T60A	Septicaemia W Cat or Sev CC	1,433	0.4582	8,560	4	3,566	–58	–	1,225	–	–	16,457	–
67	U66Z	Eating & Obsessive-Compulsive Diso	205	0.2376	13,719	3	16,624	–272	–	–	–	–	34,509	–
68	W01Z	Ventilation or Craniotomy Procs for Multiple Sign Trauma	310	0.2687	60,354	4	42,152	–	–	–	–	–10,571	63,370	16,477
69	Z61Z	Signs and Symptoms	3,477	0.5939	1,706	6	241	6	183	317	–	1,062	10,007	–
70	Z64B	Other Factors Influencing Health Status Age <80	9,195	0.2463	932	6	414	–4	–105	426	–	941	17,266	–

AR-DRG AO6Z Tracheostomy, any age, any condition; G02A Major Small and Large Bowel Procedures with Catastrophic CCs; E62B Respiratory infections/inflammations with severe or moderate CCs; F06A Coronary Bypass no investigative Cardiac invasive procedures with Catastrophic/Severe CCs; F10Z Percutaneous Coronary Angioplasty with AMI; G44C Other Colonoscopy Same day; L61Z Admit for Renal Dialysis; R63Z Chemotherapy. This model might be relatively easy to implement compared to the other options, and might conceptually be the easiest for the industry to understand and accept.

Model 3: training and development grant

With this formulation, the percentage distribution of the total available funding for the complexity component of the T&D grant would be based on the percentage distribution of each hospital in the total of the expanded RASG concept, but which is calculated based on the data from RAWG hospitals in receipt of the T&D grant. The R^2 value for this option ranged from 0.00437 for AR-DRG L61Z (Admit for renal dialysis) up to 0.64173 for AR-DRG 901Z (Extensive OR procedures unrelated). Around 35 (or 50%) AR-DRGs had R^2 values that were higher than 0.40, which is a very good outcome. As before, negative coefficients on certain severity measures would warrant further consideration. The results are summarised in Table 3.

The advantage of this model is that is builds upon a framework already used in Victoria for calculating the complexity component of the T&D grant. A challenge for its implementation, however, is the same as that outlined for Model 2 above. It requires careful calculation of both the gross RASG and the net RASG. The latter requires calculation of the revenue that would be derived from WIES and other sources, such as specified grants, and, hence, is dependent on good revenue modelling that is consistent between hospitals. This is not considered to be a major impediment but will require more work. Overall, it seems that Model 4 would be the easiest to implement and trial in the short term, pending additional severity marker data. Should more comprehensive severity marker data become available from the hospitals, then the use of an additional variable (i.e. disaggregrated severity markers) *might* be considered for Model 4 (and also Model 2). This would simply involve the inclusion of these additional variables in Eq. 2. Models 3 and 2 will require much more work on the revenue modelling side. The validity of Model 1 is an issue, given the small size of the R^2 values, especially for aggregated severity markers.

Table 3 Model 3: T&D grant (Risk Adjustment Working Group (RAWG) hospitals only)

Obs.	Victorian DRG (W10)	DRG label	N	R^2	Dependent mean	Number of Parms.	Intercept	Age	Sex	No. of body systems	Emerg. dept. admission	Patient transferred in	High LOS outlier	Severity marker
1	901Z	Exten O.R. Proc Unrel to Prin Diag	611	0.6417	1,1882	5	254	–	–	1,835	4,328	3,402	18,659	–
2	A04A	Allogenic Bone Marrow Transplant	112	0.6352	43,970	5	19,494	–325	–	3,793	–	–	96,380	13,251
3	A06Z	Tracheo Any Age, Any Condi	1,067	0.3869	69,574	4	11,874	–	–	5,354	–	–	76,565	13,014
4	B02C	Craniotomy W/O CC	842	0.1405	11,317	6	10,237	–55	–	920	1,431	–	13,835	1,359
5	B70A	Stroke W Severe or Compl Diag/Proc	826	0.3510	12,833	4	–3,557	54	–	2,190	–	–	26,086	–
6	B76B	Seizure Age >2 W/O Cat or Sev CC	1,983	0.3126	1,764	6	1,147	–10	–	295	–	1,413	8,540	4,770
7	B81B	Other Disord of Nerv Sys W/O Cat or Sev CC	1,121	0.5238	1,884	5	1,324	–9	–	239	–	1,730	8,724	–
8	C01Z	Proc for Pen Eye Inj	129	0.7238	4,981	4	3,016	–	–	–	1,395	5,148	25,682	–
9	C03Z	Retinal Proc	1,104	0.1675	2,849	5	2,667	–4	–	213	–	6,023	3,991	–
10	C05Z	Dacryocrystorhinostomy	298	0.0735	2,289	4	2,164	–	–327	252	–	–	1,736	–
11	C08Z	Major Lens Proc	6,270	0.0840	1,778	4	1,589	–	–50	133	–	–	5,449	–
12	C10Z	Strabismus Proc	505	0.0825	1,640	3	1,301	8	–	187	–	–	–	–
13	C11Z	Eyelid Proc	645	0.4427	1,777	4	958	–	194	382	–	–	9,018	–
14	C12Z	Other Corneal, Scleral & Conjunctival Proc	397	0.5213	1,382	3	733	–	–	348	–	–	3,527	–
15	D06Z	Sinus, Mastoid & Comp Mid Ear Proc	724	0.4685	3,948	6	3,034	–19	–	872	1,542	6,658	7,324	–
16	D09Z	Misc Ear, Nose, Mouth & Throat Proc	1,094	0.3119	3,000	4	2,290	16	–	–	–	6,016	7,457	–
17	D10Z	Rhinoplasty (W or W/O Turbinectomy)	555	0.1083	2,647	4	2,503	–9	–	287	–	–	4,274	–
18	D11Z	Tonsillectomy or Adenoidectomy	1,639	0.3969	1,644	5	1,107	11	–	268	–402	–	4,637	–
19	D13Z	Myringotomy W Tube Insertion	1,358	0.4667	911	6	420	4	–	343	1,235	16,553	3,359	–
20	D40Z	Dental Extractions and Restorations	825	0.3598	2,434	7	1,842	9	–	213	–556	2,093	5,492	799
21	D66B	Other Ear, Nose, Mouth & Throat Diag W/O CC	995	0.2667	1,387	2	1,303	–	–	–	–	–	6,946	–
22	E02C	Other Respir Sys O.R. Proc W/O Cat Sev CC	1,286	0.5698	2,748	4	1,234	–	–	441	1,768	–	7,876	–
23	E62B	Respir Infect/Inflam W Sev or Mod CC	1,270	0.4081	5,065	5	7,116	–26	–	423	–	–	14,001	–2,778
24	E65A	COAD W Cat or Sev CC	1,365	0.3125	6,041	7	2,960	–33	–	668	2,162	3,514	14,824	1,438
25	E71A	Resp Neoplasms W CC	605	0.4808	4,552	5	530	–	–	628	1,222	3,040	9,009	–
26	F06A	Cor Bypass W/O Invas Cardiac Inves Proc W Cat/Sev CC	1,309	0.3965	20,833	6	5,690	93	–	1,829	3,182	–	26,042	3,439
27	F10Z	Percutaneous Coronary Angioplasty W AMI	947	0.2529	9,537	5	5,152	–	–	977	1,918	–992	14,385	–
28	F12Z	Cardiac Pacemaker Implantation	962	0.3366	10,732	6	11,679	–63	–	946	1,209	–1,230	10,832	–
29	F15Z	Percutaneous Coronary Angioplasty W/O AMI W Stent Imp	1,753	0.3335	6,315	6	2,484	19	–	766	2,307	–1,073	6,480	–
30	F42A	Circ Diso W/O AMI W Inv Card Inves Proc W ComDX/Pr	1,345	0.3810	5,216	6	4,244	–30	–	638	1,420	–618	11,211	–
31	F42B	Circ Dis W/O AMI W Inva Card Inves Proc W/O ComDX/Pr	2,103	0.1741	2,808	4	2,239	–	332	–	1,416	–	5,099	–
32	G02A	Major Small & Large Bowel Proc W Cat CC	358	0.5534	23,666	4	3,932	–	–	2452	–	6,736	60,524	–
33	G03A	Stomach, Oesophageal & Duodenal Proc W Malig	129	0.4761	24,582	3	10,031	–	–	2,173	–	–	66,103	–

Table 3 continued

Obs.	Victorian DRG (W10)	DRG label	*N*	R^2	Dependent mean	Number of Parms.	Intercept	Age	Sex	No. of body systems	Emerg. dept. admission	Patient transferred in	High LOS outlier	Severity marker
34	G07B	Appendicectomy W/O Cat or Sev CC	908	0.2416	4,554	4	2,512	–	–	554	1,259	–	8,057	–
35	G44C	Other Colonoscopy, Sameday	3,237	0.0100	1,173	3	1,210	–3	–	56	–	–	–	–
36	G45B	Other Gastroscopy for Non-Major Digestive Dis, Sameday	4,639	0.1265	915	3	831	–	–	–	227	–	–	578
37	H04B	Cholecystectomy W/O Closed CDE W/O Cat or Sev CC	748	0.5114	4,851	4	3,431	–	–	312	2,533	–	4,847	–
38	I08A	Other Hip & Femur Proc W Cat or Sev CC	501	0.3768	16,463	3	7,864	–	–	1,322	–	–	23,310	–
39	I13C	Humerus, Tibia, Fibula & Ankle Proc Age <60 W/O Cat or Sev CC	652	0.4500	7,000	4	3,090	60	–	679	–	–	11,880	–
40	I18Z	Knee Procedures	798	0.3198	3,624	6	3,417	–36	–	769	1,987	–3740	9,642	–
41	I68A	Non-Surg Neck+Back C W/O Pain Man/ Myelo (Age <75 W CC)/Age >74	766	0.4884	3,514	5	1,918	–19	–	593	–	–	11,754	9,812
42	I68B	Non-Surg Neck+Back C W/O Pain Man/ Myelogram Age <75 W/O CC	1,548	0.4140	1,527	6	568	–11	–	341	429	–	7,472	6,784
43	J06A	Major Proc for Malig Breast Condi	368	0.5411	6,771	5	6,689	–	–3,628	1,150	4,249	–	13,112	–
44	J64B	Cellulitis (Age >59 W/O Cat or Sev CC) or Age <60	1,718	0.3052	2,929	5	816	–	–	430	818	1,041	6,006	–
45	K60B	Diabetes W/O Cat or Sev CC	1,269	0.4246	3,145	8	2,591	–40	588	219	1,037	1,726	9,630	585
46	K62C	Misc Metabolic Disord W/O Cat or Severe CC Age <75	1,134	0.5290	1,678	6	1,053	–12	–	269	349	2,577	6,902	–
47	L61Z	Admit for Renal Dialysis	92,762	0.0044	417	5	477	–1	6	18	–	84	–	–
48	L62A	Kidney & Urinary Tract Neoplasms W Cat or Sev CC	91	0.6266	4,523	5	1,894	–38	–	716	2,706	–	18,670	–
49	M06A	Other Male Reproductive Sys O.R. Proc For Malig	176	0.4006	9,692	5	–1,606	77	–	–	–15,336	–	32,755	6,412
50	N09Z	Conistation, Vagina, Cervix & Vulva Proc	178	0.4209	5,576	6	212	–49	–	1,855	–	18,830	4,449	2,851
51	O01A	Caesarean Delivery W Multiple Comp Diag, At Least One Sev	183	0.5067	9,008	4	2,803	–	–	1,735	–	4,731	18,777	–
52	O01D	Caesarean Delivery W/O Complic Diag	319	0.2460	5,551	2	5,417	–	–	–	–	–	21,275	–
53	O60D	Vaginal Delivery W/O Complic Diag	1,003	0.0272	2,739	3	1,259	–	–	677	–	–	2,176	–
54	O65A	Other Antenatal Adm W Sev Complic Diag	529	0.3193	1,744	4	–512	36	–	493	–	–	6,089	–
55	O65B	Other Antenatal Adm W Mod or No Complic Diag	1,033	0.2708	1,224	6	380	13	–	247	–474	1,118	4,233	–
56	P67B	Neonate, AdmWt >2499 G W/O Sign O.R. Proc W Major Prob	261	0.5085	8,131	4	739	–	–	1,994	–	4,468	19,856	–
57	P67C	Neonate, AdmWt >2499 G W/O Sign O.R. Proc W Other Pro	421	0.4380	3,634	5	42	–	–	1,382	1,627	2,422	11,185	–
58	Q02A	Other O.R. Proc of Blood & Blood Forming Organs W Cat or Sev CC	96	0.5599	26,142	3	–6,983	–	–	3,591	–	–	109,536	–
59	Q60A	Reticuloendothelial & Immunity Dis W Cat or Sev CC	611	0.6132	8,169	4	–3,158	–58	–	2,219	–	–	28,130	–

Table 3 continued

Obs.	Victorian DRG (W10)	DRG label	*N*	R^2	Dependent mean	Number of Parms.	Intercept	Age	Sex	No. of body systems	Emerg. dept. admission	Patient transferred in	High LOS outlier	Severity marker
60	R04B	Other Neoplastic Dis W Other O.R. Proc W/O Catastr or Sev CC	440	0.4812	3,773	6	4,987	–23	–1377	–	4,055	–	13,098	1,139
61	R61A	Lymphoma & Non-Acute Leukaemia W Cat CC	259	0.5084	15,863	4	4,209	–98	–	2,118	–	–	25418	–
62	R61B	Lymphoma & Non-Acute Leukaemia W/O Cat CC	1,319	0.4276	5,616	6	4,719	–54	–542	1,001	–	2,325	10,271	–
63	R63Z	Chemotherapy	16,883	0.0051	924	3	918	–	–	–	–	–	3,130	1,027
64	R64Z	Radiotherapy	1,833	0.4321	8,567	6	–1,446	–	–	1,597	2,026	4,119	19,055	1,281
65	T01A	O.R. Proc for Infect & Parasitic DisW Cat CC	244	0.4173	24,306	4	6,428	–196	–	3,886	–	–	59,281	–
66	T60A	Septicaemia W Catast or Sev CC	720	0.4629	9,772	4	3,944	–70	–	1,404	–	–	16,131	–
67	U66Z	Eating & Obsessive-Compulsive Diso	154	0.2111	15,677	3	22,720	–557	–	–	–	–	34,490	–
68	W01Z	Ventilation or Craniotomy Procs for Multiple Sign Trauma	282	0.2687	62,045	4	45,001	–	–	–	–	–11,443	64,823	14,532
69	Z61Z	Signs and Symptoms	1,891	0.6339	1,922	5	1,204	–8	222	294	–	–	10,976	–
70	Z64B	Other Factors Influencing Health Status Age <80	4,201	0.2784	1,190	4	636	–	–210	325	–	–	44,043	–

However, further exploration of the data using disaggregated severity markers may produce a better outcome.

Severity marker code analyses

Given that severity marker codes were provided by only five of the eight RAWG hospitals and used in the analysis, the need has been identified for the extension and validation of severity marker code choice for each high-deficit AR-DRG across *all* of the teaching hospitals. For example, some specific AR-DRGs (e.g. A06Z) were high deficit across four teaching hospitals, but only one hospital provided severity markers for this AR-DRG. In such instances, there would be under-representation of all of the severity codes for that AR-DRG. In other cases, three other hospitals did not provide any severity markers for their high-deficit AR-DRGs. Hence, those hospitals would be under-represented in the analyses. Whilst the preliminary regressions run to date do shed some light on the power of severity markers to explain costs, much more work is required to address these issues. The validity and reliability of these markers may be compromised, given the relatively small number of hospitals that have identified severity markers for deficit AR-DRGs and the variability in cost data across hospitals and time. For example, the following list of severity markers was identified by one hospital for AR-DRG A06Z (Tracheostomy any age, any condition) for 2002–2003:

Code	Description
T862	Heart transplant failure and rejection
Y830	Surgical op w transplant of whole organ
S250	Injury of thoracic aorta
S251	Injury innominate or subclavian artery
Z942	Lung transplant status
G8251	Tetraplegia, unspecified, acute
4001201	Third ventriculostomy
3901500	Insertion of external ventricular drain

An analysis of the 2002–2003 inpatient cost data for this one AR-DRG shows:

- Across all cost-reporting hospitals, the distribution of costs for episodes with one or more severity marker fall within the distribution of costs for episodes without a severity marker
- Six campuses report episodes with one or more of the above severity markers; for these six campuses combined, there is no significant difference in the average cost between episodes with and without severity markers ($P>0.05$)
- Three campuses report the highest average cost for episodes without a severity marker

– Three campuses report the highest average cost per bed day for episodes without a severity marker.

This analysis of one AR-DRG could be replicated in the future once severity marker information is received across all hospitals with a deficit in the specified AR-DRG, since the array of severity markers will vary depending on their state-wide referral service. The above analysis only included severity markers identified by the hospital (related to transplantation and trauma) and it then analysed the impact across all hospitals. That hospital's severity markers are not necessarily those of other teaching hospitals with different state-wide referral services. It might be reasonable to hypothesise that, if the costs associated with any individual severity marker represented the actual costs required to treat the patient condition rather than costs associated with an individual hospital practice, then a severity marker should be high cost for all hospitals. Where this is not the case, reimbursing hospitals for higher than average costs in their hospital alone could, potentially, result in funding inappropriate hospital practice rather than funding severity per se.

Other important issues involve the potential for self-selection bias in the identification of severity markers by various teaching hospitals. This is important because some hospitals may select a relatively high number of severity markers compared to other hospitals. In our exploratory work, not all hospitals identified severity flags and we did not consider how new severity measures might be added in the future. Moreover, the prevalence of these flags might change once hospitals know that they affect funding. All of these issues would need to be addressed, should this approach be implemented. Guidelines could be developed to clearly define codes that could be counted as severity indicators. The variability in cost data across hospitals and time has been emphasised and could be further explored in future.

Limitations and policy concerns

Some of the variables that we included in our regression models raise concerns about incentives and fairness. The inclusion of a high outlier flag and an emergency status variable are two examples.

Under Victoria's casemix formula, high outliers are designed to be ''loss'' patients. The assumption of the RASG models is that high outlier status is a reflection of severity rather than inappropriate hospital practice. While this might be a valid assumption, refunding aggregated patient losses for high outliers through an RASG model could provide a perverse incentive for hospitals to retain patients with above-average hospital stays until they exceed the high boundary, thereby becoming high outliers and eligible for the augmented funding. If RASG models were implemented that included additional payments for outliers, it could encourage hospital inefficiency.

Similarly, while emergency patients do have higher costs than non-emergency patients in some DRGs, the Victorian DHS has considered and rejected the application of ''emergency'' WIES copayments on the basis of their potential to adversely impact on patient care. Without clear definitions of what represents an ''emergency,'' the reporting and counting of emergencies is problematic, relying largely on clinician judgement. Providing financial incentives for admitting emergency patients has the potential to change the types of patients reported as ''emergency,'' thereby reducing the hospital's ability to identify those patients that are most in need of immediate admission. Funding hospitals for ''emergency'' patients through RASG could be associated with the same risks.

Our analysis is subject to other limitations that we wish to highlight here. In analysing the reasons for the deficit position of hospitals for some AR-DRGs, evidence about the relative efficiency of the hospitals is required, in addition to the results of econometric analyses of risk adjustment variables. This matter was previously explored by Antioch and Walsh [1–3], who used benchmarking data developed by the Health Round Table (HRT) to demonstrate relative efficiency.

Further, we have estimated our models without including any response by hospitals to any new incentives that would be created. More refined estimates could capture changes in efficiency in response to payment formula changes. Another issue is that there is a wide variation in methods for allocating costs among patients at different hospitals. Allocation methods will affect both the identification of high-deficit AR-DRGs and the estimated coefficients. We have used an incomplete set of severity measures. A more comprehensive approach might be to start with a comprehensive classification system, such as the DCG system of Ash et al. [6], for grouping diverse diagnosis codes. Some preliminary results from this approach are discussed later.

Hospital-level simulations of refined AR-DRG models

In order to better understand the implications of the regression models for the explanation of individual-

level spending, we conducted policy simulations of hospital-level costs and predicted payments under a variety of assumptions. For this analysis, we focussed on the 59 problematic AR-DRGs for which this study's clinicians had identified severity markers. We used a sample of 23 hospitals considered to have the most reliable cost information for 2002–2003. Altogether, the sample contained data on 743,628 separations, with a total cost of $2,058 million. The results of our simulations are presented in Table 4.

We started by simulating, as the base case, a very simple hospital payment model: for each patient in a given AR-DRG, every hospital received a constant payment amount just equal to the state average cost for that AR-DRG. By construction, this payment system will pay out the same amount as the sum of the total cost for all hospitals combined. For specific hospitals, however, this constant AR-DRG payment will systematically over- and underpay relative to the actual hospital costs. So, to avoid the controversy of looking at specific hospitals, we collected the five hospitals that had the largest amount of underpayment (which were all among the RAWG hospitals) and the five hospitals with the largest amount of overpayment using this simple system. The 13 remaining hospitals were grouped in an intermediate category which we call the ''rest of the hospitals.'' As shown in Table 4, the underpaid hospitals would collectively experience a loss of $88 million under this stylised system, representing a loss of $392 per case. The overpaid hospitals would experience a profit of $63 million ($320 per case), while the rest of the hospitals would experience a cumulative profit of $25 million.

We then simulated a modified payment system in which the predictions from our Model 4 regression model (Eq. 2) were used to predict the payments for each case, rather than the constant AR-DRG mean. The results from this simulation are summarised in the second section of Table 4. Altogether, Model 4 increased payment to the five most underpaid hospitals by only $9 million, representing about 10% of the imputed deficit. Payments to the five most overpaid hospitals were reduced by about $5 million, with the rest of the hospitals seeing a reduction of about $4 million.

To see if this modest impact on the budget allocation to underpaid Victorian hospitals would differ if the existing structure of risk adjustment is superimposed on the simulated payment model, we repeated the simulations using a different dependent variable. Rather than using the total cost of each case, we used the total cost minus the existing WIES payment amount, which captures the total payment before teaching and certain other adjustments. The grand sum

Table 4 Results from using regression models to simulate hypothetical risk-adjusted diagnosis-related group (DRG) payments

	No. of hospitals	No. of patients	Sum of total actual costs, in millions	Sum of regression-predicted revenues, in millions	Calculated profit (loss), in millions	Calculated profit (loss) per case
All hospitals	23	743,628	2,058	2,058	0	0
Base case, with all cases in each DRGs paid a constant amount for that DRG						
Top five most underpaid hospitals	5	225,428	764	675	–88	–392
Rest of the hospitals	13	321,368	808	834	25	79
Top five most overpaid hospitals	5	196,832	486	549	63	320
Model 2/4 simulation						
Top five most underpaid hospitals				684	–79	–351
Rest of the hospitals				830	21	66
Top five most overpaid hospitals				544	58	294
Base case, with each case paid the imputed WIES payment amount with adjustments						
Top five most underpaid hospitals	5	225,428	289	199	–89	–397
Rest of the hospitals	13	321,368	220	247	27	86
Top five most overpaid hospitals	5	196,832	101	163	62	315
Model 2/4 simulation						
Top five most underpaid hospitals				208	–80	–355
Rest of the hospitals				243	24	74
Top five most overpaid hospitals				157	56	286

All results used 2002–2003 data from 23 hospitals in Victoria, Australia, in 59 high-volume DRGs identified as being particularly problematic to certain hospitals. The five hospitals with the greatest absolute losses were identified within this sample, as were the five with the largest absolute gains. Regression Model 1 uses age, sex, number of diagnoses, number of body systems, emergency department flag, transfer flag, outlier flag and the aggregate severity marker to predict the total cost. Regression Model 2 is the same as Model 1, but uses the total cost minus the imputed WIES payment as the dependent variable

of this new payment decreases from $2,058 million to $609 million, reflecting that most (about 70%) of the hospital payments to the sampled hospitals in our selected AR-DRGs is captured by the existing WIES payment calculations. As shown in the bottom half of Table 4, the impact of using regression Model 4 rather than a constant amount for each case on top of the existing WIES amount was to increase payments to the most underpaid hospitals by about $9 million. In short, the hospital-case-based formulae developed here reduce the imputed deficits by only about 10%, regardless of whether they were implemented on top of the WIES system or in place of it.

Re-calibrating DCG/HCC using Victorian cost data

One limitation of the approach used here is that only a relatively small subset of all diagnoses was identified as possible risk adjusters. An alternative approach would be to start with a comprehensive classification system, such as the diagnostic cost group/hierarchical condition category (DCG/HCC) system described in Ash et al. [6]. The HCC system uses diagnoses generated during patient encounters to infer medical problems. Diagnostic profiles and patient demographics predict costs. The ''condition categories'' capture both chronic and serious acute disease manifestations and expected costs, while hierarchies on these conditions promote clinical coherence. When included in a regression framework, each condition category coefficient reflects the increment to expected costs that is associated with that condition [6].

In 2004, preliminary work was undertaken using solely diagnoses as classified using the DxCG risk adjustment software. That framework uniquely classifies every ICD-10 diagnosis into 763 detailed clinical groups, called DxGroups, as well as into 173 more aggregated categories, called hierarchical condition categories (HCCs). Victorian data were processed using DxCG 6.1 Global Edition software using the hospital cost data for 2002–2003. Two preliminary regressions were estimated. Regressions using the full set of 763 DxGroups achieved an adjusted R^2 value of 0.4422, while a second preliminary regression using 173 HCCs achieved an adjusted R^2 value of 0.3626. Although encouraging, both sets of coefficients had negative coefficients for some covariates, (including intercept), suggesting that nonlinearities and interactions would need to be corrected.

In subsequent work at the DHS by Gillett [9], hospital data was analysed after merging individual cost data across episodes using a unique patient pin to group multiple separations together, rather than considering each patient's hospitalisation as a separate observation. A concurrent R^2 value of 55%, was obtained—a very good outcome. In that preliminary HCC model, 18 of the parameters had negative coefficients, which would need to be explored in further work.

Conclusions

Concerns about the viability of hospitals in the face of highly imperfect diagnosis-related group (DRG) payments have led many countries to explore various reforms to their hospital payment system. This paper has evaluated alternative possible hospital payment reforms using data from Victoria, Australia, with the goal of understanding how different explanatory variables and different payment frameworks affect hospital revenues.

The review of hospital price and resource allocation by the Victorian Department of Human Services (DHS), Premier, Cabinet and Treasury and Finance identified non-salary cost escalation and variable management performance as key impacts on declining hospital financial performance. Hence, the arguments advanced by the hospital industry about pricing reform agendas should be carefully considered within this broader assessment of the role of variable hospital management performance and the non-salary cost escalation as important additional factors impacting on hospital deficits. The Victorian government has already made significant inroads in trying to resolve issues of hospital deficits. In response to financial concerns, the DHS increased hospital base prices by $95 million in 2004–2005. Savings targets and transitional grants were developed for each health service still in deficit following the initial allocation. Transition grants will be in place for 1 year and a maximum of 2 years, and all health services are expected to achieve balanced budgets by the end of 2005–2006. Non-salary costs were indexed to 4.8% increases, and hospitals were asked to improve efficiencies by at least 0.75% of total operating revenue (DHS, 2004; [14]). The Victorian DHS has already made significant in-roads in risk-adjusting elements of the Training and Development grant (T&G), including the recent separation of the training and development payments into complexity and teaching components.

Notwithstanding these initiatives, further refinements will still be needed. The various funding models explored by the Risk Adjustment Working Group (RAWG) in this paper may provide guidance on the

most desirable directions to explore. The use of only severity markers as independent variables (Model 1 variants) appears to lack sufficient explanatory power to be worthy of further consideration. Models such as the expanded risk-adjusted specified grants (RASG) (Model 2) and the T&D grant (Model 3), linked to deficit AR-DRGs show some promise, but, to be useful, they would require more refinement. When some risk-adjustment variables are included, simulations using the adjusters identified in Victoria only reduce underpayment to the high-loss hospitals by about 10%. Preliminary results presented here suggest that the most promising directions to consider use refinements similar to our Model 4 that involve replacing the existing Australian-refined diagnosis-related groups (AR-DRG) formulae with new formulae.

One approach that appears promising would use the diagnostic cost group/hierarchical condition category (DCG/HCC) classification system, involving patient relative risk scores to risk adjust the AR-DRGs, and better control for within-DRG severity. An alternative possibility would be to reimburse hospitals for the expected cost of individuals for a period of time (such as a year), rather than pay for an inpatient episode as the unit of payment. This might be appropriate for patients requiring chronic care.

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Kathryn M. Antioch[1,2] · Michael K. Walsh[1]
[1] Bayside Health, The Alfred Hospital, Melbourne, Australia
[2] 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 χ^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 sub-acute 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:

WIES10=base_WIES +mv_copay
+th_copay +AAA_copay +ASD_copay
+colonocopay +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=thalessaemia 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; colonocopay=colonscope 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

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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 multicollinearlity. 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
Allied health: allied health staff providing in-patient care and associated consumables and supplies	Minutes of care
Operating room management: theatre staff, infusion/bypass and operation consumables	Minutes of care
Specialized procedural services: 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
Anaethetics: Supply and staffing costs.	Theatre minutes
Implantable prostheses: artificial joints and limbs, pacemakers and hearing aids	Weighted prosthetic items, purchase costs
High-dependency costs: coronary care unit, high-dependency unit and intensive care unit services	Length of stay in intensive care unit and coronary care unit
Ward: nurses and other ward staff, ward consumables and high dependency services	Length of stay in ward
Imaging: medical, scientific, nursing, administrative staff, and supplies involved in providing this in-patient service	Weighted procedure type
Pathology: as above	Weighted pathology type
Pharmacy: as above	Stock price of prescription drugs–Imprest pharmacy: ward bed-days
Medical and surgical services: medical, surgical consultants, visiting staff, registrars, resident medical officers and associated staff, supplies and consumables	Bed-days
Emergency: medical, nursing, administrative and other staff assigned to the emergency department, consumables and observation ward costs in the emergency department	Triage category minutes
Other services: 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 myocardial 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, multicollinearlity, 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 (β_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 (β_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 (β_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 (β_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 (β_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 comparisons 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: *Principal diagnoses*: intracerebral, subarachnoid haemorrhages. *Procedure*: 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: *Principal diagnoses* of pneumonia due to either staphylococcus or pseudomona; legionnaires disease. *Principal procedure*: injection of gamma globulin, computed tomography of brain and chest, bronchoscopy and therapeutic thorancentesis. *Co-morbidities:* left ventricular failure and congestive heart failure, primary pulmonary hypertension, acute respiratory failure and bronchectasis. Selective deficiency in immunoglobulin G subclass with bronchectasis and legion naires 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: *Principal procedures*: insertion of intercostal catheter for drain; percutaneous central vein catheterization; bilevel positive airway pressure; percutaneous biopsy of bone marrow and computed tomography of chest. *Principal diagnosis*: bronchiectasis. *Co-morbidities and complicating procedures:* State-wide referral services for lung, heart, and bone marrow transplantation and chronic heart failure. *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* 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 thorancentesis. 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: *Procedures:* coronary angiography with left and right heart catheter; Bx myocardium by cardiac catheterization; right heart catheterization; bone densitmetry dual-energy radiography at least two sites. *Diagnosis severity markers:* congestive heart failure, dilated cardiomyopathy, left ventricular failure, cardiomyopathy unspecified and ischaemic cardiomyopathy. *Co-morbidities and complications*: 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: *Principal diagnosis*: ischaemic cardiomyopathy. *Principal procedures*: Coronary angiography with left and right heart catheterization and also right heart catherization 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 referral 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 hypogammaglobulinaemia. 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 densitmetry 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 catherization, 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 Statewide 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 inpatient care to include community services and pharmaceuticals. DCGs can further 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_e; n=total number of patients; β_o=constant, y intercept-base rate payment for DRG_e; $Outlier_{ie}$= LOS outlier status for $patient_i$, DRG_e; $Procedures_{ie}$=number of procedures for

Infobox

$$Y = \beta_o + \beta_{11}*D_1BR + \beta_{12}*D_1LPA + \beta_{13}*D_1HLT + \beta_{14}*D_1LT + \beta_{15}*D_1BIBAP + \beta_{16\ 1}AGE + \beta_{18}*D_1SEX + \beta_{19}*D_1PROC + \beta_{110}*D_1DIAG + \beta_{111}*D_1DISEASE*D_1LVF + \beta_{17}*D_1AGE + \beta_{18}*D_1SEX + \beta_{19}*D_1PROC + \beta_{110}*D_1DIAG + \beta_{111}*D_1DISEASE\ TYPES + \beta_{112}*D_1COMPLEX + \beta_{113}*D_1OUTLIER - + \beta_{114}*D_1EMERG + \beta_{21}*D_2BR + \beta_{22}*D_2LPA + \beta_{23}SEX + ß_{29}*D_2PROC + \beta_{210}*D_2DIAG + \beta_{211}*D_2DISEASE*D_2HLT + \beta_{24}*D_2LT + \beta_{25}*D_2BIPAP + \beta_{26}*D_2LVF + \beta_{27}*D_2AGE + \beta_{28}*D_2SEX + \beta_{29\ N5}*D_NBIPAP + \beta_{N6}*D_NLVF + \beta_{N7}*D_NAGE + \beta_{N8}*D_NSEX + \beta_{N9}*D_NPROC + \beta_{N10}*D_NDIAG + \beta_{N11}*D_NDISEASE*D_2PROC + \beta_{210}*D_2DIAG + \beta_{211}*D_2DISEASE\ TYPES + \beta_{212}*D_2COMPLEX + \beta_{213}*D_2OUTLIER + \beta_{214}*D_2EMERG + \ldots\beta_{N1}*D_NBR + \beta_{N2}*D_NLPA + \beta_{N3}*D***D_NHLT + \beta_{N4}*D_NLT + \beta_{N5}*D_NBIPAP + \beta_{N6}*D_NLVF + \beta_{N7}*D_NAGE + \beta_{N8}*D_NSEX + \beta_{N9}*D_NPROC + \beta_{N10}*D_NDIAG + \beta_{N11\ *D\ N}DISEASE\ TYPES + \beta_{N12}*D_NCOMPLEX + \beta_{N13}*D_NOUTLIER + \beta_{N14}*D_NEMERG + E$$

Where

Y	=Per patient costs
β_o	=Y intercept
β_{ij}	=array of coefficients, one set for each of j hospitals
D_1BR	=Dummy variable bronchiectasis teaching hospital D1=1, other=0.
D_1LPA	=Dummy variable lung part absence teaching hospital D1=1, other=0
D_1HLT	=Dummy variable heart and lung transplantation teaching hospital D1, =1, other=0
D_1LT	=Dummy variable lung transplantation teaching hospital D1=1, other=0.
D_1BIPAP	=Dummy variable Bilevel Positive Airway pressure (BIPAP) teaching hospital D1=1, other=0.
D_1LVF	=Dummy variable Left Ventricular Failure teaching hospital D1=1, other=0.
D_1AGE	=Patient age, teaching hospital D1=1.
D_1SEX	=Dummy variable 1 if male, other=0 (gender of patient), teaching hospital D1
D_1PROC	=Number of procedures at teaching hospital D1
D_1DIAG	=Number of diagnoses at teaching hospital D1
$D_1DISEASE\ TYPES$	=Number of body systems at teaching hospital D1
$D_1COMPLEX$	=Dummy variable at teaching hospital D1, 1 of patient classified as high complexity case (PCCL) level 1 if 4.0 if 3.
$D_1OUTLIER$	=Dummy variable at teaching hospital D1, 1 if patient an outlier on length of stay, otherwise 0
D_1EMERG	=Dummy variable at teaching hospital D1, 1 if patient admitted through emergency department, otherwise 0

patient *i* in DRG_e; Disease $Types_{ie}$=number of disease types for patient *i* in DRG_e.

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.[1] 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, brochiectasis 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

[1] Consideration of the relative disadvantage of The Alfred vis a 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 elaborate 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 other 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 multisites. 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 in-patient 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 distribution 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, given 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 principal 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 bronchectasis 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

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Finally, the current analysis based only on the reference system for reimbursement; we did not consider the pricing law. The maximum price in The Netherlands is constrained by this law, which means that the maximum price depends on the average price of a drug in the neighboring countries of The Netherlands: Germany, Belgium, United Kingdom, and France. Hence the price for AD resulting from the AHP analysis may be adjusted downwards when the price law is taken into consideration.

The conclusion is that the AHP concept may be applied to the pricing and reimbursement environment, and that it may be used for an assessment of the pricing potential of a new drug. Further research is required to explore in more detail the methodological considerations which we address.

Corresponding author

Mark J. C. Nuijten

MEDTAP International, Dorpsstraat 75, Jisp,
1526 LG Amsterdam, The Netherlands
e-mail: nuijten@medtap.nl

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Erratum

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Kathryn M. Antioch[1,2] · Michael K. Walsh[1,2]

[1] Bayside Health, The Alfred Hospital, Melbourne, Australia

[2] 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

Eur J Health Econom (2004) 5: 95–109

Unfortunately there were errors in the footnotes and in table 3. The correct versions are shown below.
The correct equation in the footnote is:
1. Consideration of the relative financial disadvantage of The Alfred vis a 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 the COPD DRG, where severity markers are included in the equation, along with teaching hospital dummy variables for each teaching hospital and all other variables. This specification can be used to explain why certain hospitals are more expensive than others, and to understand whether some factors systematically vary, or are the same, across all hospitals.

$$
\begin{aligned}
Y = {} & \beta_o+\beta_{11}*D_1BR+\beta_{12}*D_1LPA \\
& +\beta_{13}*D_1HLT+\beta_{14}*D_1LT+\beta_{15}*D_1BIPAP+\beta_{16}*D_1LVF+\beta_{17}*D_1AGE \\
& +ß_{18}*D_1SEX+ß_{19}*D_1PROC \\
& +ß_{110}*D_1DIAG+ß_{111}*D_1DISEASE\ TYPES+\beta_{112}*D_1COMPLEX \\
& +\beta_{113}*D_1OUTLIER+\beta_{114}*D_1EMERG \\
& +\beta_{21}*D_2BR+\beta_{22}*D_2LPA+\beta_{23}*D_2HLT \\
& +\beta_{24}*D_2LT+\beta_{25}*D_2BIPAP \\
& +\beta_{26}*D_2LVF+\beta_{27}*D_2AGE+\beta_{28}*D_2SEX \\
& +ß_{29}*D_2PROC+ß_{210}*D_2DIAG \\
& +\beta_{211}*D_2DISEASE\ TYPES \\
& +\beta_{212}*D_2COMPLEX \\
& +\beta_{213}*D_2OUTLIER+\beta_{214}*D_2EMERG \\
& +\ldots\beta_{N1}*D_NBR+\beta_{N2}*D_NLPA \\
& +\beta_{N3}*D_NHLT+\beta_{N4}*D_NLT \\
& +\beta_{N5}*D_NBIPAP+\beta_{N6}*D_NLVF \\
& +\beta_{N7}*D_NAGE+\beta_{N8}*D_NSEX \\
& +\beta_{N9}*D_NPROC+\beta_{N10}*D_NDIAG \\
& +\beta_{N11}*D_NDISEASE\ TYPES \\
& +\beta_{N12}*D_NCOMPLEX \\
& +\beta_{N13}*D_NOUTLIER \\
& +\beta_{N14}*D_NEMERG+E
\end{aligned}
$$

Where:
Y = Per patient costs
b_o = Y intercept
b_{ij} = Array of coefficients, one set for each of i hospitals, for j explanatory variables

D_1BR = Dummy variable bronchiectasis teaching hospital D1 = 1, other = 0
D_1LPA = Dummy variable lung part absence teaching hospital D1 = 1, other = 0
D_1HLT = Dummy variable heart and lung transplantation teaching hospital D1 = 1, other = 0
D_1LT = Dummy variable lung transplantation teaching hospital D1 = 1, other = 0
D_1BIPAP = Dummy variable Bilevel Positive Airway Pressure (BIPAP) teaching hospital D1 = 1, other = 0
D_1LVF = Dummy variable Left Ventricular Failure teaching hospital D1 = 1, other = 0
D_1AGE = Patient age, teaching hospital D1 = 1
D_1SEX = Dummy variable 1 if male, other = 0 (gender of patient) teaching hospital D1
D_1PROC = Number of procedures at teaching hospital D1
D_1DIAG = Number of diagnoses at teaching hospital D1
$D_1DISEASE\ TYPES$ = Number of body systems at teaching hospital D1
$D_1COMPLEX$ = Dummy variable at teaching hospital D1, 1 if patient classified as high complexity case (PCCL) level 4, 0 if 3
$D_1OUTLIER$ = Dummy variable at teaching hospital D1, 1 if patient an outlier on length of stay, otherwise 0
D_1EMERG = Dummy variable at teaching hospital D1, 1 if patient admitted through emergency department, otherwise 0

Table 3 shown on page 10 of the version published online has excluded (by typographical error) the regression findings for DRG E 62A in one row, which should read as follows:
CostPP=6950 (β_0) -70 (Age) +14070 (Outlier) +1440 (Procedures) + E

Corresponding author

Kathryn M. Antioch

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

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Original papers

K. M. Antioch · M.K. Walsh
Faculty of Medicine, Monash University, and Bayside Health Services, Melborne, Australia

Risk-adjusted capitation funding models for chronic disease in Australia: alternatives to casemix funding

Abstract

Under Australian casemix funding arrangements that use Diagnosis-Related Groups (DRGs) the average price is policy based, not benchmarked. Cost weights are too low for State-wide chronic disease services. Risk-adjusted Capitation Funding Models (RACFM) are feasible alternatives. A RACFM was developed for public patients with cystic fibrosis treated by an Australian Health Maintenance Organization (AHMO). Adverse selection is of limited concern since patients pay solidarity contributions via Medicare levy with no premium contributions to the AHMO. Sponsors paying premium subsidies are the State of Victoria and the Federal Government. Cost per patient is the dependent variable in the multiple regression. Data on DRG 173 (cystic fibrosis) patients were assessed for heteroskedasticity, multicollinearity, structural stability and functional form. Stepwise linear regression excluded non-significant variables. Significant variables were 'emergency' (1276.9), 'outlier' (6377.1), 'complexity' (3043.5), 'procedures' (317.4) and the constant (4492.7) (R^2=0.21, SE=3598.3, F=14.39, Prob<0.0001. Regression coefficients represent the additional per patient costs summed to the base payment (constant). The model explained 21% of the variance in cost per patient. The payment rate is adjusted by a best practice annual admission rate per patient. 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. State and Federally funded home and palliative services are 'carved out'. The model, which has national application via Coordinated Care Trials and by Australian States for RACFMs may be instructive for Germany, which plans to use Australian DRGs for casemix funding. The capitation alternative for chronic disease can improve equity, allocative efficiency and distributional justice. The use of Diagnostic Cost Groups (DCGs) is a promising alternative classification system for capitation arrangements.

Keywords

Capitation funding model · Casemix funding · Diagnostic Cost Groups · Diagnosis-Related Groups · Health Maintenance Organization

Introduction

The aim of this study was to develop a capitation funding model for cystic fibrosis (CF) that is risk adjusted for an Australian Health Maintenance Organization (AHMO), The Alfred Hospital. The model facilitates integrated care for chronic disease and is a complementary modification to casemix funding arrangements in Australia. This is also important for European countries such as Germany that are planning to use Australian Diagnosis-Related Groups (DRGs) for casemix funding. While incorporating features of various capitation models, its final form represents an original model suited to the Australian setting. First, we discuss the Australian health care system and the reform context. Then we provide a brief overview of capitation based funding models and risk adjustment issues. We consider models used across broad health insurance systems through to the disease-specific perspective. The strengths and weaknesses of the funding models are evaluated, with a balance of risk sharing between purchaser and provider. We then provide the results of econometric regression analyses used to develop the risk-adjusted in-patient component of the funding model. The full funding model, incorporating out-patient care, Hospital In The Home, fee-for-service, transplant payments, community-based care and retrospective risk-sharing outlier payments is also discussed. Finally, we consider the good potential for introducing the Diagnostic Cost Group (DCG) classification system in Australia to facilitate capitation funding.

Australian health care system and reform context

Australia's health care system is complex, loosely organized and technically sophisticated. High standards of medical care prevail. The system involves Australia's federal structure of government, including Commonwealth, State and Local levels. 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 Commonwealth to en-

Kathryn M. Antioch
Bayside Health Services, The Alfred Hospital, East Block Commercial Road, Prahran, Melbourne VIC 3181 Australia,
e-mail: K.Antioch@alfred.org.au

sure that the system offers some choice, especially for hospital care. The Commonwealth Government funds universal benefits schemes for private medical services via the Medical Benefits Schedule (MBS) and pharmaceuticals via the Pharmaceutical Benefits Scheme (PBS). 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 Australian Health Care) Agreements between Commonwealth and States.

Various supply-side approaches to containing government outlays include limiting the range of items attracting subsidies under the Medical Benefits Schedule and the Pharmaceutical Benefits Scheme, encouraging best practice and budgeting a fixed amount for each person (capitation) as is undertaken by Health Maintenance Organizations in the United States and by the United Kingdom [28]. The Commonwealth Government has analysed income and expenditure components of the Coordinated Care Trials (CCTs) to assess the expenditure level required to sustain them. It is also considering alternatives to the economic benchmark for the proposed fund pool [17], which was determined from historic use, not health need or risk. Demand-side measures include the introduction of co-payments by consumers for gaps not covered by the government subsidy for health care. Governments have promoted competition, emphasized evidence-based medicine, separate purchasers, providers and regulatory functions, primary care, prevention and better systems integration [28].

An important element of health care reform in Victoria, one of Australia's largest States, is casemix funding issues impacting on major teaching hospitals. For casemix payments to be acceptable the average price and cost weights must be set at an appropriate standard. The average price is based on a normative, policy basis rather than benchmarking. The averaging principle inherent in cost weights has resulted in some DRG weights being too low for teaching hospitals that are State-wide providers of chronic disease services such as those for CF [3]. The Victorian Government is examining alternative funding models, consistent with integrated and coordinated care to develop a comprehensive purchasing model [40]. A risk-adjusted capitation funding model has been developed for cystic fibrosis patients treated by an Australian Health Maintenance Organization (AHMO) to facilitate greater efficiency and equity in Victoria's health system. The integration of cost-effective best practice evidence into clinical practice guidelines, protocols and pathways for conditions such as CF further reinforces the move towards greater efficiency [5, 6].

The impetus for the current study arose during successful negotiations by the Alfred Hospital to obtain specified grants for CF from the Victorian Government during 1999. The hospital argued that such financial compensation was required, given previous financial loss under the standard casemix funding formulae, cost-effective service provision and its very complex casemix associated with its State-wide Centre for Adult Cystic Fibrosis. Econometric analyses provided evidence that the significant independent variables explaining per patient costs were related to our more complex casemix. The hospital did secure specified grants for 1998–1999 and 1999–2000 on an on-going basis and the cost weight increased during 1999–2000 [3, 7]. The disease-specific risk-adjusted capitation funding model discussed in this paper builds upon the evidence developed during these government negotiations. See Antioch et al. [4] for further discussion of models of care and clinical guidelines for CF and international best practice.

Defining capitation 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. Consequently, capitated managed care organizations assume financial risk for providing medical care to their enrollees [19]. Three key clinical and financial questions have emerged internationally as more chronically ill individuals enrol in managed care and capitation becomes an important source of revenue. First, how should capitation payments be adjusted to reflect the higher health costs associated with those with chronic illness? Unless capitation rates are adjusted to reflect the higher expected costs associated with chronic illness, plans or capitated providers have a financial incentive to avoid or undertreat chronically ill individuals. Second, what level of risk is appropriate for capitated physicians, health plans or sponsors to assume and what methods are available to limit their risk? Hospitals that treat the chronically ill may face substantial levels of financial risk under capitation. Third, how can access to essential services and providers be assured for those with chronic illness [19, 38]. Without adequate risk adjustment it is difficult to achieve both fairness and efficiency in competitive health plans [38]. Clearly, risk adjustment is a crucial component of any capitation model, especially for chronic disease.

Risk-adjusted capitation models

Risk adjustment means the use of information to calculate the expected health expenditures of individual consumers over a fixed interval of time (for example, by quarter or year) and set subsidies to consumers or health plans to improve efficiency and equity. Although risk adjusters may be used by insurers for risk-rating their premiums, we do not focus on this application. The discussion here is in the context of competitive health plan markets. A 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 expenditures across individuals. Health plans may also manage or provide health care, and this can influence how risk adjustment payments should be made. 'Competitive' in this context refers to markets in which consumers have some choice of health plans which can, in turn, act to attract or repel enrollees. Examples of health plans include managed care organizations such as HMOs, private health insurance companies and GP fund holders in the UK [38]. In the model developed here, the Alfred Hospital is the health plan, called an AHMO, for the delivery of CF services. Figure 1 provides an overview of the model, which is a derivative of "Modality A Risk Adjustment System" in Van de Ven and Ellis [38]. A full discussion of Fig. 1 is provided in a later section.

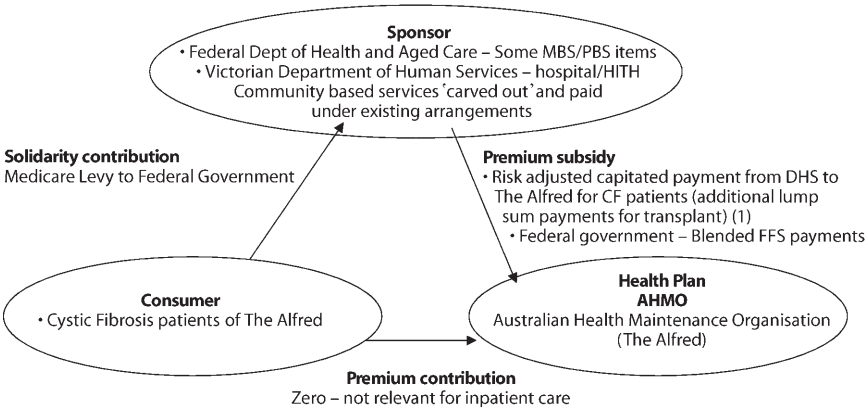

Fig. 1 ▲ **Risk-adjusted blended capitation and fee-for-service payment system, cystic fibrosis patients of an Australian Health Maintenance Organization**

Under capitation, plans face large differences in expected health costs due to heterogeneity in demographics and the incidence of illness. A competitive market forces health plans to break even. In the absence of any restrictions on premium rates a competitive health plan market tends to result in plans charging risk-adjusted premiums to patients that differentiate according to the individual consumer's risk, known as the equivalence principle. Is this fair? Premiums, which reflect such large differences, are not fair, and cross-subsidies are needed. Problems are exacerbated if there is asymmetric information, with consumers knowing more than health plans. This asymmetry can create moral hazard and adverse selection inefficiencies [38]. The adverse selection problem has limited applicability to our scenario in Victoria because consumers do not pay such premiums directly to the AHMO. Rather, they pay for their coverage via the Medicare levy. We exclude health insurance funds as risk sharers, given the very small number of private patients receiving in-patient treatment in the AHMO. Moral hazard issues are relevant where consumers are fully insured against financial risks, given their potential to over-consume health services. Since the AHMO's patients have full coverage for health services under our Medicare arrangements, moral hazard warrants consideration and is discussed in a later section.

The payment received by a health plan for an enrollee need not be the same as the payment made by that enrollee: the supply price and the demand price for health insurance can differ. In most health plans most of the insurance premium is paid by a sponsor, who acts as a broker in structuring coverage, contracting with and regulating health plans, and managing enrollment. The sponsor may also reallocate the burden of the health plan premiums across clients, and enters into risk-sharing arrangements with the health plan. The sponsor can be of many types, such as a government agency, for example, Health Care Financing Administration in the USA, which negotiates *at-risk* contracts with HMOs for Medicare beneficiaries [38]. In our scenario the sponsors are the Federal and Victorian State Governments.

On the demand side, payments made by the client are called *contributions*, which include both premium and solidarity contributions (see Fig. 1). Premium contributions are those that the client pays toward his or her own health insurance coverage. *Solidarity contributions* are made toward all clients covered by the sponsor. The solidarity principle holds that high-risk individuals should receive a subsidy to increase their access to health insurance coverage. On the supply side, the payments made by the sponsor are called *subsidies*. The most important is the premium subsidy which is a prospective subsidy mostly paid directly to the health plan. The total prospective payments for one client, received by the health plans under capitation in other countries, is called the health plan premium, or simply premium. This includes the premium contribution by clients plus the premium subsidy by the sponsor. There are many ways to calculate the client's contributions and the sponsor's premium subsidies as well as for organizing the actual payment flow [38]. In our scenario, clients of Alfred Hospital (that is, patients of the AHMO) pay no premium contributions to the AHMO. Client payments are to the Federal Government via the Medicare levy on taxable income. Rather, the total premium received by the AHMO is from the Victorian Department of Human Services and Federal Government sponsors.

Risk adjustment models

The sponsor plays a crucial role in enabling the health plan premiums to be risk-adjusted (reflecting the expected health cost of the plans' enrollees) while not insisting that payments by individuals reflect each person's own expected cost. This can be achieved by the sponsors risk adjusting the premium subsidies prospectively to competing health plans while charging consumers a solidarity contribution that does not reflect their own expected costs [38]. In Australia clients would (and currently do) pay a solidarity contribution under our Medicare arrangements via the Medicare levy, which is collected by the Federal sponsor. It is common for solidarity contributions to be income-based.

If premium subsidies cannot be adequately risk-adjusted prospectively, retrospective risk sharing can also be undertaken between the sponsor and health plans. Risk sharing implies that the health plans are retrospectively reimbursed by the sponsor for some of their costs [38]. Both prospective and retrospective risk adjusters can therefore be used [13] and are used in the scenario developed here.

There are seven classes of risk factors that explain variations in health spending across individuals. These include age and sex, health status and socio-economic factors, provider characteristics (practice style and supply of facilities or providers), input prices, market power (health plan's ability to negotiate price discounts) and benefit plan features (covered services, utilization review and management strategies, financial incentives between plans and providers). The risk factors fall into two subsets: those factors for which solidarity is desired (the 'S type'); and those fac-

tors for which solidarity is not desired (the 'N type'). In most societies, age, sex, health status and input prices are considered to be S type risk factors. Most countries with a system of risk subsidies in a competitive health plan market, have used only age and gender as risk adjusters sometimes with a disability indicator (in The Netherlands) and institutional and welfare status [38].

Information on hospitalizations and costs in preceding years can identify 4% of its patients whose predicted costs are threefold their average age/gender-adjusted expenses. Ideally, for each health plan, the predictable losses on its high-risk members should be compensated by the predictable profits on its low-risk members. This ideal situation, however, may not be achieved because of selection, namely adverse selection and cream skimming [38].

Good risk adjustment can reduce selection so that the heterogeneity of the subsidy for risk groups is small, and the expected cost of cream skimming exceeds its expected profitability. Specific risk factors and models have been examined to calculate the best estimate of acceptable costs (that is, those chosen by the plan to sponsor) [38]. The model developed in our scenario blends risk-adjusted prospective and retrospective capitation payments with separate fee-for-service and transplant payments.

It is desirable to calculate prospective health-based payments at the individual level, which are then summed across individuals rather than contracts, such as families or employers. The advantage is that as one individual moves from one health plan to another, the expected payments can be calculated easily. Prospective models attach relatively more weight to information related to chronic conditions while retrospective payment can weight information that signals the presence of acute problems [38]. Using *both* forms of risk adjustment enables acute exacerbations of CF to be adequately compensated by the sponsor, along with compensations for the chronic features.

Ellis and Azzone (unpublished, cited in [38] prefer simple linear models, and most risk adjustment models have used them and adjusted for heteroskedasticity using the Huber/White formula [38]. The regression model used in developing our prospective risk-adjusted payments is a simple linear model, and the White formula adjusted for heteroskedasticity [21, 22].

In measuring the proportion of the variance in individual expenditures explained by a set of risk adjusters, Newhouse et al. [24] found R^2 values of 0.05 for in-patient care and 0.25 for out-patient care for those aged 14–64 years. Wouters [43] found similar results, with drugs ranking first (R^2=0.40), followed by visits, diagnostics, procedures and surgery (R^2=0.005). Van Barneveld et al. [37] analysed expenditures for expensive long-term care using 2-year prior costs as a risk adjuster and found an R^2 of 0.56. Analyses using broad population groups found that health expenditure in 1 year is correlated with expenditure in the following year in the range of 0.2–0.3 [38].

Risk sharing

There is a clear analogy between risk sharing and the outlier payments in the DRG payment system. The goal of risk sharing is to reduce the health plan's predictable losses and profits, while preserving its incentives for efficiency. There are several forms of risk sharing. Under *'risk sharing for all members'* the sponsor, such as the Victorian Department of Human Services, may retrospectively reimburse each health plan (the AHMO) a fixed percentage, e.g. 50 % of all its acceptable costs.

Under *'outlier risk sharing'* the sponsor can compensate each health plan for only a certain percentage of the acceptable expenditures above a certain annual threshold, for example, $20,000 per member. In *risk sharing for high risks* each health plan can prospectively designate a specified percentage of its members (for example, 1 or 4%) for whom the sponsor would retrospectively reimburse all or some acceptable expenditures. In *condition specific risk sharing* health plans are retrospectively reimbursed some prospectively determined payments dependent on the occurrence of some non-discretionary high cost medical problems [38]. Such risk sharing may be a valuable addition to the DCGs/Hierarchical Condition Category (HCCs) developed by Ellis et al. [14] and has recently been introduced in the USA for capitation payments to HMOs under Medicare [27].

There are both prospective and retrospective risk adjustment in the model developed here. The current research uses the previous year's expenditure combined with health status (through patient casemix complexity scores and emergency status), number of procedures and outlier on length of stay status to prospectively risk adjust payments from the sponsor. 'Outlier risk sharing' on costs (loss) is also used to retrospectively risk adjust by the sponsor for expensive patients in the AHMO.

Information arriving near the end of the base period is more predictive of spending patterns in the following year [38]. The current research does use patient level utilization data as closely as possible to the end of the previous year to calculate the risk-rated capitated subsidies. Risk adjusters have been developed for selected sub-populations, such as paediatric populations [18, 25], End Stage Renal Disease (ESRD) [16] and Chronic Obstructive Pulmonary Disease (COPD) [19]. The latter two studies along with Van de Van and Ellis [38] were instructional in developing the current method. Such studies often 'carve out' specific services from the capitation component such as pharmacy, behavioural health care, dental coverage, neonates [38], nursing home, hospice and home health care [19]. Some disease-specific models incorporate prospective lump sum payments for kidney transplants and graft failure events [16]. In the case of CF in our model all patients undergoing a lung transplant should be subject to an additional lump-sum payment.

Disease-specific models

Farley et al. [16] developed a modified capitation payment method for a Medicare (ESRD) program to facilitate best practice and protect health plans from undue financial risk. It involves risk-adjusted monthly capitation payments for those on dialysis or with functioning kidney graphs, lump sum event payments for kidney transplantation or graft failures and outlier payments for expensive patients. This method explained 25% of variation in annual payments per patient. Risk adjustment captured substantial variation across patient groups, and outlier payments reduced health plan risk by up to 15%.

The original capitated payments prior to modifications were flat rates based on state-level adjusted average per capita costs for all ESRD beneficiaries that did not recognize differences in services used and cost amongst ESRD patients using different treatment modalities [16].

The method for risk adjusting capitation payments for dialysis patients used regression models to predict part A and part B (Medicare) monthly expenses per patient. The dependent variable was the standardized monthly expense for each dialysis patient. Patient characteristics that were statistically significant were used as risk factors for service usage, including years since renal failure, male gender, diabetes, failed transplant, age groups, old age and disability Medicare eligibility. Patient expenses were weighted by their dialysis service periods.

The predicted payment amounts (or coefficients) for each risk factor are the risk-adjusted dialysis capitation monthly payments that are summed to the base payment (intercept coefficient). The one time adjustment to cover the entire period was based on the multiplication of the coefficient by the average number of months of service per new patient. The significant risk factors were retained in the final formulae, using additive linear models, and all were positive except male gender, which had a coefficient of –108. The model obtained an R^2 of 0.03 for both part A payments (in-patient and post-hospital services) and B payments (out-patient services). Farley et al. [16] recommends a much smaller set of adjusters for implementing such risk adjustment for administrative ease. The outlier policy would pay 75% of the loss for cases that had annual loss of a standardized value of at least $50,000. Loss was the difference between a patient's total actual expenses for 1990 and total estimated payments under the modified capitation method. The addition of outlier payments reduced the health plan risk by around 15% for all plan sizes. Farley et al. [16] emphasize that additional risk factors are required for comorbidities in future to improve the explanatory power of the model. The current study developing risk adjusters for the AHMO does include such complexity measures and emergency admissions. The other instructional study for the current research concerned COPD.

Grasso et al. [19] analysed data on chronic obstructive pulmonary disease, which is instructive for considering cost drivers and risk issues under capitation and managed care arrangements. They analysed utilization and expenditure for a 5% national sample of fee-for-service aged Medicare beneficiaries and reported some of the financial risks facing managed care plans and physicians who accepted capitation payments for such individuals. Comparable data were not available for managed care programs, but this did not imply that fee-for-service data were the *gold standard*. Nursing home, hospice, and home health care expenditure and utilization data were excluded, since they are often *carved out* of standard managed care benefit packages. Diagnostic and procedure codes for all other covered services were reviewed. Expenditures were grouped into hospital in-patient, hospital out-patient and physician. The distribution of expenditures for services received by COPD patients was compared to all Medicare beneficiaries. The claims data were stratified by specific comorbid diagnoses, procedures, and a comorbidity index. They examined procedures and therapies considered to be markers for resource intensity and severity, such as long-term oxygen therapy, bronchoscopy, intubation and tracheostomy. Per capita expenditures for COPD patients were 2.4 times the per capita expenditures for all Medicare beneficiaries. The most expensive 10% of Medicare beneficiaries with COPD accounted for nearly half of total expenditures. Higher comorbidity and/or specific procedures were associated with higher expenditures. COPD with upper respiratory tract infection increased per capita expenditures by 10%. Those with pneumonia had over twice the average expenditure for all beneficiaries with COPD. Heart failure and septicaemia comorbidities were associated with expenditures 1.6 and 3 times the average for all COPD beneficiaries, respectively.

Method: Capitation funding model and risk adjustment for CF

An overview of the funding model, incorporating in-patient, out-patient, community services and Federal Government fee-for-services payments is provided in the discussion section. The method for calculating the in-patient component is outlined below. The dependent variable was cost per patient (Costpp). The general model includes the following independent variables:

1. 'Age': patient age
2. 'Emergency' (dummy variable: coded '1' if patient was admitted through the emergency department; 'o' if otherwise).
3. 'Outlier': (dummy variable: coded '1' if patient was an outlier on length of stay; 'o' if otherwise)
4. 'Complexity': (dummy variable: coded '1' if patient was classified as high complexity, level 3 or 4; 'o' if otherwise)
5. 'Diagnoses': number of diagnoses
6. 'Procedures': number of procedures
7. 'Sex': gender of patient (dummy variable: coded '1' if patient was male, 'o' if female)

The equation took the following form: $Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+e$.

Costs per patient included wards, medical, nursing, allied health, prostheses, theatres, imaging, pathology and emergency. All costs were the gross costs of providing the service to the hospital's patients. Overhead cost inclusions were for finance, information technology, supply, cleaning, orderlies, teaching and research not tied to patient care (for example, medical library) and laundry. The overhead allocation approach was to spread costs to patient care centres. Cost and revenue exclusions were depreciation, superannuation, teaching and research externally funded and reimbursements from patients, insurers or governments. The method of cost allocation has been developed by the Health Round Table Australian and New Zealand chapters involving over 20 major teaching hospitals that benchmark their services.

Diagnostic tests 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 non-significant independent variables. This method was based on the *top-down* approach, in which non-significant independent variables are excluded on a step-by-step

basis, that is, stepwise linear regression. Each exclusion step involves running a number of regressions with different variable combinations in an effort to identify variables that are non-significant in all circumstances. When a variable was found to be non-significant across a wide range of model specifications, it was excluded. The *t* statistic was used to determine which variables were non-significant at the 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. The sample size was 202 separations in DRG 173.

Results: in-patient payment rates for CF

The final results, identifying significant variables, enable the following to be specified:

'Costpp'=4492.723 (intercept value) +1276.886 ('Emergency') +6377.113 ('Outlier') +3043.526 ('Complexity') +317.3643 ('Procedures') +e (adjusted R^2=0.2104, standard error of regression=3598.296, F=14.39, P<0.0001) White's test indicated some heteroskedasticity associated with 'Procedures' (t=–2.39, P=0.0177) and 'Outlier' (t=3.77, P=0.0002). The data were therefore adjusted for heteroskedasticity with the White formula [22]. Multicollinearity is often a problem in risk adjustment models. A correlation coefficient matrix of all independent variables indicated that there was no multicollinearity with the correlation coefficients in the range of 0.06–0.15. The regression model above explained 21% of the variance in annual in-patient payments per patient. Risk adjustment captured substantial variations across the patient group, with risk adjustment payments in Table 1 calculated for emergency admissions, high complexity patients, number of procedures and length of stay outliers [3].

Discussion

Funding model

The model for capitation and risk adjustment for CF patients is shown in Fig. 1. Under this model The Alfred Hospital would be the health plan called the AHMO and would have responsibility for providing all of the care or would pay to have some of the care provided by others. The funders would enter into discussions with the AHMO to determine exactly what services and what type of patient would be covered by them. The Hospital would be both the provider and health plan simultaneously. The sponsors would be the Federal Government and the Victorian Department of Human Services. There is both prospective and retrospective risk sharing with the State Government. Health funds and physicians are excluded from risk sharing given the current method of funding physicians and the very high proportion of public patients treated at The Alfred Hospital.

The payment rates would be calculated to include both Commonwealth and State payments. State Government payments by the Victorian Department of Human Services would include all hospital in-patient care, Hospital In The Home, ambulatory care currently funded through Victorian Ambulatory Classification System and allied health grants. The capitation rates for in-patient and ambulatory allied health components are discussed in more detail below.

Federal Government payments would be in the form of blended fee-service payments and cover services billed by medical staff to the Health Insurance Commission including ambulatory medical services and lung function tests; drugs prescribed for ambulatory patients funded under the Pharmaceutical Benefits Scheme and pharmaceuticals funded by the Commonwealth under Section 100 for access to high cost drugs. Community based psychosocial services and other community services billed to the Health Insurance Commission would also be included through current payment arrangements, but 'carved out' of the capitation component. Services provided by the Royal District Nursing Service and palliative care services, along with community-based psychosocial services and other community services billed to Department of Human Services, would be 'carved out' of the capitation component of the model and funded through current arrangements. Further, the AHMO would not include services provided by secondary centres jointly agreed with the specialist services.

In-patient payments

The prospective risk-adjusted payment premium subsidy paid by the Department of Human Services to the Alfred Hospital for all CF patients would be based on a payment level determined for each patient adjusted for *best practice* admission rate per *registered* patient, and summed across all registered CF patients for the year to arrive at a total prospective payment. The in-patient prospective payments would be based on regression coefficients from regressing per patient costs and the previous year's entire patient level record analyses against independent variables of patient complexity, emergency admit, number of procedures and length of stay outliers for DRG 173 (CF; see Table 1). During 1996–1997, 85% of all admitted patients with CF were admitted at least once throughout the year under DRG 173. Their risk adjustment data could be based their last admission under DRG 173 and involving any of the above significant independent variables that are captured in the medical record for their admission. For the remaining 15% (or 15 patients) any admission in the previous year for DRG 173 would serve as the data source.

The coefficients in Table 1 are interpreted as the additional cost per patient

Table 1
Risk adjusters for cystic fibrosis patients in DRG 173

Variable	Coefficient ($)	*t*	*P*
Constant	4492.723	11.1817	<0.0001
'Emergency'	1276.886	2.2462	0.0258
'Outlier'	6377.113	1.8953	0.0595
'Complexity'	3043.526	2.4587	0.0148
'Procedures'	317.3643	4.1803	<0.0001

per episode attributable to the relevant independent variable. For example, an emergency admission would accrue $1,277 in addition to the base rate of $4,493. If the patient was also an outlier, an additional $6,377 would be payable for a total amount of $12,147. Here, the constant (intercept value) is the base payment. A Cystic Fibrosis Expert Panel convened by the Victorian Department of Human Services considered a proposal for 2.5 in-patient admissions per registered patient per annum. Therefore this utilization figure of 2.5 could be multiplied by the risk-adjusted cost derived for each patient based on his or her risk adjusters obtained from the DRG 173 admission and summed across all registered patients to derive the total amount payable to the AHMO [3]. This would be analogous to the method adopted in the USA for ESRD, where monthly adjusted estimates that were risk adjusted were calculated for the entire period in question [16]. This general multiple regression approach to risk adjustment is consistent with elements of the method developed by Van de Ven and Ellis [38]. The above analysis assumes that DRG 173 is a significant proportion of in-patient care for CF patients provided in the hospital. During 1996–1997 there were around 100 CF *patients* who were admitted to the hospital. In all there were 203 CF *separations* admitted under DRG 173. Therefore on average there are already around two admissions per year under this DRG.

The *premium subsidy* for in-patient care from the Victorian Department of Human Services sponsor to the AHMO is therefore in the form of a risk-adjusted capitated payment for all CF patients. Modifications apply to CF patients undergoing transplants [3]. These services would be paid at the general rate determined by their risk assessment and also a lump sum amount. During 1996–1997 the average cost for a lung transplant patient under DRG 009 was $50,000. The use of a lump sum amount for transplant is consistent with the approach adopted in the USA for ESRD [16]. The precise funding arrangements for such transplants, however, would need to consider the current Commonwealth-State funding arrangements for these patients.

There would also be an end of year retrospective payment for some costs, that is *outlier risk sharing* between sponsor (Department of Human Services) and AHMO (Alfred Hospital). This could involve a specified proportion (75%) of costs (loss) above a threshold level of say $25,000 per patient per year [3]. Risk sharing for adjustments for high outliers on costs was also adopted for ESRD [16]. This is essentially a reinsurance method that would protect the AHMO from the risk of very costly patients. This outlier payment option is analogous to cost outliers under the Medicare prospective payment system. When a health plan's expenses for a patient exceed a threshold, Medicare reimburses the plan for a proportion of all expenses incurred beyond the threshold. The capitation rate would be reduced by some percentage to set aside funds as an outlier pool. The outlier policy for the AHMO is a fixed-loss policy that would pay 75% of the loss for cases that had an annual loss of a standard value of at least $25,000. Loss is the difference between a patient's total actual annual expenses and total estimated payments under the modified capitation method.

The patient specific annual risk-adjusted prospective capitated payments include a coefficient for length of stay outlier. The additional cost (loss) outlier payment in the context of risk sharing is different. The cost outlier payment is payable when the AHMO incurs a financing deficit for a patient of at least $25,000 over the entire year. Of the deficit 70% is payable by the State Government. This formulation avoids potential double counting for outliers as it is payable at the end of the financial year and only for a funding deficit.

Further analysis is required to determine the final recommended threshold level for the risk sharing outlier payment option. This would involve the observed distribution of estimated losses for CF patients in the annual data and a level of risk protection would have to be determined by both the AHMO and the Victorian Department of Human Services. In Farley et al. [16], 4.5% of total in-patient and post-hospital service payments and 1.3% of total out-patient services payments went to outlier payments. The data explored in the modelling were comprehensive, given that international studies often exclude severity variables. A major strength of the current study is its inclusion of the *complexity* and *emergency admissions* variables. An additional useful independent variable could involve results of lung function tests.

There should also be flexibility around redistribution of funding from the above pool to link to the Hospital in the Home Program (HITH). Since its inception in 1994 the utilization of HITH services has grown significantly across the State. Patient satisfaction with HITH services is high, and access to services is widely available with 44 hospitals in metropolitan and country Victoria participating in the Program. For most conditions HITH can be funded from within the casemix system and is less costly than in-patient stays. Under the scheme patients are eligible to receive the full range of services they would normally have received in hospital. Participating providers may either provide HITH services directly or purchase services from health and community care providers [40].

The AHMO will work with the Victorian Department of Human Services to ensure appropriate accountability mechanisms are in place to facilitate appropriate coding. Up-coding of cases is unlikely to occur through implementation of the risk-adjusted capitation-funding model. Significantly improved funding arrangements will be achieved given coefficients will compensate for higher risk through complexity, emergency, outlier and number of procedure variables, along with best practice admission rates.

The capitation payments for the ambulatory allied health grants would include the best practice annual utilization rate determined by the Victorian Government for physiotherapy, dieticians, social workers and occupational therapy, multiplied by the per visit payment rate of $40 (39, p 73).

Efficiency and fairness

The risk-adjusted capitation funding model is implicitly based on broad approaches to distributive justice articulated by Rice [31] and Reinhardt [32], whereby we grapple with allocative and distributive issues concurrently and contend that "we will start with certain redistributive principles, and once they are established, allow the market to operate around these principles" (31, p 48). This reflects a belief that we should start with principles of fairness and then proceed to efficiency. This method – rather

than the method advocated through the competitive model – is how policy is traditionally made in most countries, including the USA and Australia. In the USA, public programs such as Medicare and Medicaid were established outside the competitive market place to ensure the priority of access to medical care services for the poor and elderly was achieved [31]. Likewise in Australia, our Medicare arrangements are designed to ensure coverage of the population to enable access. The AHMO model remains within our current Medicare arrangements as it covers public patients treated at the AHMO. The solidarity contributions from consumer to Federal sponsor are a feature of our existing Medicare arrangements that would continue under the proposed AHMO. From an insurance perspective, all patients potentially have coverage to access our services, given their solidarity contributions. In their study of financing and equity in nine health systems in Europe and USA Wagstaff and Doorslaer [41] found broad consensus on the notion that access to and receipt of health care should depend on need, rather than ability to pay, while payments toward health care should be related to ability to pay rather than the use of health facilities.

In our scenario developed for the AHMO such goals are also inherent via vertical and horizontal equity. Horizontal equity implies that similar persons are treated the same with respect to a characteristic thereby enabling 'equality' [31]. Vertical equity is 'the unequal treatment of unequals' such as a lower tax for the poor [23]. Both types of equity are implicit in the features of the AHMO through the solidarity payments for Medicare and the risk-adjusted prospective capitated premiums from the government sponsor to the AHMO.

The solidarity contributions by consumers to the Federal Government sponsor are achieved via the taxation system (the Medicare levy). Here payments enable vertical equity, given they relate to *ability to pay* – higher incomes result in higher payments via the levy. Horizontal equity is achieved by ensuring the same Medicare levy rates for each income group, although there is a 30% rebate for those that have also taken out private health insurance.

The risk-adjusted premium subsidies from the State Government to the AHMO achieve greater vertical equity through differential payments related to different risk (or *need*) determined through per patient payments rates inherent in the risk adjuster coefficients. Here patients with higher complexity result in capitated payments from government based on the likely higher costs associated with higher risk. However, Van de Ven and Ellis [38] emphasize that such general equity arguments (monotonicity) does not always apply in all empirically derived risk-adjustment models. Ellis et al. [15] found that dementia patients among USA Medicare enrolees had lower predicted medical costs than individuals with otherwise identical demographic and diagnostic information. Horizontal equity is achieved through similar payment rates by the sponsor to the AHMO for those with similar risk profiles. Given our demonstration of previous underfunding of these services in the face of a more complex casemix vis-à-vis other hospitals, then aligning the payments to the higher risk profiles should improve equity.

Additionally, instigation of the 'best practice' admission rate under consideration by government would enable the total funding pool to be calculated at a more appropriate level. The capitation funding models would be implemented, along with clinical practice guidelines, based on cost-effectiveness evidence. This is discussed further below.

These represent the principles of *fairness* that we articulate initially and then we proceed to efficiency, via two key mechanisms. The first efficiency mechanism is the stimulation of greater cost-effective practice patterns through the implementation of CF clinical practice guidelines, protocols and pathways, which are based on international cost-effectiveness evidence [1, 6]. The second efficiency mechanism is via the fund-holding concept by the AHMO, which is implicit in most traditional arguments advanced in favour of capitation arrangements – managed care organizations receive a fixed amount of money for each enrolee, regardless of the amount of services actually provided. Consequently, capitated managed care organizations assume higher levels of financial risk for providing care to their enrolees and are encouraged to be more efficient. However, these ideas need to be balanced against the 'appropriateness' of the funding level prior to risk-adjusted capitation, which has been shown to be too low.

There were 200 CF patients registered with The Alfred Hospital, but only 100 were admitted. If the 'best practice' admission rate of 2.5 per patient was accepted, the admission rate could *increase* and the total prospective capitation pool of funds from the Department of Human Services would increase. The total pool of funds would be required to cover an additional 250 episodes per annum. The AHMO, however, including its physicians, should have delegated authority to provide the mix of services from the total Department of Human Services capitated funding pool deemed medically appropriate so that the 'funds follow the patient'. This could involve reallocations between funds for hospital in-patient, out-patient, allied health and, most importantly, the HITH Program. Efficiency may therefore improve if this full risk-adjusted capitated model is implemented and patient's health needs are more adequately satisfied through greater horizontal integration of services. The increased flexibility for the AHMO to use the funds pool will enable ready uptake of rapidly evolving best practice guidelines.

The emphasis of the above analysis of efficiency and fairness for our AHMO differs, to some extent, from the key 'traditional' arguments advanced in this area for competitive health plans (by van de Ven and Ellis [38]). This difference in emphasis partly reflects the unique nature of the Australian model developed for the AHMO and related health insurance arrangements. It also reflects the relatively lower level of *competition* inherent in the 'market' for patients using the AHMO vis-à-vis HMOs in the USA. Further, in our scenario, there was previous inappropriate *underfunding* in the face of efficient practice patterns.

Van de Ven and Ellis [38] emphasize lack of fairness of plans charging risk-rated premiums to patients and the need for cross subsidies, along with problems of moral hazard and adverse selection inefficiencies. Given that our patients in the AHMO do not pay such premiums directly to the AHMO (but rather via solidarity contributions), the adverse selection problem has less relevance to efficiency and fairness arguments. Likewise, arguments around the welfare losses resulting from the inefficiency prob-

lem of consumers not being permitted to equalize the marginal utility of income across different annual or lifetime health profiles (Van de Ven and Ellis [38]) are not relevant to the AHMO.

Of all these problems articulated by Van de Ven and Ellis [38] that beset international models of capitation, perhaps that of moral hazard has the most relevance to the AHMO. Asymmetry of information certainly may potentially lead to moral hazard. This implies that when consumers are fully insured against financial risks, they tend to overconsume health services because of the moral hazard problem. Health plans can respond to this via supply or demand incentives. In an Australian setting the supply side incentives would involve case management and selection of providers. The demand incentives possibly involve waiting time.

Health plans may also try to attract a favourable selection of enrolees [38]. Cream skimming (or 'cherry picking') is the selection that occurs because health plans prefer low-risk consumers to high-risk consumers within the same premium risk group. Health plans may actively cream the preferred consumers and dump non-preferred consumers [10].

There is clearly *some* competition inherent in the Australian model for the AHMO (although much less than in the USA) given that patients can choose a 'health plan' (or hospital) – they can choose treatment at The Alfred Hospital, Monash Medical Centre or Royal Childrens' Hospital, even though The Alfred Hospital is the key state-wide provider of such services. Given that there are some potential alternative treatment facilities for treating CF patients, there may be potential for an AHMO to either cream skim or dump in the absence of adequate funding mechanisms. However, given more *appropriate levels of funding* via risk-adjusted capitation funding payments by the State Government, along with the retrospective risk sharing payments, cream skimming and dumping are less likely.

Much of our arguments around equity relate to the 'equity in health care' issue rather than the 'actual capacity to be in good health'. Equity of opportunity and the reach of social responsibility have sometimes been interpreted in this way [36]. This is of particular significance in the context of chronic diseases, such as CF, which can be incurable with the potential for full health status simply an impossibility.

Health Care Financing Administration risk-adjusted funding models and classification systems: lessons for Australia

The approach proposed for Australia, involving risk-adjusted capitation and *risk scores* for patients reflects recent developments in the USA that took effect from 2000. Previously HMOs received a fixed payment for each beneficiary, adjusted only for factors such 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 [27]. The Health Care Financing Administration (HCFA) uses a DCG model to set capitation rates for Medicare plus Choice health plans [11]. That model uses Principal In-Patient Diagnostic Cost Groups (PIPDCG) [30] and is transitional to full-encounter risk adjustment by HCFA in 2004, who has supported research on DCGs [12, 14, 15, 29]. The Diagnostic Cost Group/Hierarchical Condition Category (DCG/HCC), using multiple conditions over full encounters, is further assisting HCFA [8].

DCGs/HCCs uses diagnoses generated during patient encounters to infer medical problems. Diagnostic profiles and patient demographics predict costs. The 'condition categories' hierarchies capture both chronic and serious acute disease manifestations and expected costs. Each condition category coefficient reflects the increment to expected costs that is independently associated with the condition [8]. The DCG/HCC classification system has been selected by the Medicare program for implementation in 2004 and is being evaluated in Canada, Germany, and Israel (R. Ellis, personal communication). DCGs identify the person's full range of medical conditions over time from in-patient, ambulatory and multi-sites. HCFA's independent evaluations found DCG-HCCs had the highest explanatory power (higher R^2) for all enrolees relative to two new versions of the ADGs. For atypical sub-groups DCG-HCCs had predictive ratios (expected expenditure/actual expenditure) closer to 1 for COPD, diabetes and Acute Myocardial Infarction [20]. The closer this ratio is to 1, the better the performance. DCGs can also assist in population-based health management, disease management analysis, provider profiling, negotiating capitation rates, resource allocation among provider groups, planning, budgeting, establishing targets for expenditure, savings and health status and identifying opportunities for casemix management and risk (health status) based contracting [11, 44, 45, 46]. For health plans that lack reliable all-encounter claims data, a risk model using both pharmacy and in-patient diagnoses may be best [46].

Whilst our Australian DRG classification system has proven very useful in the current 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 Victorian Health Services and Area Health Boards in New South Wales. Should Australian State or Federal Governments trial a 'whole of system' capitation funding mechanism across all diseases, the DCG/HCC classification system would be suitable. It certainly has direct application to the National Coordinated Care trials. One advantage of the DCG/HCC classification system is that it enables a more comprehensive costing basis across a broader range of health services including in-patient, ambulatory and multi-sites. It also includes condition category hierarchies that capture both chronic and acute disease and expected costs. Given these advantages, Australian health insurance funds may also find DCGs instructive for capitation funding models.

Proposals for the introduction of capitation or managed care have been advanced in Australia but have attracted strong opposition from the medical profession [9]. There has been extensive discussion of large-scale system wide managed care models (see [33, 34, 35]). However, the disease-specific RACFMs and other foregoing models applied to CCTs represent incremental change on the margin, which can be easily accommodated within the current political and funding structures in Australia without significantly changing our health

insurance arrangements. The medical profession may find it more attractive than large-scale change. Indeed, incrementalism in health care policy (rather than radical change) has been shown to be far more successful in Australia and elsewhere.

Conclusion

Full implementation of the risk-adjusted capitation model for CF could reduce the financial risk and burden faced by the AHMO and lead to more appropriate funding levels. It may also provide a more appropriate incentive for the treatment of CF patients by increasing flexibility in service provision and increasing the total funding pool [26]. A key advantage of the risk-adjusted capitation funding model is its capacity to predict individual level expenditure on specific services instead of in aggregate terms. It uses patient complexity measures related to health status that increase predictive power. The findings reinforce the need for RACFM for some chronic disease as a complementary modification to DRG casemix funding arrangements in Australia, given its potential impact on equity, allocative efficiency and distributional justice. European countries that plan to use Australian DRGs for casemix funding may therefore find the model instructive. The USA's DCGs is a very promising alternative classification system to use for risk-adjusted capitation models in Australia and internationally.

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