Determinants of length of stay: implications on differential funding for rural and metropolitan hospitals

ANDY H LEE AND JIM CODDE

Andy Lee is senior lecturer at School of Public Health, Curtin University of Technology. Jim Codde is director of Epidemiology and Analytical Services at the Health Department of Western Australia.

Abstract

This study analysed and compared the determinants of length of inpatient stay between the rural and metropolitan public hospitals. The investigation was based on the 1998/99 Western Australia patient discharge data. A Cox regression model was used due to the high proportion of patient transfers in the rural hospitals. It was found that several variables were associated with length of stay (LOS) variations within Diagnosis Related Groups (DRG). The method provides additional insights to hospital management and clinicians in assessing the risk of prolonged hospitalisation. From a state government perspective, a DRG payment adjustment strategy may be developed for different categories of admitted patient episodes. The analysis has implications on the formulation of differential funding rates between rural and metropolitan hospitals.

LOS and DRG-based funding

The Australian National Diagnosis Related Group (DRG) classification has provided a basis for casemix funding of public acute hospitals in Australia. In the casemix funding model, outlier payments are defined using length of stay (LOS) as a splitting variable. As reported by the Victorian Auditor-General's Office (1998), casemix is a superior mechanism to the previous process based on historical expenditure.

Recently, Xiao et al (2000) assessed the effects of casemix funding on hospital utilisation in the Northern Territory. It was found that casemix funding has a positive impact in terms of hospital output, yet efficiency in the provision of care has not been reduced and there is no evidence of decline in the quality of care. While casemix appears to be effective in many respects, there are legitimate concerns on the ability of DRG to measure variations in severity and socio-economic status (Hindle, Degeling and van der Wel 1998; Beaver et al 1998).

There are three main reasons why variations in observed LOS may not be explained by DRG cost weights: (1) differences in hospital practices/efficiency, (2) differences in the severity of illness not captured by DRG, (3) differences in patient characteristics which result in different responses to treatment. Since the aim of casemix is to take account of all patient variations, such causes in LOS (and consequent cost) variations not reflected in the DRG classification should be adjusted in the funding model.

Accounting for within-DRG variations

Several approaches have been suggested in the literature to account for within-DRG variations in the funding context. First, the classification can be (and indeed is being) progressively refined. For example, AR-DRG

Version 4 represents a major improvement on Version 3 mainly through refinements in use of data on secondary conditions and through reorganization of the principal diagnosis and procedure clusters. The second option involves combination with other classifications such as the Computerised Severity Index by Horn et al (1991). The third type of approach involves sub-classification through funding rules, such as additional payments made to teaching hospitals, which effectively introduces an extra variable (hospital category) as an indicator of casemix. The fourth approach aims for progressive improvement in clinical coding, so that they become more sensitive to differences in severity. This has already been happening with the implementation of ICD-10-AM codes last year.

A different approach to control for within-DRG variations makes use of other variables in the routine discharge data set. This approach has been successfully applied in the South Australian acute hospital funding model (Hindle, Degeling and van der Wel 1998). Multiple regression techniques were used to identify relevant factors, which were then combined into a hospital-specific severity index. This has allowed South Australia to reduce the significance of the hospital category weightings. Beaver et al (1998) adopted a similar strategy to develop a severity and socio-economic adjustment model for budget allocation among Northern Territory public hospitals.

Refinement of AN-DRGs and the enhancement of clinical coding classifications are highly desirable, but cannot be undertaken without the support by all states. Similarly, the data and software required to support the combination with other classifications were not readily available. Sub-classification through funding rules would be used as required, but it is a poor substitute for use of clinical data. We therefore adopt, in principle, the approach proposed by Beaver et al (1998) to determine factors influencing LOS in public hospitals. The analysis, which explores the differences between rural and metropolitan hospitals, is expected to provide further insights on enhancing the equity of resource allocation between hospitals. Differences in hospital efficiency (eg, in terms of admission and discharge policies, and coding practices) as a cause of LOS variation will be discussed separately but can be accommodated within the model.

The rural and metropolitan health differentials

It is generally accepted that health disadvantage is experienced by Australians living in rural and remote regions. The AIHW (1998) health statistics indicated that rural residents sustain higher rates of death and hospital separations than those in capital cities and metropolitan centres. Associated with this are different numbers of comorbidities and disease patterns for the same DRG. The lower number of primary care providers, a relative lack of awareness of risk factors and lifestyle variations, and more common indulgence in risky behaviours by rural inhabitants, have contributed to some of the heterogeneity in health status. However, such differences may be confounded by the higher proportion of Indigenous people living in the rural environment, who as a population group have comparatively poor health status (Trickett, Titulaer and Bhatia 1997).

In the Western Australian context, a high percentage of Indigenous patients and remoteness of catchment area are two major characteristics of health services delivery in rural WA. As in other states, general practitioners tend to be under-represented in non-metropolitan areas. There are also limited resources, clinical coders and casemix expertise available to the smaller rural sites (Freeman 1999). The inequities in health care provision are further compounded by the high proportion of rural patient transfers due to lack of facilities, high-technology equipment and medical experts in dealing with complicated cases that need to be referred to hospitals with more sophisticated capabilities and resources (typically large metropolitan teaching hospitals). In view of such differentials, it is important to analyse LOS separately for rural and metropolitan hospitals.

Cox regression model

It is well known that the empirical distribution of LOS is positively skewed, plurimodal, and varies significantly across DRGs. This poses a problem for statistical modelling and analysis of LOS. For example, Marazzi et al (1998) assessed the adequacy of three conventional parametric models - lognormal, Weibull, and Gamma, for describing the LOS distribution but none appeared to fit satisfactorily across a variety of samples. Consequently, application of standard regression and associated tests on LOS may not be appropriate because the normality assumption cannot be attained by the logarithmic transformation or other forms of transformation of LOS. In the context of rural hospitals, a high proportion of transfer patients (typically to large teaching hospitals) adds to the complexity by contributing censored LOS observations.

The Cox regression model, also known as the proportional hazards model, is a method of modelling time-to-event data in the presence of censored observations. It is a semi-parametric approach in the sense that no particular distribution type (such as normality) is assumed for the outcome variable (LOS). The LOS from admission to discharge can be considered as a time-to-event variable. Most patients are discharged home but some are transferred to another hospital or institution, or die at the hospitals. These patients are regarded as censored cases. The Cox regression model allows joint estimation of the effects of explanatory variables on the hazard rate - the discharge probability, rather than the LOS itself. It improves statistical power by using all available information including censored data as well as 'outlier' episodes. The model assumes the conditional probability of being discharged at a particular time, given that the patient has not yet been discharged, is proportional among patients, the proportionality parameter depending on the patient's characteristics and other health provision factors. Effects of such potential determinants can be assessed through the individual regression coefficients on the hazard rate, with positive coefficients being associated with a decreasing LOS, while covariates with negative coefficients may prolong the patient's LOS. The assumption of proportionality can be tested by plotting the log-minus-log (LML) of the cumulative survival estimates and contrasted between variables of interest. Further details on the methodology are available from Altman (1996) and Kerr, Taylor and Heard (1998). Some applications to modelling length of postoperative hospitalisation can be found in Milano et al (1993) and Ferraris and Ferraris (1996).

Source data

All discharges of admitted patients from Western Australia public hospitals between July 1998 and June 1999 were extracted. Then 23% of the records were removed because they were judged to be out of scope, including two DRGs with majority of same-day patients (DRG 572, renal dialysis and DRG 780, chemotherapy); nursing home, palliation, and rehabilitation patients; and boarders and in-transit patients because they were either not appropriately categorized by DRG, or were funded via special programs in WA.

After these deletions, there were 290,123 discharges (acute episodes and qualified newborns) available for analysis. Unlike previous studies, hospital transfers and discharges due to death were included as censored observations, and no statistical trimming was undertaken. Patients' characteristics (age, gender, Indigenous and marital status), health provision factors (admission type, referral source, patient payment classification) and severity factors (such as number of diagnoses, number of procedures, presence of external causes) were reviewed and selected or computed from the WA Hospital Morbidity Data System. These candidate factors were chosen based on the findings of Xiao et al (1997) and Beaver et al (1998). The data were analysed using SPSS Version 9.

Results

Table 1 compares the characteristics of rural and metropolitan hospitals in Western Australia. Among the total 290,123 separations, 86,686 (30%) came from rural hospitals.

There are substantial differences between the two groups. The rural patients were generally younger and had shorter average LOS than their metropolitan counterparts. However, the rural hospitals had a high percentage of emergency admissions (61.8%), a greater proportion of transfers, and a significant proportion of Aboriginal patients (6 times that of metropolitan hospitals). This is expected because Aboriginal patients in rural areas are more likely to use hospitals as a mean of primary care, and partially due to the shortage of services provided by general practitioners (Strong, Titulaer and Phillips 1999).

The metropolitan (including large and teaching) hospitals have more sophisticated resources, which attracted the more complicated referrals from small and remote hospitals. This is reflected by the greater numbers of diagnoses and procedures per discharge. Analysis of residential postcodes also shows that while the majority (98%) of the metropolitan area residents were admitted to metropolitan hospitals, only 83% of the rural residents stayed in rural hospitals. Overall, the proportions of censored cases are 8.3% (rural) and 4.7% (metropolitan). If these cases were removed, the ALOS become 2.96 days (standard deviation = 4.19) and 3.77 days (standard deviation = 7.66) for rural and metropolitan hospitals, respectively. This is a plausible result. In a study of 105 New South Wales rural public hospitals, Hindle, Frances and Pearse (1998) also found actual costs decrease with reductions in hospital size but with increased isolation, though they noted that the impact of size and distance might be masked by the effects of referral practices and other factors not captured in their model.

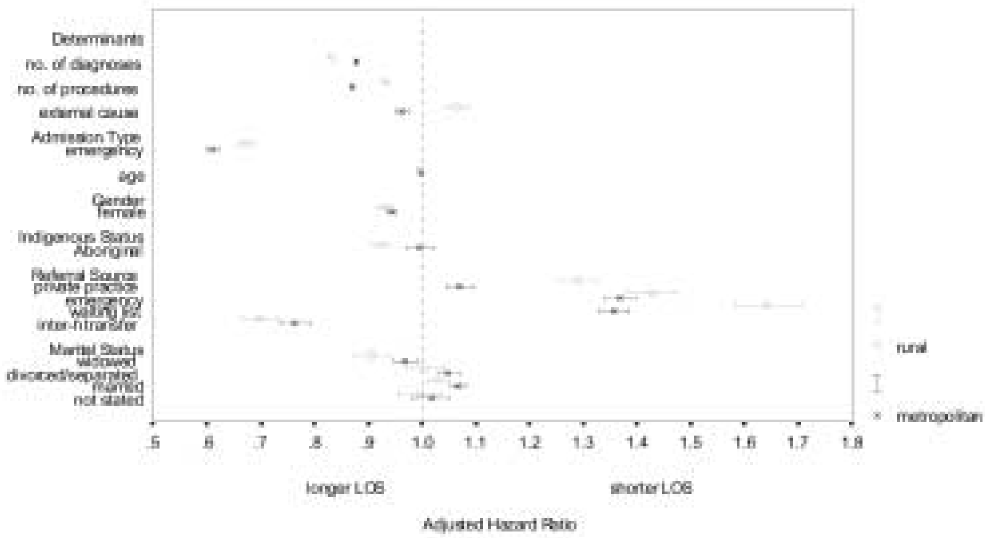
We further highlight the characteristics of admitted episodes for Aboriginal patients in Table 1. The results are consistent with evidence from other studies: Aborigines, predominately public patients, are younger, stay longer, have higher proportion of emergency admissions, higher severity of illness and incur more hospital transfers, compared to non-Aboriginal patients.

Table 1: Characteristics of WA rural and metropolitan hospitals, 1998/99

	Hospital Location			
	Metropolitan		Rural	
	All	Aboriginal	All	Aboriginal
Number of separations	203,437	6,711	86,686	18,074
Number of bed-days	829,141	33,574	261,854	59,144
Mean LOS in days (standard devn)	4.08	5.00	3.02	3.27
	(8.30)	(8.69)	(4.46)	(4.26)
Mean age in years (standard devn)	44.51	28.28	39.86	29.09
	(25.27)	(19.77)	(24.17)	(20.66)
Mean no. of diagnoses (standard devn)	3.56	4.53	2.44	2.65
	(2.93)	(3.43)	(1.70)	(1.80)
Mean no. of procedures (standard devn)	1.73	1.83	0.73	0.43
	(1.83)	(2.21)	(1.03)	(0.83)
Presence of external causes (%)	18.3	25.5	16.9	19.8
Proportion of same-day separations (%)	38.1	19.4	28.7	14.1
Proportion of male patients (%)	45.6	45.2	44.5	43
Proportion of emergency admissions (%)	44.6	67.7	61.8	82
Proportion of public patients (%)	89.8	97.6	90.2	99.2
Proportion of separations to homes (%)	93.3	88.9	88.4	82.4
Proportion of transfers to other hospitals (%)	3.5	4.8	7.6	9.1
Proportion of censored observations (%)	4.7	5.7	8.3	9.5
Proportion of Aboriginal patients (%)	3.3	-	20.8	-

Cox regression models were next fitted to the data regardless of DRGs but separately for rural and metropolitan hospitals. The likelihood ratio test statistics are 14,994 (rural) and 62,939 (metropolitan) on 19 degrees of freedom, which are clearly significant. The adjusted hazard ratios and associated 95% confidence intervals for various determinants of inpatient LOS are plotted in Figure 1. For categorical variables, a hazard ratio (exponential of its regression coefficient) less than 1 implies a lower conditional probability of discharge relative to the reference category, after adjusting for other factors affecting LOS. There are similarities between the two groups. According to the Wald statistics, number of diagnoses was the most significant determinant, followed by number of procedures, reflecting the strong association with the severity of illness. The hospitalisation likelihood was also related to the patient's age, gender, marital status, referral source and admission type, with scheduled admissions tend to shorten LOS compared with emergency admissions within the same DRG. As expected, inter-hospital transfers have a significant effect in delaying discharge, but we found no statistical association between LOS and the state of origin of a patient.

Figure 1: Adjusted hazard ratios and 95% confidence intervals for variables associated with LOS – rural versus metropolitan hospitals *

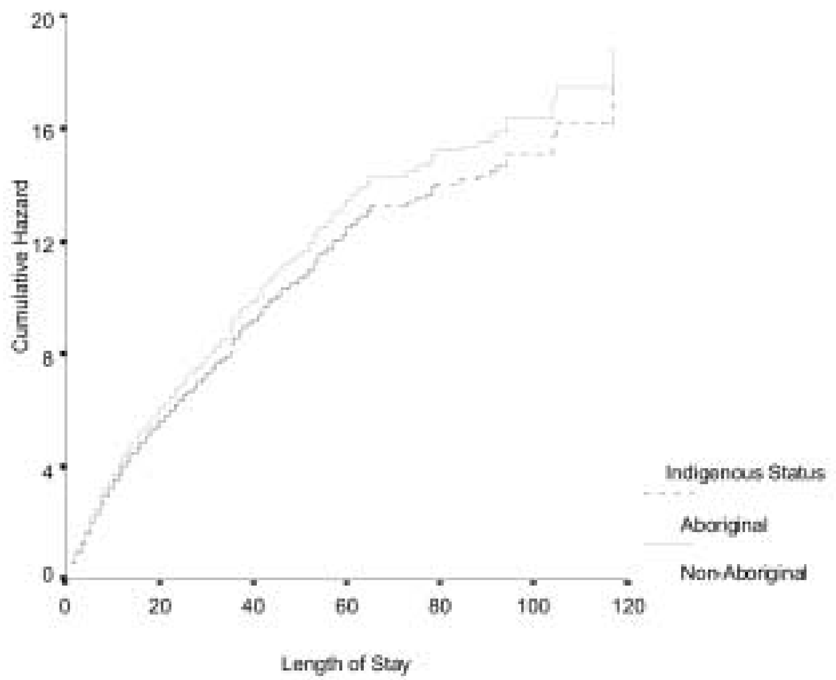


* The reference category for admission type, gender, indigenous status, referral source, marital status are elective admission, male, non-Aboriginal, other, and never married, respectively.

There are also notable differences between the two groups. In particular, Aboriginal patients admitted to rural hospitals were more likely to incur a late discharge compared to non-Aborigines, possibly due to a lower demand for hospital beds so doctors can keep their Aboriginal patients longer to ensure drug compliance or treatment of other less serious conditions. Their cumulative hazard (discharge) functions are plotted in Figure 2. However, there are no apparent differences for metropolitan patients. This is also evident from the proportion of same-day separations reported in Table 1. Incidentally, Strong, Titulaer and Phillips (1999) also found that the poorer health of Indigenous people only has a significant impact on the health statistics for remote populations. To further contrast the two hospital groups, their cumulative hazard functions after controlling for determinants of LOS are plotted in Figure 3, which show that patients from rural hospitals are more likely to incur a prolonged hospitalisation than their metropolitan counterparts.

The adequacy of the specified models was evaluated by means of partial residuals and other diagnostics, which reported no problem in the overall goodness-of-fit. The LML plots (not presented) show that the hazard rates for significant variables are essentially parallel, therefore satisfying the proportionality assumption. To assess the sensitivity of the analysis, the fitted model was cross-validated with the previous year's data (1997/98). The results of the Cox regression fits are consistent. There is also good agreement between predicted and observed probability values across the data sets, suggesting that the model described above is a satisfactory representation of the observed findings.

Figure 2: Hazard functions for rural hospitals – Aborigines versus non-Aborigines



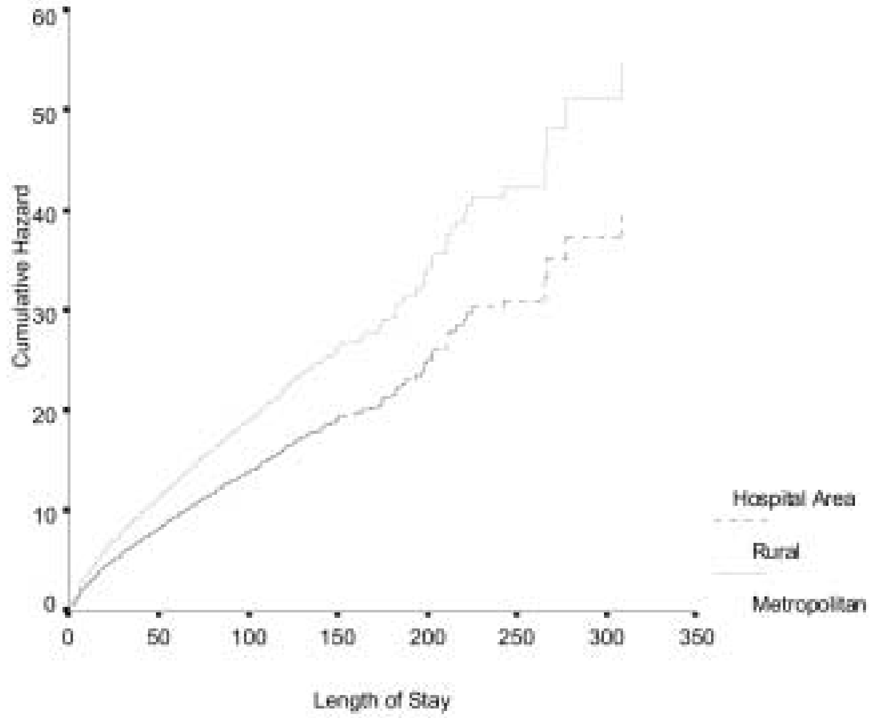
Discussion

In this study, Cox regression analysis is applied to examine the duration of inpatient stay as it provides a logical model of LOS in the presence of censored data and outlier episodes. Several variables reported in the literature that potentially affect LOS were investigated. The analysis shows that there is a significant proportion of the within-DRG variation in LOS (and hence cost) that can be explained by use of routinely available data. Application of the Cox regressions highlighted the differences between rural and metropolitan hospitals that were generally consistent with other evidence. Such differences need to be addressed in the design of an equitable funding strategy.

Our results suggested that rural Aboriginal patients have higher risk of prolonged hospitalisation than non-Aboriginal patients, and that patients admitted to rural hospitals have a lower conditional probability of discharge than those admitted to metropolitan hospitals, after controlling for relevant risk factors. The analysis also confirms that metropolitan hospitals tend to attract patients with more complicated problems (such as additional comorbidities), thereby increasing the overall ALOS (which is a consequence of additional severity of illness, and the requirement to perform multiple procedures).

From the analysis, there is potential to develop DRG payment adjustments by use of routinely available data items. Firstly, a discharge scoring system may be constructed from the Cox regression model to measure the risk of prolonged LOS for each DRG, following the suggestion by Ferraris and Ferraris (1996). The risk-adjusted (discharge) score for each patient may be determined from the coefficients of significant determinants applicable to that patient. Computation of the weighted discharge score for a particular patient episode can provide an objective estimate of the chance of prolonged hospitalisation and thus increased cost. Both clinicians and hospital administrators can benefit from such knowledge, in terms of identifying the proper treatment approach, providing informed consent on high-risk clinical procedures, and targeting selected groups of patients for interventions that might reduce LOS. Finally, such risk-adjusted scores may be used to formulate differential funding rates for public hospitals, where the case payment is computed based on the benchmark price, DRG cost weight, and the standardized risk adjustment score analogous to Beaver et al (1998), for rural and metropolitan models separately.

Figure 3: Hazard functions – rural versus metropolitan hospitals



There is no doubt that some of the within-DRG variation in resource use is a consequence of differences among providers, so that funding models must provide the incentive to measure and control such differences. For example, the effects of hospital size and degree of isolation have not been investigated in this study. Evidence from Hindle, Frances and Pearse (1998) indicated that such influences might have been compensated by the variations in severity that affect the referral practice and consequent LOS patterns. Nevertheless, since poorer health is generally associated with increasing remoteness (AIHW 1998), further investigation to model refinement in terms of controlling for size and distance appears worthwhile. The new Accessibility/Remoteness Index for Australia, developed recently by the Commonwealth Department of Health & Aged Care, may provide a reference benchmark in quantifying the geographical variation in hospital casemix.

Another limitation of the model is that LOS data collected from the same hospital are often correlated. The differences in hospital efficiency as a relevant attribute of LOS variations have been explored hardly at all in the literature. This dependency can be controlled via a hierarchical Cox regression model that adjusts for inter-hospital variation directly and provides estimates on (random) hospital effects, while accounting for the clustering of observations. As a result, hospital performance may be evaluated based on patient outcomes (such as LOS) after adjusting for patient casemix and associated severity and socio-economic factors. This hierarchical approach is currently under investigation. In summary, although appropriate adjustment models would be statistically complex to develop, they are essential for understanding variations in health care outcomes such as inpatient LOS.

References

Altman DG 1996, *Practical Statistics for Medical Research*, London: Chapman & Hall.

Australian Institute of Health & Welfare 1998, *Health in rural and remote Australia*, Canberra: AIHW.

Beaver C, Zhao Y, McDermind S & Hindle D 1998, 'Casemix-based funding of Northern Territory public hospitals: adjusting for severity and socio-economic variations', *Health Economics*, vol 7, no 1, pp 53-61.

Ferraris VA & Ferraris SP 1996, 'Risk factors for postoperative morbidity', *The Journal of Thoracic and Cardiovascular Surgery,* vol 111, no 4, pp 731-741.

Freeman SP 1999, 'Funding health services within the North West Health Zone of Western Australia', *Proceedings of the Eleventh Casemix Conference in Australia*, pp 68-72.

Hindle D, Degeling P & van der Wel O 1998, 'Severity variations within DRGs: Measurement of hospital effects by use of data on significant secondary diagnoses and procedures', *Australian Health Review*, vol 21, no 1, pp 37-49.

Hindle D, Frances M & Pearse J 1998, 'Casemix funding in rural NSW: Exploring the effects of isolation and size', *Australian Health Review*, vol 21, no 4, pp 174-91.

Horn SD, Sharkey PD, Buckle JM, Backofen JE et al 1991, 'The relationship between severity of illness and hospital length of stay and mortality', *Medical Care*, vol 29, no 4, pp 305-17.

Kerr C, Taylor R & Heard G 1998, *Handbook of Public Health Methods*, NSW: McGraw-Hill Book Company Australia Pty Ltd.

Marazzi, A, Paccaud F, Ruffieux C & Beguin C 1998, 'Fitting the distributions of length of stay by parametric models', *Medical Care*, vol 36, no 6, pp 915-27.

Milano CA, White WD, Smith, R, Jones RH, Lowe JE, Smith PK & Van Trigt P 1993, 'Coronary artery bypass in patients with severely depressed ventricular function', *Ann Thorac Surg*, vol 56, pp 487-493.

Strong K, Titulaer I & Phillips A 1999, 'Health service availability and use in rural and remote Australia', *Proceedings of the Eleventh Casemix Conference in Australia,* pp 54-60.

Trickett P, Titulaer I & Bhatia K 1997, 'Rural, remote and metropolitan area health differentials: A summary of preliminary findings', *Australian Health Review,* vol 20, no 4, pp 128-37.

Victorian Auditor-General's Office 1998, Acute Health Services under Casemix - A Case of Mixed Priorities: Special Report 56, http://hna.ffh.vic.gov.au/annrep98/.

Xiao J, Douglas D, Lee AH & Vemuri SR 1997, 'A Delphi evaluation of the factors influencing length of stay in Australian hospitals', *International Journal of Health Planning and Management*, vol 12, no 3, pp 207-18.

Xiao, J, Lee AH, Vemuri SR & Beaver C 2000, 'An assessment of the effects of casemix funding on hospital utilisation: A Northern Territory perspective', *Australian Health Review,* vol 23, no 1, pp 122-36.