The annual variation in activity and funding for acute public hospitals in NSW, 1988–89 to 1992–93

DAVID SIBBRITT AND ROBERT GIBBERD

David Sibbritt is a Statistician for the Health Services Research Group based at the Department of Statistics, University of Newcastle. Robert Gibberd is the Director of the Health Services Research Group and Associate Professor at the Department of Statistics, University of Newcastle.

ABSTRACT

Casemix-based funding was introduced into the Victorian health system without an assessment of the annual variation in inpatient activity. Before undertaking such a funding reform, it would be appropriate to determine the level of annual variation in inpatient activity for individual hospitals that could be attributable to chance or random variation. If the annual random variation is not accounted for, then casemix-based funding may actually lead to inefficiencies. For this study, hospital inpatient activity and funding data for 120 acute public hospitals from New South Wales for the years 1988–89 to 1992–93 were used to estimate the standard deviation of the annual random variation in activity and gross operating payment. Through linear regression, estimates of the standard deviation of random variation about the underlying trend were obtained for each hospital. The results showed that, depending on the size of the hospital, total diagnosis related group cost weights have a standard deviation in the range of 2 to 16 per cent of total activity, whilst gross operating payment has an equivalent standard deviation that ranges from 1 to 10 per cent annually. The magnitude of the variation would suggest that funding of hospitals should either be based on average activity over several years or based on bands of activity in order to reduce the potential random variation in funding levels.

Introduction

The use of case-payment to achieve greater efficiency in the public sector in Australian hospitals has been criticised on several grounds. It has been noted that case-payment will not achieve its objectives in the long run for the following reasons.

1. It sets up a form of internal competition in which hospitals strive to look good or better than their fellow hospitals (Street 1994). Looking good on the 'efficiency index' becomes more important than ensuring high-quality work and attention to patients (Editorial 1995a). For example, hospitals may increase patients' time in emergency departments to four hours to ensure they are counted as inpatients or, conversely, inpatients may be discharged early, creating unnecessary risk to patients (Editorial 1995a; Duckett 1995; Editorial 1995b; Phillips et al. 1995).
2. Hospitals will not accept or will try to pass on difficult or expensive cases which they do not want to appear in their data (Editorial 1995a; Duckett 1995).
3. It encourages hospitals to circumvent the system for financial gain (Editorial 1995a; Duckett 1995; Editorial 1995b; Phillips et al. 1995; Hindle 1995).
4. Case-payment undermines cooperation between institutions and even between departments within an institution (Street 1994).
5. Case-payment rewards the 'lucky' hospitals and penalises the 'unlucky'. The biggest factor that determines a hospital's 'output' is the demand for patient services. But even if every staff member in the hospital did their best, this will not influence the patient demand, which is determined by external factors outside of the hospital's control. The patient demand is subject to a large amount of statistical or common cause variation caused by climate, virus levels, referral patterns, and so on. Thus those hospitals which receive a statistically high number of patients will be rewarded on the 'funding index', compared to those which have a statistically low number. Such a system may create cynics who will see the intellectual flaws in case-payment.

Many reports on points 1 to 4 have been published, but we are not aware of any attempts to quantify point 5. This paper discusses point 5 by determining the magnitude of the statistical fluctuations in patient demand for individual hospitals.

Current funding models

The Victorian Government has recently attempted to introduce competition into the public health system by implementing casemix-based funding. Under this new funding method, 'output [activity] based funding accounts for about 50% of overall hospital budgets' (Galbraith 1993).

The theory behind Victoria's change to casemix-based funding is that it will '...encourage hospitals to focus on the need for increased efficiency' (Tehan 1994). Efficiency in this context represents increased patient throughput for a decrease in per-unit cost. However, if strictly applied, casemix-based funding may lead to inefficiencies for the following reasons. Assume that the expected inpatient activity in a hospital is constant over time, and hence the annual funding should be constant. Now assume that, due to chance, the actual annual activity varies by 3 per cent. The hospital does not incur major additional costs from this 3 per cent variation. (If the marginal cost is assumed to be less than 20 per cent of the average cost, a 3 per cent change in total diagnosis related group cost weights implies a variation of less than 0.6 per cent in total expenditure.) If casemix payment allows 50 per cent for the additional activity, hospital funding increases by 1.5 per cent. Similarly for a random reduction in activity of 3 per cent. Casemix payment translates the random variation in inpatient activity into random variation in annual funding levels.

An alternative to the casemix funding used in Victoria is the resource allocation formula used in New South Wales (New South Wales Department of Health 1993). The New South Wales Department of Health has been implementing the resource allocation formula as a tool for financial planning by setting funding targets for the areas/regions within New South Wales. The formula determines the percentage share of the State's acute hospital budget that each area/district should obtain to better meet the health demand for the current population and the projected demand for the year 2006. What is not provided for the areas/districts is a model on how to fund the individual hospitals within each area/district. It was also suggested in the resource allocation formula that in terms of future funding, due to the small population size of some of the districts, 'an alternative model such as activity projections may lead to a more appropriate model' (New South Wales Department of Health 1993).

If activity is going to vary by ±3 per cent each year due to chance, then it would suggest that either a banding system for funding is required or that projected activity that smooths out random variation could be used. If activity lies within ±3 per cent from the projected activity, then funding would be based on the projected activity. If large deviations from projected activity occurred, the projections would need to be re-assessed.

The first question associated with these issues is: How much does the annual inpatient activity and the funding of a hospital vary over time? If substantial, then a second question arises: How should the variation be incorporated into funding formulas?

Data

Inpatient data and gross operating payments (GOPs) for all New South Wales public hospitals for the years 1988–89, 1989–90, 1990–91,1991–92 and 1992–93 were obtained from the New South Wales Department of Health.

The diagnosis related group (DRG) and the Australian national diagnosis related group (AN-DRG) cost weights were used to estimate the expected costs of treating inpatients. DRG cost weights were used for the years 1988–89 to 1989–90 and AN-DRG cost weights were used for the years 1990–91 to 1992–93. The DRG cost weights were derived by the Health Services Research Group (Gibberd, Lam & Fahey 1990). They are basically modifications of United States service weights for New South Wales hospitals. The AN-DRG cost weights used were those derived by KPMG Peat Marwick (1993).

Method

Hospitals with less than 500 admissions were excluded. In addition, the following hospitals were also excluded from the analyses due to:

- changes in the services that they provided to the community (Western Suburbs – Sydney, Liverpool, Lidcombe, Royal Newcastle)
- a new hospital gradually increasing to full operational capacity (John Hunter)

- changing public bed numbers over the study period (St Vincents – Bathurst).

Of the remaining hospitals, further 'cleaning' of the data was necessary. Upon investigation, it appeared that such items as capital works programs or area/region administration costs had been included in the GOP of some hospitals as a 'one-off' occurrence. To further remove unusual sources of variation, if the estimate of the scaled standard deviation (σ/α) was greater that 0.40 (that is, 40 per cent annual variation in GOP or activity), then the offending hospital was omitted (see below for methods to estimate (σ/α). Note that the *scaled* standard deviations were used so that the variations due to any trends over time were removed.

In 1988–89 there were 191 acute public hospitals. Of these hospitals, 49 were excluded for having had less than 500 separations, 16 hospitals were excluded as a result of the unusual variation, and 6 were excluded due to their changing roles. After the various exclusions there were 120 acute public hospitals remaining in the study data set. The study group of hospitals had a combined GOP of $2.3 billion (81 per cent of the total acute public hospital GOP) and 733 000 separations (84 per cent of all acute public hospital separations).

As AN-DRG cost weights are used for the years 1990–91 to 1992–93 and DRG cost weights are used for 1988–89 to 1989–90, there is a question as to the validity of using two different cost weight measures. This was overcome by ensuring that both the DRG cost weights and the AN-DRG cost weights were scaled so that the average DRG or AN-DRG cost weight per separation was 1.0. Table 1 and figures 1 and 2 show that both the total DRG cost weight and total GOP for these hospitals are increasing annually.

Table 1: Cost weights, GOP and separations for the study group of hospitals, 1988–89 to 1992–93

	1988–89	1989–90	1990–91	1991–92	1992–93
Cost weight	732 077	769 279	778 855	808 800	840 479
GOP	2 322 434	2 474 000	2 571 232	2 586 477	2 656 603
Separations	732 987	772 607	844 303	879 649	907 465

Figure 1: Total cost weights for the study group of hospitals, 1988–89 to 1992–93

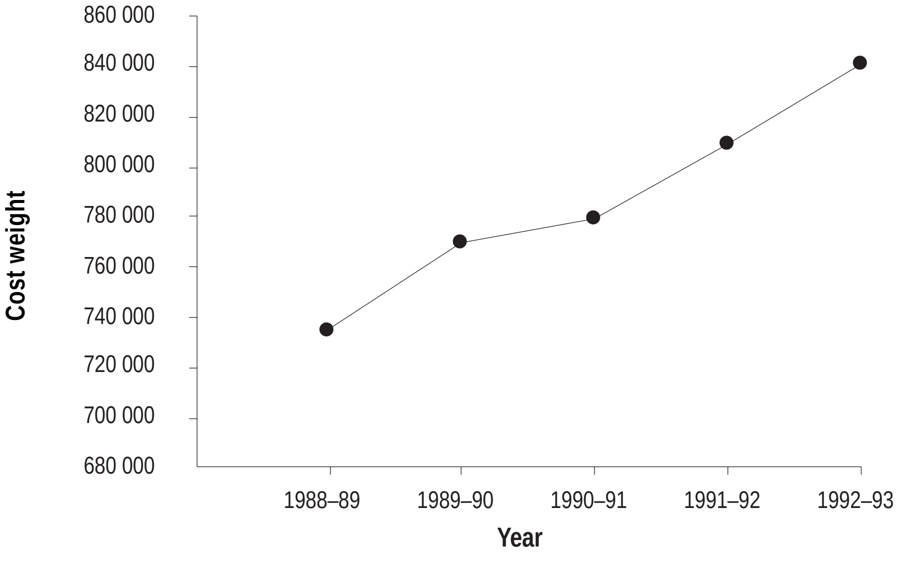
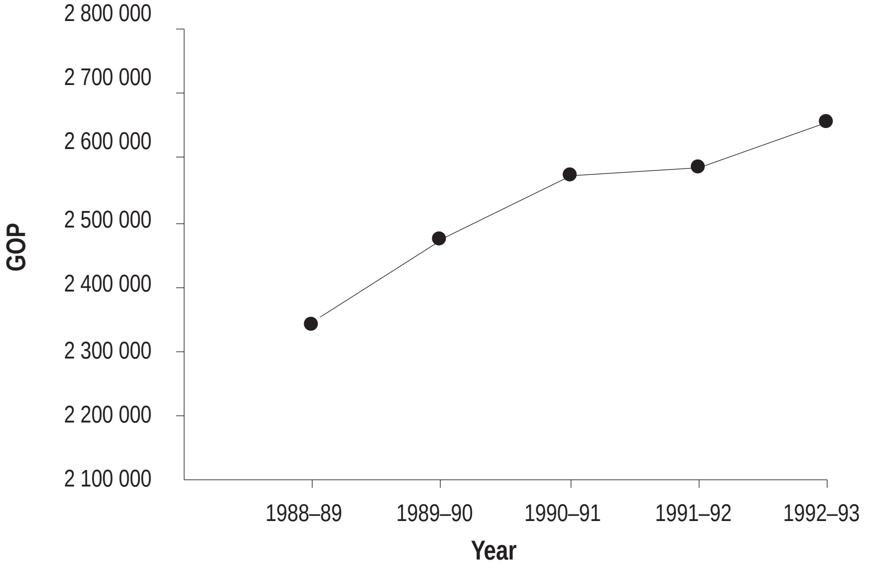


Figure 2: Total GOP for the study group of hospitals, 1988–89 to 1992–93



The amount of variation in the total cost weights for all hospitals in the study (table 1), after removing the linear trend with year, is equivalent to a standard deviation of approximately 0.9 per cent. That is, the standard deviation of the random variation inherent in the study group of hospitals as a whole is 0.9 per cent, and would be expected to be seen in individual hospitals. For GOP, the equivalent standard deviation is approximately 1.8 per cent.

How to measure annual variation in activity and GOP for individual hospitals

With five years of data, we could measure the standard deviation of DRG cost weights for each hospital. However, this includes any systematic variation, which we will assume is a linear function of time (year). To obtain an estimate of the random variation about the underlying trend, we need to subtract this linear trend from the cost weights and estimate the standard deviation of the residuals. This is done by fitting a linear regression equation (of the form shown below) to obtain estimates of α, β and σ separately for DRG cost weights and GOP, for each hospital:

α = mean value of cost weights or GOP for five years
β = trend in cost weights or GOP per year
σ = estimate of standard deviation of cost weights or GOP about the linear regression model.

The main analysis used in this study was to fit a simple linear regression model for both GOP and DRG cost weights, for each hospital, against time using the years (1988–89 to 1992–93) as the predictor variable. That is:

- GOP = $\alpha + \beta$ x year, and
- cost weight = $\alpha + \beta$ x year (where year = -2, -1, 0, 1, 2)

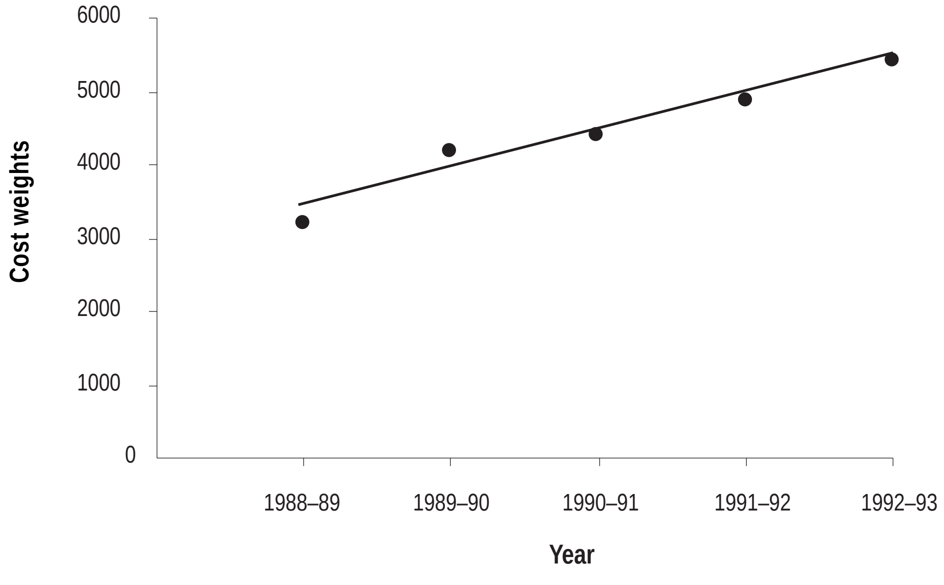
(Separate estimates of α and β are obtained for activity and GOP for each hospital.)

The quantity of interest is σ and σ/α, which is the standard deviation in activity or GOP as a fraction of the mean value, α. Another useful quantity of interest is β/α x 100, which determines the annual percentage change in activity or GOP. Note that the α and β are different for the GOP and the cost weight and for each hospital.

To illustrate these ideas we present the results for one hospital. Figure 3 shows the DRG cost weights plotted over time for the five-year period 1988–89 to 1991–92, where from the regression line:

$\alpha = 4,397$ $\beta = 516$ $\sigma = 213$ $\beta/\alpha = 0.117$ $\sigma/\alpha = 0.048$.

Figure 3: Scatter plot of cost weights against year for one hospital



Hence for this hospital the standard deviation of the annual variation in activity about the linear regression line was 213 DRG cost weights or 4.8 per cent of its average activity of 4397. The hospital also exhibits a large annual systematic increase in activity of 516 cost weights, or a 11.7 per cent annual increase during 1988–89 to 1991–92.

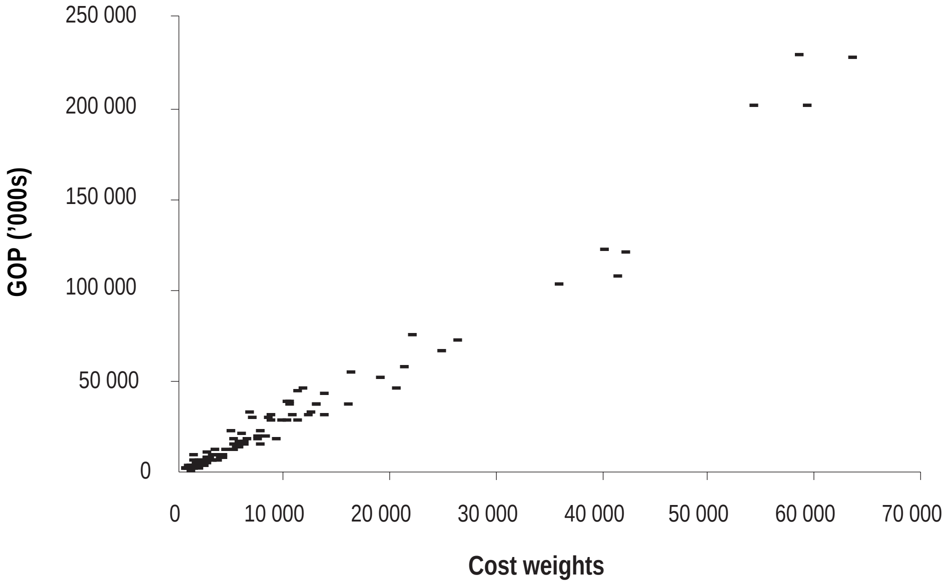
Results

To gain some insight into the relationship between GOP and cost weights, the two variables were plotted against one another, as shown in figure 4. There appears to be a strong linear relationship between GOP and cost weights, with a correlation coefficient of $r = 0.98$. Although this plot is for the year 1992–93, similar results are evident for the years 1988–89 through to 1991–92.

The high correlation implies that activity (cost weights) alone may be a particularly useful predictor for funding hospitals, although total separations or bed-days would give similar results.

Figure 4 reveals a close relationship between activity and funding. The next issue to consider is the magnitude of the variation that occurs in a hospitals' activity or funding from year to year. The indicator of variation

Figure 4: Scatter plot of GOP against cost weights, 1992–93



used was the standard deviation of the GOP or cost weights around the regression line for the years 1988–89 to 1992–93 divided by the mean value. That is, σ/α. A histogram of the values of σ/α x 100, for all 120 hospitals for cost weights and GOP are shown in figures 5 and 6.

Figures 5 and 6 show that the scaled standard deviations for activity (cost weights) were greater than the standard deviation for funding levels. The scaled standard deviation for GOP ranged from three hospitals with 1 per cent standard deviation to three hospitals with 10 per cent standard deviation. The majority of hospitals had standard deviations of 3 to 6 per cent. Standard deviation for activity (cost weights) ranged from 2 to 16 per cent, with the majority of hospitals having standard deviations in the range of 4 to 10 per cent.

To see if there was a relationship between the amount of variation in annual GOP and the size of the hospital, the scaled standard deviations (σ/α) were plotted against GOP, as shown in figure 7. For the larger hospitals there appears to be smaller standard deviations, between 1.5 to 4.0 per cent, which would be expected for hospitals with such large GOPs. The smaller hospitals, however, have standard deviations that vary from between 0.4 to

Figure 5: Scaled deviation in GOP by hospital, 1988–89 to 1992–93

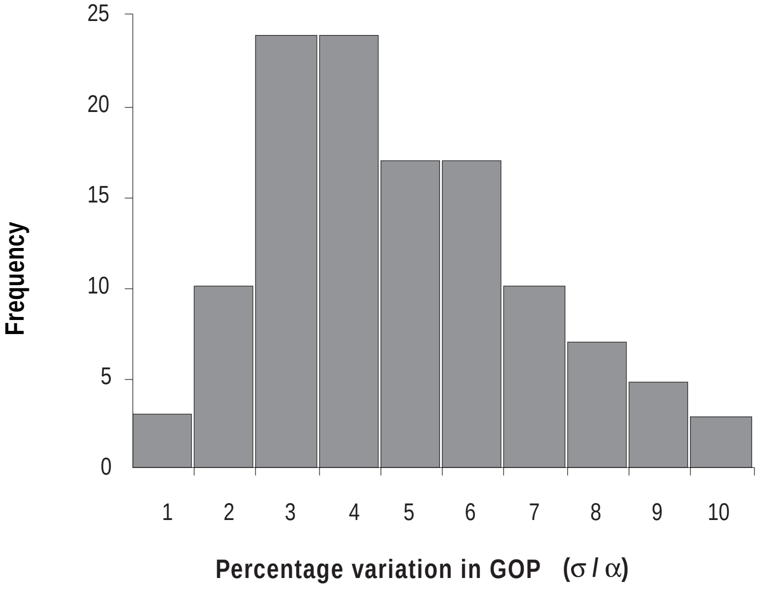


Figure 6: Scaled standard deviation in cost weights by hospital, 1988–89 to 1992–93

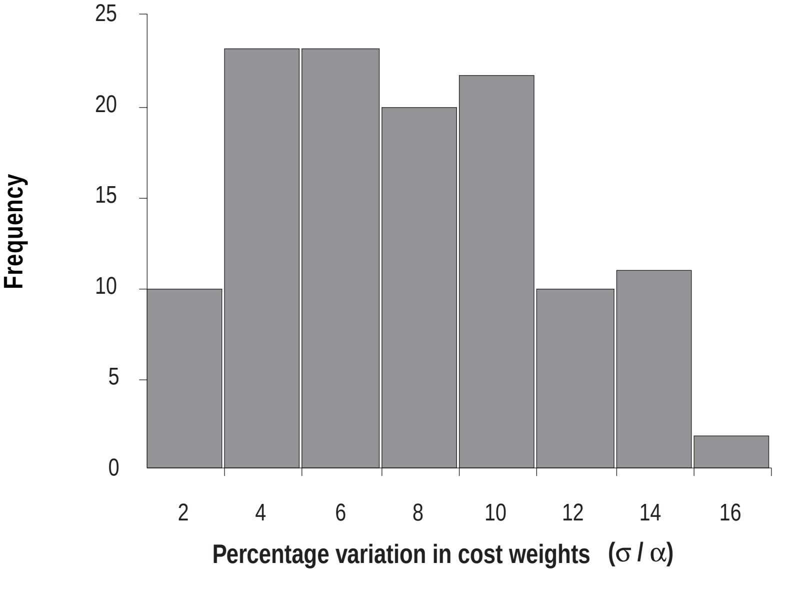


Figure 7: Scaled standard deviation in GOP by GOP for each hospital (with simple linear regression line fitted)

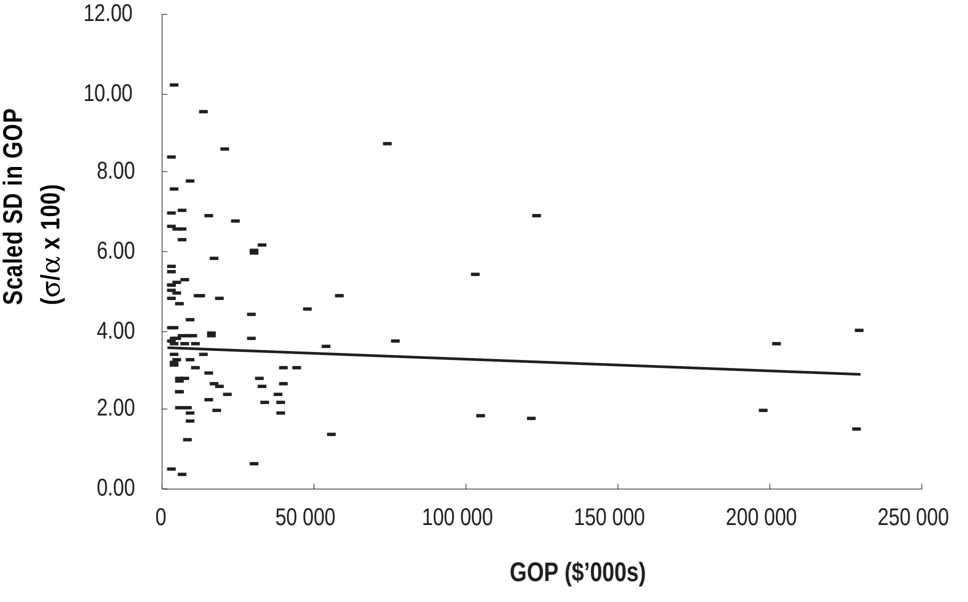
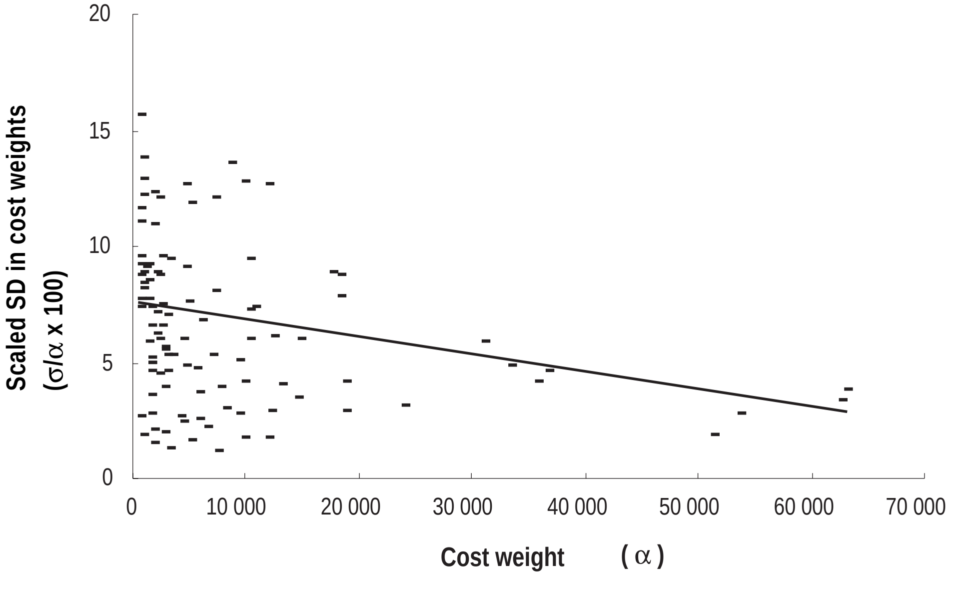


Figure 8: Scaled standard deviation of cost weights by cost weight for each hospital (with simple linear regression line fitted)



10.2 per cent. The regression line fitted in figure 7 shows that the scaled standard deviation (σ/α) exhibits no trend with GOP. Therefore the standard deviation of approximately 4 per cent appears to be independent of hospital size.

Figure 8 shows the relationship between the standard deviation in activity and the mean of the activity over five years (σ/α). The plot implies that the activity for larger hospitals has less percentage variation from year to year than that of the smaller hospitals. The larger hospitals have standard deviations that vary between 1.9 to 3.8 per cent while the smaller hospitals have standard deviations that vary between 1.1 to 15.7 per cent. This result is consistent with statistical or chance variation. Note that in absolute numbers of DRG cost weights (estimated by σ), the random variation increases with the size of the hospital. Larger hospitals (GOP greater than $200 million) have, on average, a standard deviation of 1850 DRG cost weights. For smaller hospitals (GOP less than $200 million) the average standard deviation is 310 DRG cost weights.

The systematic change (trend) in activity over the five-year period for each hospital is obtained from (β/α) and the histogram in figure 9 shows that the annual trends range from a decline of 5 per cent to an increase of 5 per cent for most hospitals.

Figure 10 shows the relationship between the percentage annual change in activity against the percentage annual change in GOP (β/α). It appears that the percentage change in activity is related to the percentage change in GOP, where a 10 per cent change in activity implies a 6 per cent change in GOP (GOP = 2.86 + 0.316 x cost weight) , with a correlation coefficient of r = 0.6.

Conclusion

The question asked at the beginning of this paper was how much does annual activity and funding vary in New South Wales public hospitals? The results have shown that the coefficient of variation in annual GOP for hospitals with a GOP of greater than $200 million is between 1.5 to 4.0 per cent. Hospitals that have a GOP under $200 million have a coefficient of variation of between 0.4 to 10.2 per cent. When comparing the variation in annual activity by hospital size, larger hospitals (cost weights greater than 50 000) clearly had a smaller range of values for standard deviations (1.9 to 3.8 per cent per year) than the range of the

Figure 9: Percentage annual trend in cost weights for each hospital

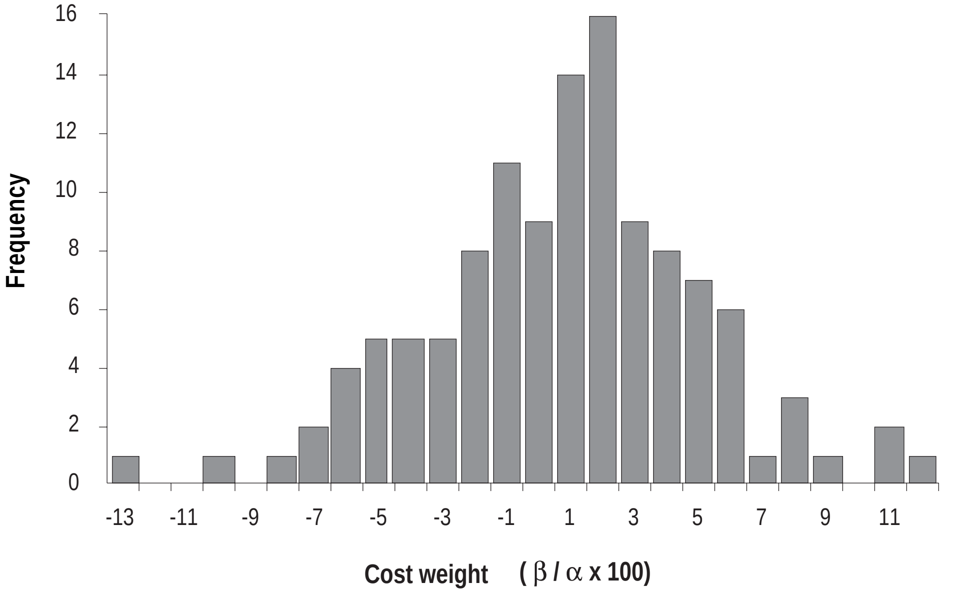
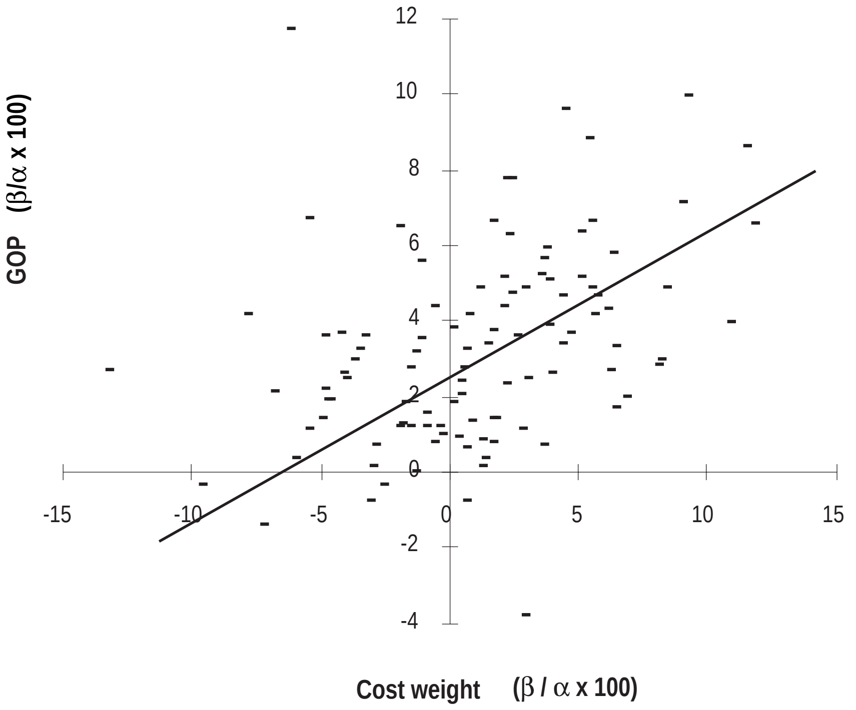


Figure 10: Percentage change in cost weights by percentage change in GOP for each hospital (with a simple linear regression line fitted)



smaller hospitals (1.1 to 15.7 per cent per year). In absolute numbers, σ ranged from 1850 DRG cost weights for large hospitals and 310 DRG cost weights for small hospitals. The impact on funding would imply (assuming $2500 per DRG cost weight) an annual variation of up to $4.6 million for large hospitals and $0.78 million for small hospitals, arising from the chance and unavoidable variation in activity.

What the results imply is that, depending on the hospital size, there is natural variation in annual activity (2 to 15 per cent). Funding therefore has to take this natural variation into consideration, otherwise a hospital's annual funding level may vary by $0.78 to $4.6 million, for factors that it cannot control (chance). However, the expenditure variation to treat these patients could be 20 per cent of these amounts if the marginal cost for absorbing this variation is 20 per cent.

Similarly, the systematic linear trend, estimated by the βs, would imply an annual change in funding of $0.62 million to $4.4 million for small and large hospitals respectively (calculated as the average β x $2500). There needs to be funding changes to accommodate systematic trends while not responding to chance fluctuations.

Of concern is the current variation in GOP, which is anywhere from 0 to 10 per cent depending on hospital size. This variation is higher than desirable for effective resource planning within the hospitals. The high variation may be a result of: changing definitions of GOP; impurities in the data (that is, capital works monies counted in GOP); or systematic changes in demand for services. The aim for funders and the hospitals themselves would be to reduce the chance variation in annual GOP – an essential prerequisite for ensuring efficiency. If a hospital has the knowledge of what its future budgets will be over the next three to five years, it will enable staff to focus on the long-term strategic issues. Figure 10 suggests to us that a reasonable performance indicator for health departments is the association between the linear shifts in funding and activity. An R^2 of over 0.6 would be a desirable minimum value.

Applying these results to the current Victorian funding model, hospitals will experience similar chance variation over the next three years and find that they need to use the extra funds from a 'good' year to cover the reduced funding in a 'bad' year. The amounts to carry forward or hold in reserve are large ($1 million to $8 million dollars). Unfortunately hospitals do not have the data or skills to know what their expected activity is, or whether they are above or below this level. Thus there will be the temptation to ignore the variation, which will result in a series of surpluses and deficits of amounts which would be difficult for a hospital to manage. On top of this, annual casemix funding creates perverse incentives in terms of increasing activity unnecessarily.

The alternative is to determine appropriate activity levels for each hospital during the next five years and provide funding appropriate to this level. If activity deviates by more than 3 per cent from this level, allow a correction for activity above 3 per cent at a marginal rate of 20 per cent. The advantages of the New South Wales resource allocation formula become clearer now. The funding level for an area is set at a rate based on the projected activity in the public hospitals and is not responsive to statistical variation.

The introduction listed several points that are seen to be problems with casemix payment. This paper has shown that a major concern is point 5, the rewarding and penalising of hospitals for chance variation.

The funding of hospitals has some similarities to universities, where a rolling triennial funding approach, based on projected student enrolments, provided an important reform. This paper shows that a similar approach is required for hospitals since both environments encounter large statistical variation in activity which does not impinge greatly on cost due to the low marginal cost for any surplus activity.

References

Editorial 1995a, 'Casemix in Victoria: The discharged patients the system forgot', *Healthcover*, vol 5, no 1, pp 14–22.

Editorial 1995b, 'Duckett: efficiency-only focus raises new ethical risks', *Healthcover*, vol 5, no 1, pp 13–14.

Duckett SJ 1995, 'Casemix funding in Victoria: The first year', *The Medical Journal of Australia*, vol 162, no 12, pp 650–4.

Galbraith L 1993, 'Priority on payments', *Australian Casemix Bulletin*, vol 5, no 4, pp 8–11.

Gibberd RW, Lam P & Fahey PP 1990, 'Estimating NSW trim points and DRG cost weights for 1986', Health Services Research Group.

Hindle H 1995, 'Getting better, feeling worse: Casemix-based funding of Victorian hospitals', *The Medical Journal of Australia*, vol 162, no 12, pp 622–3.

KPMG Peat Marwick 1993, National costing study production of cost weights for AN-DRGs version one, KPMG Peat Marwick, Adelaide.

New South Wales Department of Health 1993, Resource allocation formula for the New South Wales health system, 1993 revision.

Phillips PA, Kennedy JT, Segal GR, Jones MR & Larkins RG 1995, 'Perspectives on casemix-based funding in Victoria', *The Medical Journal of Australia*, vol 162, no 12, pp 655–7.

Street A 1994, 'Purchaser/provider separation and managed competition', *Australian Journal of Public Health*, vol 18, no 4, pp 36–79.

Tehan M 1994, 'A profile of reform in Victoria's public hospital system', An address to the Hong Kong Hospital Authority plenary session, Melbourne, Department of Health and Community Services, Victoria.