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Efficiency, effectiveness, equity (E^3). Evaluating hospital performance in three dimensions☆

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ABSTRACT

There are well-established frameworks for comparing the performance of health systems cross-nationally on multiple dimensions. A sub-set of such comprehensive schema is taken up by criteria specifically applied to health service delivery, including hospital performance.

We focus on evaluating hospital performance, using the New Zealand public hospital sector over the period 2001–2009 as a pragmatic and illustrative case study for cross-national application. We apply a broad three-dimensional matrix – efficiency, effectiveness, equity – each based on two measures, and we undertake ranking comparisons of 35 hospitals.

On the efficiency dimension – relative stay, day surgery – we find coefficients of variation of 10.8% and 8.5% respectively in the pooled data, and a slight trend towards a narrowing of inter-hospital variation over time. The correlation between these indicators is low (.20). For effectiveness – post-admission mortality, unplanned readmission – the coefficient of variation is generally higher (24.1% and 12.2%), and the trend is flat. The correlation is again low (.21). The equity dimension is assessed by quantifying the degree of ethnic and socio-economic variation for each hospital. The coefficient of variation is much higher – 40.7–66.5% for ethnicity, 55.8–84.4% for socio-economic position – the trend over time is mixed, and the correlation is moderate (.41). On averaging the rank of hospitals across all measures it is evident that there is limited consistency across the three constituent dimensions.

While it is possible to assess hospital performance across three dimensions using an illustrative set of standard measures derived from routine data, there appears to be little consistency in hospital rankings on these New Zealand data for the period 2001–2009. However, the methodology of using rankings derived from readily available data – possibly allied with multiple or composite indicator models – has potential for the cross-national comparison of hospital profiles, and assessments in three dimensions provide a more holistic and rounded account of performance.

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1. Introduction

There is increasing international interest in assessing cross-national health system performance in comparable ways across a number of dimensions, not just in health [1] but across a range of delivery systems [2]. Perhaps the most ambitious and comprehensive approach in health is that established by the World Health Organisation (WHO) [3]. Other schema mooted by official or semi-official organisations have been propounded by the OECD [4] and the Commonwealth Fund [5], among others. There are also frameworks deriving from political science [6], health services research [7] and health economics [8].

1.1. The importance of hospital performance

An important sub-set of such schema is taken up by the assessment of specifically health care or health service delivery dimensions of the health system. For most citizens and decision-makers alike, these are likely to be the areas of most pressing policy concern and sensitivity, particularly given that the great bulk of health system expenditure is allocated to personal health services, usually within the broader context of a welfare state structure of funding and delivery [9].

While primary care remains the principal point of patient contact with the delivery system for most citizens, it is the hospital sector that, because of the scale of the facilities and their resource requirements, has elicited the bulk of academic and official focus on performance issues. Thus, for management work, for health economics, and even for public administration and political science, the hospital is still a major focus of academic enquiry and policy concern. Added to this has been the more recent re-setting of conceptual frameworks to take adequate cognizance of quality and effectiveness (rather than just resource use, productivity and efficiency) [4], as well as questions of social equity, fairness and access [3].

Most of the work on assessing hospital performance has been restricted to within national jurisdictions, in part because of unique local system features that make them hard to compare, in part because of the imperative nature of internal policy priorities that gives a strong local dynamic and focus to such work, and in part because of some of the technical difficulties in making cross-national comparisons. For example, the OECD has been able only with difficulty to make comparisons of hospital efficiency on a limited number of very specific criteria for a small set of countries [10].

1.2. The New Zealand setting

New Zealand underwent major reforms of its hospital sector in the 1990s, as part of system-wide reorganisations in the context of severe fiscal and ideological pressure on the welfare state. Management systems in the wider public sector were reformed in broad terms of "the new public management", hospitals were re-shaped as corporate entities, and a more explicit contracting regime was introduced within what was otherwise, outside general practice, a predominantly National Health Service-type tax-payer, bulk-funded population-based system [11].

While the more overtly corporate and market-oriented aspects of the hospital sector have been removed within the context of regionalised, democratically-accountable health agencies (District Health Boards), the management structures have remained largely intact, together with some degree of contracting with the centre.

While the principal focus of hospital reform in the 1990s was the achievement of greater efficiency, more recent interest has turned to the safety and quality of care, as well as to equity issues [12]. It is these three dimensions – efficiency, effectiveness (i.e. clinical impact, including safety and quality), and equity – that form the basis of the assessment framework carried out in this paper.

1.3. The "balanced scorecard" approach

Given the major resource use of hospitals, the efficiency of their operation has been – and still continues to be – a major preoccupation of managers and decision-makers. However, and in keeping with frameworks adopted at the international level, authorities have increasingly deployed schema that consider a range of dimensions in assessing the performance of hospitals. In particular, one of the concerns has been that a vigorous pursuit of efficiency objectives might be at the cost of the quality of care [13], and/or possibly equity considerations [14].

Therefore, authorities in a number of jurisdictions have developed frameworks that attempt to evaluate hospitals across a number of key dimensions simultaneously [15] [16] and [17]. More than this, an objective of interest has been whether it is possible to maintain operations at a high level of efficiency, while at the same time being able to meet quality and equity criteria [18]. One approach in this area has been to adapt from the strategic management literature the concept of a "balanced scorecard", establishing whether hospitals can perform well across a number of dimensions [19] [20] [21] and [22].

Gauld et al. [23] have applied such an approach to a broader health system canvas in the New Zealand setting using international criteria and metrics. We propose to adapt the balanced scorecard concept to a standard health services research model [7] applied to the assessment of hospital performance using a selection of indicators across the three dimensions of efficiency, effectiveness and equity in order to assess its potential for cross-national application.

What we find is that the within-dimension correlation of indicators is not particularly strong and that the dimension-specific rankings of facilities do not position hospitals consistently in the "league tables" of efficiency, effectiveness and equity. Nevertheless, while our case study is primarily an illustrative and pragmatic one, we maintain that the visualisation of hospital profiles is illuminating and that a cross-dimensional approach of the kind outlined is essential to a fuller and more rounded assessment of hospital performance, albeit with a wider range or

"basket" of indicators and possibly combined using multi-indicator statistical models.

2. Methods

We analyzed all inpatient admissions between 2001 and 2009 to 35 New Zealand public hospitals (n = 3,974,316 admissions). The hospitals comprise all New Zealand general public hospitals with provision for acute (emergency) admissions and patient volume greater than 500 admissions in each year of the study. Data were obtained from the New Zealand Ministry of Health (MOH)'s National Minimum Dataset, which records routine information about all admissions to public hospitals in New Zealand, and about some (publicly-funded) admissions to private hospitals. Data were filtered according to standard MOH criteria [24]. This filtering is designed to remove variations resulting from changes to data collection processes over time [25] and [26]. We excluded private hospitals, as routine administrative data is only available for publicly-funded admissions to such hospitals (e.g., for birth events, geriatric care). We also excluded smaller hospitals, as the majority of these are specialist hospitals providing a limited range of services.

This study was approved by the multi-region ethics committee convened by the New Zealand Ministry of Health.

In the selection of performance indicators we were guided by pragmatic considerations of the availability of measures, using administrative data that were well-established in the New Zealand context, but that also had wider support (for example, development and use in the Australian health system).

We assessed the following indicators of hospital performance:

2.1. Efficiency

2.1.1. Relative stay index (RSI)

RSI is calculated as the number of days spent in hospital for selected diagnostic-related groups (DRGs) divided by the expected number of days spent in hospital (calculated as the average rates across the 35 New Zealand hospitals for 2001–2009) and standardized by age and case-mix. An RSI greater than 1 for a hospital indicates that length of stay is higher than expected given the case-mix of admissions to that hospital. An RSI of less than 1 indicates that the length of stay was less than expected [27].

2.1.2. Standardized day surgery rate

This is calculated as the ratio of the 'actual' to 'expected' day surgery rate for each hospital, multiplied by the overall day surgery rate for the 35 hospitals, expressed as a percentage. This ratio represents, for each hospital, the day surgery rate adjusted for the DRG-mix of surgeries in each hospital [28]. For consistency with other indicators – for which a high rate indicates poor performance – this indicator will be expressed as the standardised rate of overnight surgeries for each hospital (i.e., 100% minus the standardised day surgery rate).

2.2. Effectiveness

2.2.1. Unplanned readmissions

All inpatient hospital admissions that were both acute (i.e. non-elective) and occurred 30 days or less after the patient's most recent inpatient discharge were considered unplanned readmissions. In line with other studies (for example, [29]), such admissions were not required to be for the same or related condition, nor were they required to be at the same hospital.

2.2.2. 30-day mortality

Admissions during the years 2001–2007 were linked via an encrypted version of the patient's national health index (NHI) number to mortality records for those years [30], obtained from the MOH's Mortality collection (note, at the time of the study, mortality data were not available for 2008–2009). In keeping with other studies (for example, [31]), any admission that preceded the patient's death (from any cause) by 30 days or less was considered a 30-day mortality admission.

To calculate case-mix adjusted rates of each of the indicators above, predicted proportions of each indicator were calculated for each hospital by conducting separate admission-level logistic regression models for each hospital, with the following patient factors entered as covariates:

(i) sex (44% of inpatient admissions were male);

(ii) age at admission, coded in five-yearly blocks from 0 to 4 to 85+;

(iii) ethnicity, mutually exclusively categorized as New Zealand European/Pakeha (68%), New Zealand Māori (16%), Pacific People (e.g., Samoan, Tongan, Cook Island Māori, 7%), Asian (e.g., Indian, Chinese, 4%) and Other/not stated (e.g., Middle Eastern, African, not stated, 4%);

(iv) deprivation, coded according to the New Zealand Deprivation Index (NZDep), which classifies patients into deciles of deprivation based on census information regarding the socio-economic characteristics of their area of residence, irrespective of the hospital to which they were admitted [32]. For analysis purposes we formed five groups by combining adjacent deciles: deciles 1–2 (least deprived, 14%), deciles 3–4 (16%), deciles 5–6 (20%), deciles 7–8 (24%), and deciles 9–10 (most deprived, 27%);

(v) rurality (of patient area of residence), coded as urban (urban areas and their satellites, 75%) or rural (rural areas and small towns, 25%), according to Statistics New Zealand criteria [33].

(vi) admission year (2001–2009);

(vii) primary diagnosis, coded as major diagnostic category; and

(viii) clinical comorbidities, coded as the presence or absence of each of the 30 Elixhauser comorbidities [34].

It should be noted that this method of case-mix adjustment differs from the approach undertaken for efficiency measures described in Section 2.1 above, since it uses

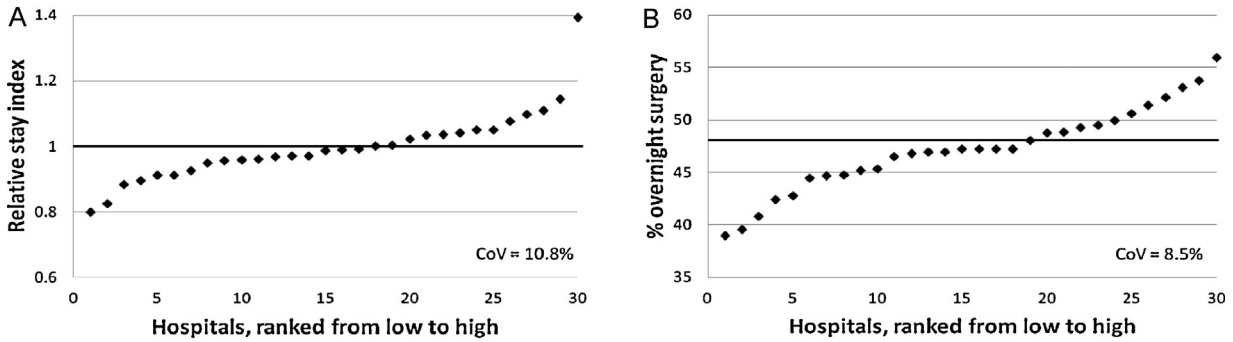

Fig. 1. Comparison of New Zealand hospitals 2001–2009 on measures of efficiency: (A) relative stay index, and (B) relative day stay surgery. CoV = coefficient of variation.

statistical adjustment rather than standardisation. This means that more factors can be adjusted for.

2.3. Equity

2.3.1. Ethnic equity

Ethnic equity was assessed for each hospital for the four efficiency and effectiveness indicators described above. To this end, scores for each indicator were calculated for each ethnic group (New Zealand European, Māori, Pacific, Asian, Other) within each hospital. For the efficiency indicators, scores were calculated by assessing (i) the relative stay index for each ethnic group within each hospital, relative to the expected length of stay for each hospital; and (ii) the standardized day surgery rate for each ethnic group within each hospital, and then expressed as a percentage of the average standardized day surgery rate across ethnic groups within each hospital. For the effectiveness indicators, adjusted rates of 30 day mortality and unplanned readmissions for each ethnic group in each hospital were calculated using the logistic regression models described in Section 2.2 above. These were then divided by the overall rate for each hospital to give an indication of the performance for each ethnic group on each indicator relative to the overall hospital performance for each indicator. An indicator of ethnic equity for each of the four indicators for each hospital was calculated as the coefficient of variation across ethnic groups.

2.3.2. Socio-economic equity

Socio-economic equity was assessed in relation to the five deprivation groups described above, and was assessed in the same way as for ethnic equity, with socio-economic groups replacing ethnic groups in calculations.

We used rankings of hospitals on each indicator rather than actual scores to compare their performance, and the coefficient of variation – the mean divided by the standard deviation – to assess variability in performance across hospitals.

3. Results

We present descriptive results for the efficiency and effectiveness measures in Figs. 1 and 2. In each case values for hospitals are ranked. Using the coefficient of variation as our benchmark, variability in performance seemed to be greater for the measures in Fig. 2 (12.2% and 24.1% versus 10.8% and 8.5%).

In Figs. 3 and 4 variation is displayed for the four performance measures by ethnic group and area deprivation respectively. Values for the coefficient of variation are much greater on these equity assessments, suggesting that the extent to which patient outcomes vary by social group may differ markedly between hospitals.

Finally, in Table 1 trends for these measures of spread are displayed. While variability for the efficiency indicators

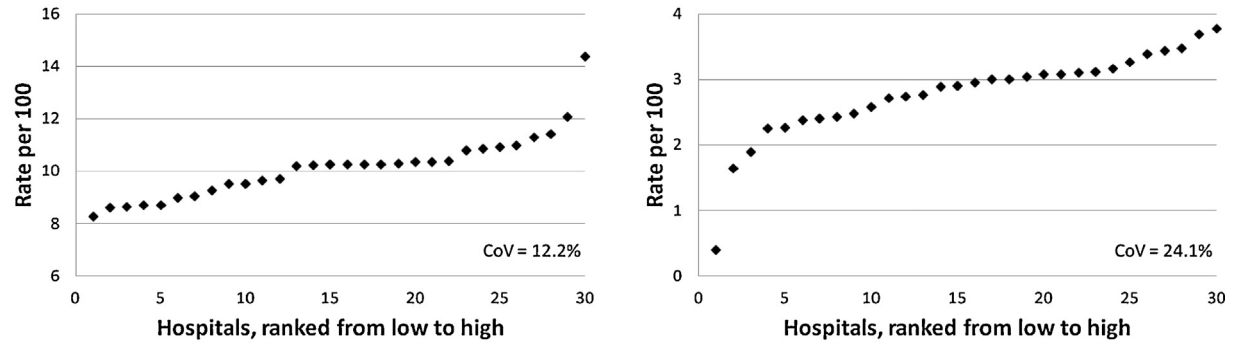

Fig. 2. Comparison of New Zealand hospitals 2001–2009 on measures of effectiveness: (A) unplanned readmissions within 30 days, and (B) mortality within 30 days of admission. CoV = coefficient of variation.

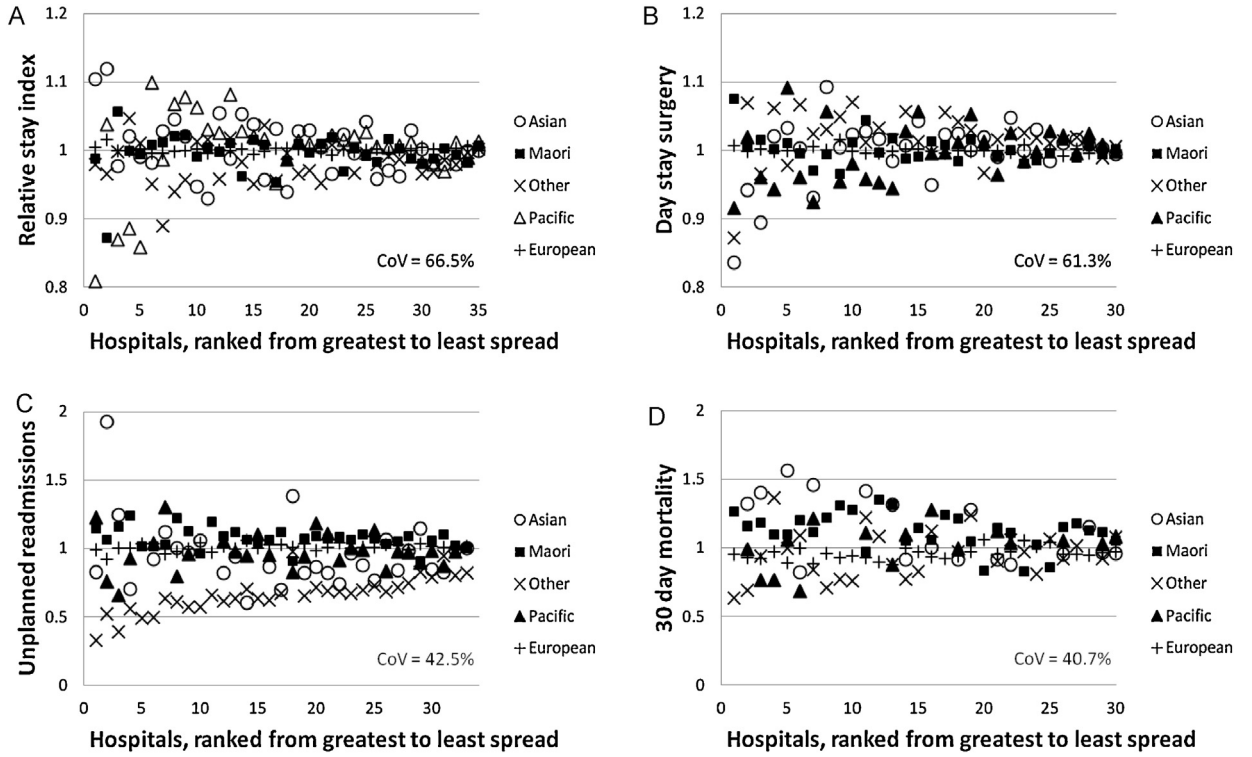

Fig. 3. Comparison of New Zealand hospitals 2001–2009 on measures of ethnic equity for: (A) relative stay index, (B) relative day stay surgery, (C) unplanned readmissions within 30 days, and (D) mortality within 30 days of admission. Rates of indicators for patients groups by ethnicity are shown. All data have been standardised so that the mean rate (across ethnicity) of each indicator in each hospital is 1. CoV = coefficient of variation.

Table 1
Coefficients of variation between hospitals for relative stay index, day stay surgery rate, unplanned readmissions and 30-day mortality from 2002–2003 to 2008–2009.

	2002–2003	2004–2005	2006–2007	2008–2009
Relative stay index ($N = 35$)	17.2	11.8	12.3	12.1
Day stay surgery rate ($N = 30$)	12.9	13.5	10.0	10.0
Readmissions ($N = 10$)	10.6	13.5	15.1	12.0
30-day mortality ($N = 10$)	17.4	16.0	18.2	–
Ethnic equity				
Relative stay index	65.4	84.4	97.3	76.0
Day stay surgery rate	78.0	97.9	129.1	74.2
Readmissions	49.7	40.8	69.8	35.5
30-day mortality	68.4	54.0	63.1	–
Socio-economic equity				
Relative stay index	88.3	76.5	119.2	92.6
Day stay surgery rate	144.0	83.0	85.1	77.2
Readmissions	45.3	50.3	70.3	71.5
30-day mortality	62.4	79.3	111.5	–

Table 2
Spearman rank correlations for each performance measure ($N = 30$ hospitals).

	Relative stay	Day-stay	Unplanned readmission	30-day mortality	Ethnic equity	SES equity
Relative stay	1	0.20	0.00	−0.20	0.11	−0.22
Day-stay		1	0.14	−0.13	−0.29	−0.21
Unplanned readmission			1	−0.21	−0.18	−0.27
30-day mortality				1	0.32	0.31
Ethnic equity					1	0.42*
SES equity						1

* $p < 0.05$.

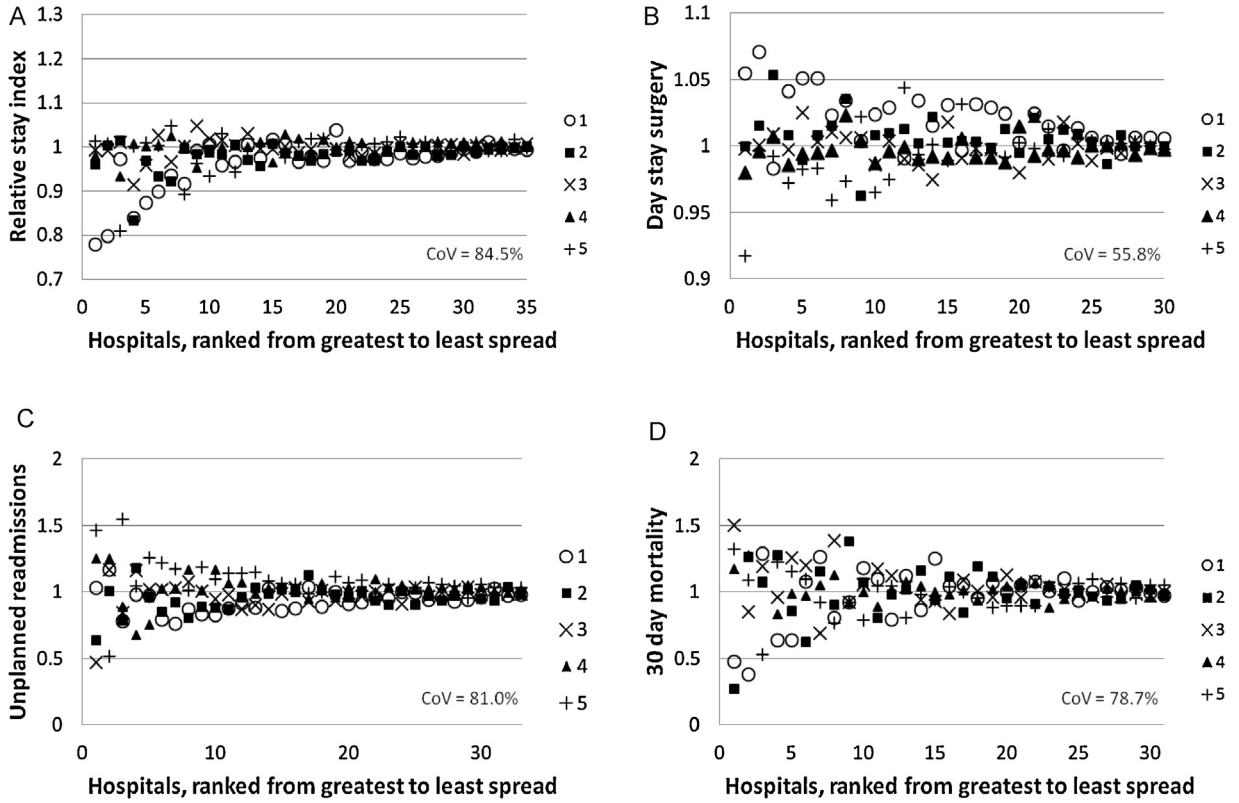

Fig. 4. Comparison of New Zealand hospitals 2001–2009 on measures of socio-economic equity for: (A) relative stay index, (B) relative day stay surgery, (C) unplanned readmissions within 30 days, and (D) mortality within 30 days of admission. Rates of indicators for patients grouped by quintiles of neighbourhood deprivation are shown, ranging from least deprived (quintile = 1) to most deprived (quintile = 5). All data have been standardised so that the mean rate (across deprivation groups) of each indicator in each hospital is 1. CoV = coefficient of variation.

declined somewhat over the period, for the effectiveness indicators variability was more or less flat, and for equity the picture was mixed (some increasing, some declining).

In Tables 2 and 3 the rankings of the hospitals under consideration are compared across the three dimensions. Table 2 presents a set of correlations based on these rankings. Correlations between the variables that are constituent of the three dimensions are positive, but weak to moderate (.20, .21, .41 respectively).

Table 3 presents the "top 5" and "bottom 5" hospitals, as ranked across all performance measures, with their constituent, dimension-specific rankings in the body of the table. As can be seen, there is little consistency across dimensions. Thus, the hospital with the top overall rank is ranked 11th on equity, and the second-ranked is averaged at 14.5 for efficiency. Similarly, the hospitals ranked 27th and 29th have first-place rankings within the effectiveness dimension.

Table 3
Comparisons of ranks for "top 5" and "bottom 5" performing hospitals (1 = best performing hospital, 30 = worst performing hospital). [Bold figures are overall ranks; figures in brackets are ranks on constituent indicators].

Overall Hospital Rank	Efficiency		Effectiveness		Equity		Average rank score
	Relative stay	Day-stay	Readm	30-day Mortality	Ethnic	Socio-economic	
1	**6** (10, 2)		**4.5** (7, 2)		**11** (2, 20)		**7.17**
2	**14.5** (8, 21)		**8** (13, 3)		**5.5** (10,1)		**9.33**
3	**9** (4, 14)		**11.5** (8, 15)		**11** (12, 10)		**10.50**
4	**18** (9, 27)		**10** (15, 5)		**4.5** (6, 3)		**10.83**
5	**5.5** (3, 8)		**19.5** (14, 25)		**11** (18, 4)		**12.00**
6–25							
26	**17.5** (24, 11)		**24.5** (25, 24)		**14.5** (22, 7)		**18.83**
27	**25.5** (29, 22)		**11** (21, 1)		**20.5** (28, 13)		**19.00**
28	**14.5** (11, 18)		**19.5** (22, 17)		**28.5** (29, 28)		**20.83**
29	**22** (15, 29)		**14.5** (1, 28)		**26.5** (23, 30)		**21.00**
30	**25** (22, 28)		**19.5** (9, 30)		**18.5** (12, 25)		**21.00**

4. Discussion

There is international interest in the assessment of hospital performance [10]. While traditionally the concern has been with the efficiency and resource use of such facilities [15], greater emphasis has more recently been also placed on the quality, safety and appropriateness of care [17], as well as its equitable delivery [35]. A difficulty has been in deriving measures that can be easily compiled and compared cross-nationally [36], although New Zealand has attempted work in this area through the benchmarking movement [37].

4.1. Findings

We have been able to apply commonly-used indicators of hospital performance based on routinely-available administrative data to assess publicly-funded facilities in New Zealand over a period of nearly a decade. In addition to representative measures of performance in, respectively, the broad domains of efficiency and effectiveness, we have also derived indicators of impact of these measures on the equitable delivery of care for patients of varying ethnicity and socio-economic status. This operationalisation of equity – in effect, equality of treatment – is close to that advocated by the Institute of Medicine in its landmark report on racial and ethnic disparities in health care [38].

However, while our results are plausible at the indicator level, the correlation of indicators within dimensions is weak, and there is limited congruence in the ranking of hospitals across the three dimensions. Nevertheless, these results are not inconsistent with previous research. For example, while the lack of correlation among out indicators is unsettling, there are precedents in the literature for just this kind of outcome (for example, Stausberg et al. [39]). This is also the case with the lack of congruence across dimensions at the facility level identified in our results; this has been reported by other investigators (for example, Shwarz et al. [40]).

4.2. Implications

Hospitals remain a substantial component of any modern health service delivery system, and yet in most respects the role of the hospital sector is not adequately captured in current international health performance systems. Because of the difficulties in achieving comparable measures across countries, the number of such studies remains disappointingly small [10]. Attempting to gain assessment across a number of specific dimensions compounds the difficulty of achieving international comparability, is data intensive, and can be controversial [3].

The use of the "balanced scorecard" concept – already applied at the health system level in New Zealand [23] – allows us to consider not just the efficiency and productivity of hospitals (a perennial concern of decision-makers), but also the quality of care provided, and even the degree to which different social groups in the population are equally treated for similar conditions.

While there is an obvious parallel between the "balanced scorecard" concept as applied at health system [23] and hospital levels (for example, Yuen and Nga [22]) respectively, the distinct policy levers and lines of accountability for these two levels (policy-making versus management), as well as the different requirements of data aggregation, suggest that these lines of work are at this stage best left distinct. Thus, applied at the hospital level, the "scorecard" approach allows one to consider whether facilities – rather than the health system – are optimising performance across more than one dimension simultaneously, rather than relying on implicit or explicit trade-offs to achieve "excellence" in one area to the possible exclusion of others.

Our study reveals limited consistency in performance across dimensions. Does this matter? At one level, the "balanced scorecard" concept is a normative and aspirational goal. In these terms, our finding is of limited operational significance. However, if we were to transfer these findings to a real-world setting where "balance" was set as a goal of performance management, perversities and dysfunctions would almost certainly emerge in attempting to achieve such a goal [16]. The concept is therefore probably best treated as a heuristic device in a developing field.

We have resorted to a broad, encompassing typology of efficiency, effectiveness, and equity – the E^3 of our title – to capture the essential elements of a multi-dimensional framework for the cross-national performance assessment of hospitals, and we have used facility rankings (rather than absolute scores). These two features, while suffering some disadvantages (the risk of over-simplification and imprecision), may make the task of international comparison easier. At the very least, they complement current approaches that aspire to very precise indicator comparison across jurisdictions (for example, Linna et al. [41]). Our approach does not require metrics that are comparable in every respect. Instead, by using broadly similar and accepted measures, we have sought to fashion a metric using rank-ordering, and emphasise the balance across dimensions as a feature of comparison [20] [22] rather than seeking to achieve directly commensurable metrics for each dimension in turn or on one-to-one comparison of indicators. A further refinement would be to use data reduction techniques in comparative work of this kind and treat the dimensions as latent factors tapped by multiple indicators [42].

Our results show that use of a multi-dimensional scorecard scheme does not necessarily make the task of performance assessment any easier since it introduces criteria with differing public valences – for example, efficiency versus quality [43]. Furthermore, our data suggest that there may be little consistency across these dimensions, thus adding another element of complexity into the task of evaluating overall hospital performance [44]. Nevertheless such assessments, inconsistent as they might be across dimensions, have heuristic value and provide a more rounded and holistic picture of performance.

4.3. Strengths and limitations

Our study is possibly one of the first to consider hospital performance simultaneously across three dimensions of efficiency, effectiveness and equity; while any two of these

dimensions may be considered together (for example, Arocena and Garcia-Pardo [13], Cooper et al. [14], Trivedi and Grebla [35]), it is rare for all three to be evaluated simultaneously as a more holistic assessment [20].

The availability in New Zealand of a centralised resource of routinely-collected hospital data is a particular asset. This has previously been used in international benchmarking exercises [37]. The presence in that resource of information on ethnic affiliation and proxy socio-economic position, together with a linkage to the death register (in calculating post-admission mortality), are further advantages.

There are several weaknesses in this study. First, for reasons of parsimony (and perhaps euphony as well), we deployed a conventional health services research typology of efficiency, effectiveness and equity [7] when other dimensions such as responsiveness have since been introduced to the literature [3]. Second, we did not identify sub-dimensions in our broad scheme – such as technical and allocative efficiency or the multiple aspects of equity [1].

Thirdly, in keeping with the pragmatic and illustrative thrust of the study, we only used a limited range of indicators. It is possible that these were not well selected as representative of the field and that, as discussed above, if we had used a greater number this would have allowed us to construct composite measures of our dimensions. Fourthly, we did not include private facilities. However, it should be noted that these account for a relatively small proportion of hospital admissions and are greatly restricted in scope of practice [23].

Finally, there are deficiencies in our facility data set. We excluded smaller and specialist hospitals, and we did not break down our results by hospital sector (such as tertiary, teaching), mainly because of the limited number of facilities in our sample. Also, the small number of facilities and a short period of assessment restricted the study's generalizability and statistical potential (for example, in creating composite measures).

5. Conclusion

We have conducted an initial analysis to test the feasibility of applying commonly-available indicators of hospital performance in a "balanced scorecard" assessment. We have also used facility rankings to achieve a degree of comparability across otherwise contrasting metrics, which may provide potential for cross-national comparison (for example, how hospitals in different jurisdictions perform across dimensions). Our results suggest that there is little consistency in facility ranking across the three dimensions of interest, for public hospitals in New Zealand using these data over the period 2001–2009. Further work is required to develop frameworks and metrics for the balanced evaluation of hospital performance, particularly at the cross-national level.

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