Complexity, Tertiariness and Healthcare: Unresolved Issues of Reimbursement and Incentives

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Although "complexity" in health care is commonly associated with "tertiary" hospitals in many countries, there is no accepted definition of tertiariness or agreement on structural and funding arrangements. This paper attempts a conceptual analysis of complexity in tertiary hospitals in terms of clinical views, capability requirements and process-orientations. The main insight is that we need a demand- and process based concept of tertiariness because a supply-side concept is not operational. The paper also develops some ideas what such a demand-based concept would look like.

Das Konzept der Komplexität in der stationären Versorgung wird oft mit tertiären Kliniken der Maximalversorgung in Verbindung gebracht. Allerdings erfolgt die Definition von tertiären Versorgern meist angebotsbasiert (Anzahl Betten/Fachabteilungen, diagnostische Möglichkeiten) und zudem international nicht einheitlich. Der Beitrag unternimmt den Versuch einer konzeptuellen Analyse von Komplexität in Kliniken aus Sicht der Medizin, der bereitgestellten Ressourcen sowie der Prozessorientierung. Wichtigste Erkenntnis ist die Notwendigkeit einer nachfrageorientierten Konzeption von Komplexität, da ein rein angebotsorientiertes Konzept nicht operational ist. Die Autoren zeigen ferner anhand von Beispielen wie ein solches nachfrageorientiertes Konzept aussehen könnte.

1. Complexity, Tertiariness and Healthcare: Unresolved Issues of Reimbursement and Incentives

Product complexity has long been recognised as a cost driver in the management accounting literature, particularly in activity based costing (*Miller* and *Vollman* 1985; *Shank* and *Govindarajan* 1992; *Banker et al.* 1995; *Kaplan* and *Anderson* 2004). *Innes* and *Mitchell* (1992) note the "gradual alteration of the nature of production overhead cost to reflect predominantly costs which are influenced by the diversity and complexity of output rather than simply the volume of output."

However, what is meant by *complexity*[1] varies ranging from heterogeneity in processes and technology (*Anderson* 2001; *Anderson* and *Lanen* 2002), "how wide a line of products or services is being offered to customers" (*Shank et al.* 1992), to product mix diversity (*Cooper* 1989) e.g. the inverse learning curve whereby each doubling of variants offered increases overhead costs by approximately 20-30% (*Wildemann* 1990). In many service sectors, complexity is inherent in both the range of service delivery and infrastructural capabilities. The health sector is a case in point where complexity is not only formally recognised but usually funded specifically in recognition of different organisational arrangements. More specifically, breadth (number) of services and intensity of individual services are significant drivers of overhead costs (*MacArthur* and *Stranahan* 1998).

In many countries, complexity in health care is structured around so-called "tertiary" hospitals. It appears, however, that not only is there no universally accepted definition of tertiariness but also no commonality of structural and funding arrangements between different health care systems. Notwithstanding, tertiary hospitals are generally funded at a higher level than secondary hospitals to '*reflect*' the impact of greater complexity on cost and performance. Complexity is thus treated as a major cost driver for tertiary hospitals as well as a significant environmental influence in performance measurement of hospitals (*Rouse* and *Swales* 2006). *Balakrishnan et al.* (1996) estimated that 42 to 50% of hospital operating costs are affected by complexity. Despite its importance, complexity is a grey area with multiple interpretations including levels of severity of individual cases, the type of procedure used, high cost cases, disproportionately high volumes of high severity cases, as well as specialised infrastructural capacity and resource capability.

Complexity remains a significant practical problem despite research efforts in the literature to examine cost variability with varying complexity. We extend research in this area by providing a conceptual analysis of tertiariness that reorganises and reframes the problem from supply and demand side perspectives that are more high level than the published micro focus. The paper makes the following contributions:

- We develop a coherent concept of matching provider capability with patient complexity from a demand perspective;
- Isolated aspects such as costs of teaching and treating severely ill patients have been addressed in the literature before but have not been addressed from a more comprehensive perspective. Our perspective encompasses these and provides an explanation for why tertiary hospitals still provide substantial volumes of secondary patients.
- We provide a model of incentives for secondary and tertiary hospitals around the decision to transfer and provide some preliminary evidence to support this model.

The paper proceeds as follows. In section 2, we provide a brief overview of the relevant literature and evidence from practice. Section 3 uses the overview to develop a conceptual analysis of complexity and tertiariness in terms of clinical views, capability requirements and process-orientations. From this we provide an (albeit simple) model of secondary/tertiary risk in section 4. Using some formal economic arguments, we then analyze the interdependencies between a demand and process oriented concept of tertiariness on the one hand and hospital and regulatory governance structures on the other in section 4. This

1 Complexity can have several meanings ranging from a systems or cybernetic connotation of uncertainty or disorder, to a management accounting context of complicatedness or multiple layers of sophistication.

leads to suggestions for future research to explore the impact of complexity on cost and performance in health care organisation in section 5.

2. Literature overview and a survey of national tertiary definitions and models

A look at the extant literature on the complexity question in health shows a mixed picture. Specifically, from an accounting or economics perspective, there is some work that addresses the complexity issue (see *Eldenberg* and *Krishnan* 2007) but this research does not address measures of complexity directly or tertiary versus secondary distinctions. Broadly speaking, the complexity issue has been addressed in three different but related strands of literature. The economics literature on the design of optimal reimbursement systems for hospitals argues that better informed hospitals can better assess a given patient's expected treatment costs than payors. But reimbursement regimes using high-powered incentives such as fixed price per case based on national average costs, may tempt hospitals to discriminate amongst patients and disproportionately transfer complex cases to tertiary centres (*Ellis/McGuire* 1990, 1993, 1996; *Ellis,* 1998). Here complex cases are equated with high cost cases and tertiary hospitals are viewed as hospitals of last resort that are put at a disadvantage by constantly treating the upper tail of the cost distribution and thus by definition incur losses under an average cost per case reimbursement regime.

Another literature tries to measure complexity as a hospital's case mix (Diagnosis Related Groups or DRGs), i.e. what patients it treats and how severely-ill these patients are. It is therefore mainly concerned with developing adequate performance measures to describe what a particular hospital does and how this differs from other similar or different hospitals (*Hornbrook* 1982a, 1982b). This literature is characterized by two major findings. One is the high diversity of case mix concepts used internationally, a point we argue still persists today. Secondly, *Wiley* (1992) has pointed out the crucial link between reimbursement reforms on the one hand and the adequacy of case mix measurement.

A third literature has explored how "tertiary hospitals", mostly interpreted as university medical centres, differ from 'normal' hospitals in terms of teaching, research, case-mix and objectives (*Iezzoni et al.* 1990; *Zimmerman et al.* 1993). This is obviously of high relevance for the often heard argument that tertiary care is '*different*' and should therefore be reimbursed differently (see for instance for Switzerland *Widmer et al.* 2015 and for Germany, *Albrecht et al.* 2013). In this context we argue that "*being different*" needs to be much more rigorously analyzed and rendered operational than has been the case up to now.

From an accounting perspective, there is the crucial relation between severity of illness and the resulting treatment costs. Here most evidence is found in health economics and medical studies that provide cost analyses.[2] *Kalish et al.* (1995) present evidence that U.S. hospital charges for major surgical patients with complications exceed those for patients without complications by 96,6%. *Callaghan et al.* (2003) find that coronary bypass graft surgery patients with renal problems have direct costs on average 42% higher than those without. *Burton et al.* (1999) have documented that obese patients' medical treatment costs exceed those for patients of normal weight by around 50%. *Baldwin et al.* (2003)

2 *Graves et al.* (2002), have pointed out that many of these studies leave much to be desired regarding the treatment and computation of relevant cost.

have analyzed 47 kidney operations performed on high risk patients (ASA[3] score 3 or 4) between 1999 and 2001. Severely-ill patients with ASA scores of 3 and 4 had higher lengths of stay (LOS) and treatment costs.[4] *Ernst* and *Szczesny* (2006) analysed potential cost savings for a German hospital that reduced the percentage of more severely-ill ASA 3 and 4 patients undergoing elective surgery, while holding constant capacity (measured by total minutes in the operating room). Using a simulation, potential cost savings for physician and nursing in the OR, ICU and ward were 4,8% of total costs or 1,8% of total hospital costs. These findings indicate a relationship between complexity/severity with cost and show that a more systematic approach is needed if costs are to be better managed.

In terms of tertiariness, a hospital can be viewed from two perspectives. From a supply perspective, a hospital could be classified as tertiary if it provides a tertiary capability i.e. they are a specialized facility with specialized equipment, medical and nursing staff.[5] Sometimes, a hospital may argue for a tertiary classification irrespective of whether (significant) demand for their specialised services actually exists. There are some obvious difficulties with this view from a central authority funding (and planning) perspective. However, it must be noted that tertiary capability has to be created before it can be provided but there is then a risk that tertiary services are then provided simply because the capabilities were created in the first place.

From a demand perspective, a hospital may be classified as tertiary according to the work it does. For this, tertiary services have to be translated into an operational concept such as “a hospital that provides many Diagnosis Related Groups (DRGs) with high severity scores or requiring special infrastructure like transplants”.[6] Closest to what we have in mind here is work by *Park* and *Shin* (2004) who report that South Korea classifies DRGs into:

- Class A: disease categories requiring treatment in tertiary care hospitals. Criteria include high risk of complications and death, difficult to diagnose, rare cases or procedures, newly developing area, technically difficult, requires a team of physicians, difficult and complicated post-op care, and expensive medical equipment.
- Class B: disease categories that can be treated in either tertiary or non-tertiary care hospitals where the appropriate type of admitting hospital is difficult to determine due to heterogeneity in the disease category.
- Class C: disease categories that should not be treated in tertiary care hospitals because of simplicity of treatment. Criteria include common, well known disease; single morbid condition; low risk of complications and death.

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3 The ASA (American Society of Anesthetists) Classification of Physical Status grades patients in relation to their physical state and has been shown to correlate with surgical morbidity and mortality as well as treatment costs.

4 In a recent study *Chung et al.* (2006) obtain similar results for minimal-invasive cholecystectomies at two Taiwanese hospitals.

5 This is similar to the quality concept in medicine first developed by *Donabedian (1966)*. He distinguishes between structural quality (what do we need to do it?), process quality (how do we do it?) and outcome quality (did we achieve our objectives?). The supply side view of tertiariness is obviously closely linked to structural quality.

6 Diagnosis Related Groups are a patient classification system that groups patients based on homogenous resource use. Modern versions distinguish between different levels of severity within a given DRG. The DRG system as well as the Australian AN-DRG are derivatives of the Yale Cost Model which established the basis for the development of DRG prospective payment systems.

The authors found significant statistical relationships between input structural variables and educational activity variables with case complexity i.e. tertiary care hospitals have resource intensive care, an expensive input structure and high levels of research and education.

From a funding (and management control) perspective, this approach focusing on products and demand is more closely aligned with commercial organisations and management models (*Samuel et al.* 2005). From a cost management perspective, a product-oriented view lends itself to better cost containment efforts and process improvement than the organisation supply side perspective. While there is some consensus on product definitions, the multi-product nature of hospitals is such that differences in 'product line' and practice patterns complicate and can inhibit understanding cost variations among institutions (see *Ellwood* 1996). Further complicating this is the appropriate number of 'authorised' DRGs. While health care providers would like to expand product categories to cover finer grained patient distinctions, funders/health insurers worry about a proliferation of product definitions resulting in sky-rocketing administration and maintenance costs and increased potential for gaming by providers (e.g. upcoding, see Simborg 1986).

The German DRG-system has experienced severe problems that are germane to the research objectives of the present paper. Based on "same price for the same service", the G-DRG prices do not take hospital hierarchy into account, e.g. a maximal care center and a basic care hospital receive the same amount for a given DRG. For Munich University hospital, *Billing et al.* (2004) and *Billing* (2005) have estimated a potential deficit of € 23 million, finding that five percent of patients with extreme LOS due to severity, account for 57% of this deficit. Of this, those DRGs with the highest complexity and comorbidity determined severity levels, accounted for € 16 million. Similar results were reported from other University Medical Centres and recent evidence by Albrecht et al. (2013) suggests that the problem persists.

Furthermore and pertinent to the present paper is the fact that heart vascular DRGs account for deficits of € 6 million. Since these DRGs are often also provided by both standard and special care hospitals, this suggests that these types of DRGs are similar to *Park* and *Shin's* (2006) class B category. We call these "hybrids" where cases with low severity are financially lucrative for lower level hospitals but the same cases with high severity end up at maximum care facilities where they will be *a forteriori* underfunded because DRG prices reimburse average national costs per DRG.

To complicate this further, *Linczak* (2006) shows for German university medical centres that patient cases with complications lead to high deficits at the treating institution, but the deficit per case will be roughly twice as large if these patients were originally treated at a different hospital (secondary) and later transferred to the maximal care facility. Clearly, this offers scope for cost savings without compromising quality if these cases could have been identified *ex ante* using some impartial and clearly-defined complexity/severity measure, and transferred immediately.

As the paper by Widmer (2016) in this issue shows, a similar situation seems to be developing for Swiss university hospitals since Switzerland has adopted a DRG system in 2012.

Many countries attempt to fund tertiary capability separately from secondary hospitals. The New Zealand health system has used Data Envelopment Analysis (DEA) to estimate the level of efficient expenditure for the hospital sector as a basis for a national pricing framework around DRGs and other non-inpatient services (*Rouse* and *Swales* 2006). Volumes adjusted by case weights were outputs for the production model and the proxy used to measure tertiariness was the volume of transfers to those hospitals providing a high level of services for complex cases. The tertiary funding pool was then based on this tertiary proxy. NZ still uses a separate tertiary funding pool but this is now based on a DRG cost model.

The importance of managing complexity with appropriate organisation structures was underscored by the 2006 acquisition of two previously state-owned German maximal care facilities by a private, publicly traded hospital chain which planned to build a health network consisting of outpatient facilities, basic care hospitals and maximum care hospitals (*Mueller, von der Gruen* 2006). It believed there were significant cost differences between basic care (secondary) patients and tertiary care patients. Conventionally, most tertiary hospitals provide care for both secondary and tertiary patients with growing beliefs (and some limited evidence) that secondary patients are both "over-treated and wrongly treated at tertiary hospitals" (*ibid*). Somewhat surprisingly, this project has proved a spectacular failure (*Albrecht et al.* 2013) despite the above potentials. Reasons cited were the unwillingness of academic medical staff to change treatment and practice pattern under the new regime. According to anecdotal evidence they could do this with impunity because the new organization lacked a convincing model for the division of labour between the tertiary centres and the lower level hospitals.

In summary, many countries[7] recognise differences in service provision organised around distinctions between secondary and tertiariness. Tertiary capability is often manifested in teaching hospitals and areas of critical mass. These countries have rules around tertiary provision to (i) ensure adequate provision and (ii) prevent unsupported and unneeded proliferation. However, several countries have also incorporated a demand perspective by identifying "tertiary" DRGs (e.g. Canada and Korea, German DRG severity splits, special DRGs like transplants) as a refinement to categorising hospitals into secondary and tertiary organizations. It is noteworthy, however, that no single country uses a tertiariness concept that is entirely demand-oriented. It is also noteworthy that tertiariness remains an issue in health management practice.

3. Conceptual analysis of tertiariness

Complexity as already mentioned is not an easy term to define. While the ABC literature takes a product view, it may be informative to start with a general systems perspective. "The very best way to characterize a complex system is by the states or conditions it can take on." (*Batty* and *Torrens* 2005). Thus, a system's complexity can be inferred by a number of states or conditions (variety) which would encompass not only product offerings but also organisational structure and processes. Given that tertiary hospitals offer greater variability both in terms of product and processes, they should display high variety relative to secondary hospitals.

Since the inception of the Yale cost model in the 1970's (*Fetter et al.* 1976), increasing efforts have been directed towards tracking hospital activities and resource consumption mapped onto a DRG classification model (*Fetter et al.* 1991). While approaches vary,

7 This is evidenced by an international survey of tertiariness commissioned by the NZ Ministry of Health (*Meridien* 2005). A copy of the survey may be obtained from the authors.

practically all trim extreme values (e.g. length of stay longer than (say) 18 days or less than one day) as well as relying extensively on *averaging* identified costs of resource consumption when calculating the cost weight for a DRG. While reliance on averages and a relevant range is a common (management accounting) approach given assumptions of homogeneity, funding problems can arise with significant variability of resource consumption within a DRG. It is possible, however, to refine DRG cost weights using measures of severity *within* a DRG.

In health, morbidity refers to the state of a disease i.e. its degree or severity. Complication /co-morbidity (CC) levels are a result of an evaluation of all coded secondary diagnoses and can provide four or five levels within each DRG depending on whether it is medical or surgical. CC codes are defined as additional diagnoses that are likely to result in significantly greater resource consumption. The levels are: Level 0 (no secondary diagnosis that is CC); 1 (at least one secondary diagnosis that is a minor CC); 2 (at least one secondary diagnosis that is a moderate CC); 3 (at least one secondary diagnosis that is a major CC); 4 (at least one secondary diagnosis that is a catastrophic CC – surgical only).

The assessment of CC levels is not without its problems. There is a view that a teaching hospital assesses a patient as having a higher potential morbidity than a non-teaching hospital. Two reasons suggested for this[8] are first, the concerns of students and trainees of not identifying co-morbidities or considering possible rarer diagnostic alternatives; second, tertiary hospital consultants are trained to identify or consider the possibility of rarer alternatives and cannot afford the risk to their reputation of a missed diagnosis. A different style of clinical care that is more holistic and more integrated is therefore claimed for these more complex hospitals. There may also exist medical and/or economic reasons for this more comprehensive approach towards a patient. Specific diagnostic and/or therapeutic assets only available to a maximum care centre (e.g., PET-scanners), often invoke an "it's there, let's use it mentality". There may be economic incentives to place patients into more highly-reimbursed severity-related DRGs. The reason is that additional diagnostics might reveal co-morbidities or even trigger procedures that cause the patient to be placed into entirely different DRGs.[9] Also, tertiary centres commonly tend to employ the most qualified physician and nursing staff who, apart from costing more, might be more apt to spot additional medical problems.

Notwithstanding, CC levels have the potential to better fine-tune funding allocations. *Figure 1* depicts two DRGS with the same mean severity but DRG1 has low variability while DRG2 has high variability of severity. It is likely that the cost weight for DRG1 is a more reasonable estimate of relative cost than for DRG2 whose average cost weight can be seriously wrong for a particular hospital provider.

We believe it is useful to draw a distinction between severity and complexity. Severity is aligned with patient condition and co-morbidities and is consequently patient centric. In contrast, complexity reflects the organization's response to patient severity and can encompass other aspects other than the patient specifically e.g. resource capabilities, hospital acquired infections, hospital protocols.

8 Confidential submission to the NZ Health Funding Authority 2000.

9 *McClellan* (1997) has pointed out that many DRGs are procedure rather than diagnosis based. This is a problem because diagnoses are (arguably) objective, whereas there is a lot of physician discretion whether or not a procedure is appropriate.

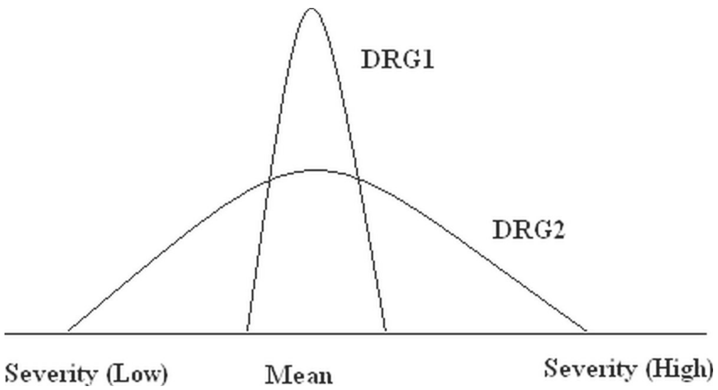

Figure 1: Differences in severity variability between two DRGs

As the number of possible states increases with higher values of PCCL for a DRG, we can say that complexity (in terms of response activity) is likely to increase with higher PCCL levels.[10] It should also be noted that some procedures by their very nature are complex but these are captured by the DRG cost weight (and do not have CCLs assigned to them). Complexity therefore relates to (a) DRGs that by their nature or procedure are complex (i.e. liver transplants) and (b) DRGs that i) display significant variability of PCCLs ii) have high PCCL values and iii) already consume significant resources as indicated by their cost weights.

Some countries have classified DRGs into tertiary/non-tertiary along complex/noncomplex distinctions. An example is the DRG classes A, B and C in South Korea described by *Park* and *Shin* (2004). For many countries service delivery is not so prescriptive and 'Class A' DRGs might be provided by both tertiary and secondary hospitals. Notwithstanding, there will be some DRGs that can only be provided by particular (tertiary) hospitals either because of resource capability or central state funding requirements. This would lead to a higher level of case mix complexity for tertiary hospitals. For DRGs within Class B severity can range from low to high and once severity levels exceed some critical point, they can become *hybrid* complex DRGs.[11]

Consequently we provide the following classification of DRGs:

- Tertiary
  - Only certain hospitals can provide these due to specificity of resource requirements or prescription by central funding authorities
  - DRGs that have high levels of severity *and* are provided mainly or solely by certain hospitals that are usually regarded as tertiary
- Secondary
  - DRGs with non- specific resource requirements that are funded without prescription by central funding authorities.

10 A study of cardiac and respiratory DRGs by *Hyun* (2011) for 2008 found that PCCL was a positive and statistically significant driver of costs within a DRG.

11 Recall in this context that Germany maximum care facilities claim that apart from the most severely ill, it is these high-cost hybrids that are responsible for a substantial part of their deficits.

In a perfect world where the transfer decision between secondary and tertiary hospitals is made based on expectations about patient resource needs, *figure 2* would describe how the secondary and tertiary complexity product mix should manifest. Using a distinction based on a standard mix, Hospital A would be classified as secondary and hospital B as tertiary.

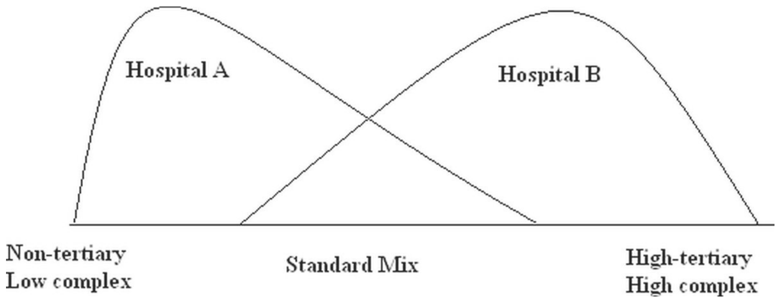

Figure 2: Conceptual model of case mix between secondary (Hospital A) and tertiary (Hospital B) hospitals

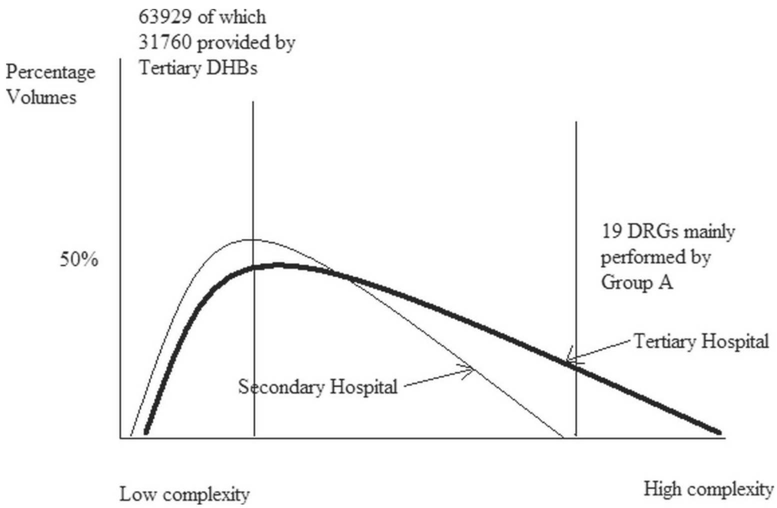

Figure 3: Expected practice model of case mix between secondary and tertiary hospitals

Tertiary hospitals, however, also undertake a significant amount of ‘secondary’ work which is perceived as profitable and helps to cross-subsidise the more complex activities. Therefore the production mix is more likely to be represented by *figure 3* where both tertiary and secondary hospitals perform relatively high volumes at low levels of complexity but the difference between the two hospitals becomes apparent at high levels of complexity.

Therefore, in this model, the higher costs of tertiariness comprise firstly, measurement or mapping problems manifested by variability of severity within a single DRG and secondly, infrastructure costs associated with relatively higher volumes of complex DRGs.

DRGs % provided		Volumes									
by Group A	# of DRGs	Group A	Group B	Group C	Total	Cumulative		Overall	Group A	Group B	Group C
>90%	16,00	6.506,00	394,00	9,00	6.909,00		Average PCCL	1,23	1,33	1,12	1,13
							Average CW PCCL	**3,21**	**5,00**	**1,70**	**1,49**
> 80% <90%	3,00	955,00	168,00	15,00	1.138,00	8.047,00	Average PCCL	1,35	1,32	1,56	1,00
							Average CW PCCL	**2,56**	**3,78**	**1,73**	**1,48**
> 70% < 80%	8,00	6.787,00	1.168,00	1.464,00	9.419,00	17.466,00	Average PCCL	1,11	1,11	1,33	0,92
							Average CW PCCL	**2,58**	**3,66**	**1,82**	**1,54**
> 60% < 70%	6,00	762,00	167,00	205,00	1.134,00	18.600,00	Average PCCL	2,25	2,22	2,56	2,09
							Average CW PCCL	**2,57**	**3,79**	**1,73**	**1,51**
>50% < 60%	5,00	1.569,00	498,00	846,00	2.913,00	21.513,00	Average PCCL	0,76	0,71	0,54	0,99
							Average CW PCCL	**2,47**	**3,65**	**1,64**	**1,48**
<50%	29,00	21.517,00	10.243,00	32.169,00	63.929,00	85.442,00	Average PCCL	1,16	1,22	1,12	1,14
							Average CW PCCL	**2,05**	**2,95**	**1,52**	**1,44**
Totals	67,00	38.096,00	12.638,00	34.708,00	85.442,00		Average PCCL	1,20	1,28	1,13	1,13
							Average CW PCCL	**2,53**	**3,76**	**1,67**	**1,48**

Group A: those DHBs officially viewed as tertiary for cardiac services

Group B: those DHBs not officially viewed as tertiary for cardiac services but tertiary for other services

Group C: those DHBs not officially viewed as tertiary for any services

Table 1: Cardiac DRGs with Severity Levels for Tertiary and Secondary Hospitals

Table 1 reports the results of an analysis[12] of 85.443 cases comprising 67 cardiac DRGs provided by NZ hospitals for the 2006/7 period where the hospitals are classified into three groups: Group A hospitals officially recognised by the central funding organisation as tertiary with respect to cardiac services; Group B hospitals not officially recognised as tertiary for cardiac services but are for other services; and Group C hospitals that are regarded as secondary. The first row shows that 16 of the 67 DRGs are almost entirely provided by Group A hospitals with volumes of 6.506 relative to total volumes of 6.909. There are a few hundred cases provided by Group B and an almost negligible number provided by Group C. The DRGs in this and the next row can be regarded as tertiary since mainly Group A hospitals can provide these. Successive rows show increasing provision by Group C (and Group B) hospitals with over half the volumes of 29 DRGs provided by Group C in the final row.

Columns 9 through 12 report the average PCCL score per row as well as the case weighted PCCL average score. In general the scores for Group A are higher than Groups B and C indicating a higher level of severity and thus complexity. The analysis also revealed considerable variability across DRGs in terms of PCCL scores with some DRGs clustered tightly around the mean and others ranging across the entire PCCL range (0 to 4).

Relating this data to *figure 3* there are 63.929 patient numbers for the 29 DRGs in the lowest level which represent 75% of the total volumes of 85.442. It is noteworthy that the tertiary hospitals (Groups A and B) still provide 31.760 (21.517+10.243) of this lowest group (just under 50%). At the higher levels, secondary hospitals also do just under one-fifth of volumes (846+205+1.464 =2.515) for the three levels above 50%.There are thus incentives for tertiary hospitals to do more secondary work and for secondary hospitals to do more tertiary work than *figure 2* would suggest. Note that the 19 DRGs to the right of *figure 3* are almost entirely the domain of the tertiary hospitals (see the top two levels of *table* 2).

On the basis of this analysis, the following conclusions can be drawn for cardiac DRGs:

1. Tertiary Hospitals treat more severe/complex cases than secondary hospitals.
2. Tertiary hospitals provide a wider scope of services than secondary hospitals.
3. There is considerable variability across severity values among DRGs.
4. Severity levels in terms of PCCL for hybrid DRGs are higher in tertiary than secondary hospitals.

Our analysis shows that non-tertiary hospitals (Group C as well as Group B for this specialty) are providing tertiary DRGs albeit in limited volumes. Although there is an argument for restricting provision to Group A hospitals only (resource and infrastructural capabilities), two major reasons why in practice Group C (and B) hospitals become involved with tertiary work are career and political. Health professionals have career aspirations where progression is often correlated with greater involvement in more complex cases (*Eisenberg* 1986). The lack of an accepted classification for complex/noncomplex DRGs compounded by the hybrid nature of DRGs with high variability of severity can lead to

12 Further details can be found in *Rouse et al.* (2008) and Rouse et al. (2010). Parts of that research was previously published in the New Zealand Medical Journal in Rouse et al. (2010).

inappropriate case mix provision at local hospitals.[13] Political actions dictated by local community demands can also lead to inappropriate provision especially where governing health bodies are locally elected politicians. The risk is not uni-directional. Tertiary hospitals can provide too many low-end, non-complex cases leading to inefficient (costly) delivery. Needs for full utilisation of capacity can squander capability of high-cost, specialised facilities. For instance, there is a clear incentive for hospitals high in the hierarchy to treat 'light' cases because they can use the resulting profits to cross-subsidise any deficits from treating the most severely ill (class A DRGs) and the upper tail of hybrid class B DRGs.

There is a need for further research into whether reimbursement rates for hybrid DRGs adequately cover costs. Evidence from Germany shows that hospitals that mainly treat the upper tail fail to adequately cover cost (*Albrecht et al.* 2013). It is also likely that the cost of complex DRGs is greater in secondary than tertiary hospitals due to economy of scale effects. Conversely, the cost of noncomplex DRGs may be greater in tertiary than secondary hospitals.

We analysed the costs for the 67 cardiac DRGs reported in *table 2* to obtain more insight into these effects. Based on our earlier conclusions where the 19 DRGs in the first two rows are regarded as tertiary, we find that for 46 out of the remaining 48 DRGs where Group A provide less than 80% of the volumes, the mean average cost per DRG for tertiary hospitals exceeds the average cost per DRG for secondary hospitals by an overall average of around 360%. This provides some support for noncomplex DRGs costing more in a tertiary hospital than secondary. We investigated this further using a classification of the same secondary and tertiary DRGs provided by a senior clinician. He classified 40 as secondary with 4 unclassified and the remainder (23) as tertiary.[14] Of the 40, 34 were higher cost in tertiary hospitals than secondary. Of the 16 DRGs classified as tertiary, we find only one is lower in cost in the tertiary hospital group than secondary hospitals. However, this result is distorted by the low number of secondary hospitals providing volumes for these DRGs which makes it difficult to evaluate our first supposition in the previous paragraph. Furthermore, those tertiary DRGs that did have costs recorded for secondary hospitals may have incurred these prior to being transferred to the more specialised facility.

This leads to an alternative perspective of tertiariness which is more supply-side oriented. Providing capacity in resource form is necessary but not sufficient. It is not so much the resources but the way that they are used that leads to a tertiary level of provision. This aligns well with the resource-based view (RBV) of the firm (*Barney* 1991) especially notions of causal ambiguity and historical accident. Tertiary hospitals require high levels of specialised expertise and usually utilise a team approach to patient diagnosis and treatment. Reputations of tertiary hospitals are likely consequences of history and cultural approaches that are imperfectly imitable. The more holistic and integrated approach posited as tertiary is difficult to replicate by other hospitals without a sustained period of investment in processes, systems and culture.

13 Some anecdotal evidence suggests physicians at basic care and intermediate care hospitals (who were usually trained at tertiary centres) perform 'risky' operations on patients that should have been admitted to a tertiary centre.

14 Several of these were provided across all the DHBs in significant volumes which indicates the difficulty of classifying DRGs out of context; an issue recognized by the clinician.

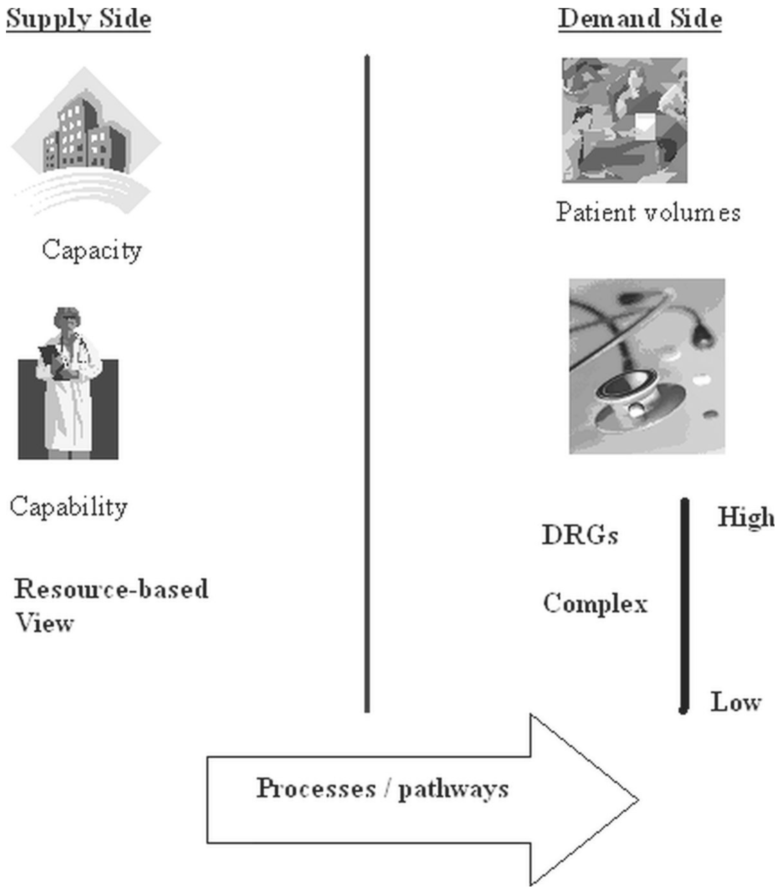

Figure 4: Dual views of hospital provision

The political perspective of investment in tertiary institutions has focused mainly on tangible monuments (buildings) as opposed to processes. Cost-benefit analyses (CBA) work better matching building and equipment costs with values of forecast volumes than with the grey area of costing the development of processes, building teams and related culture. However, research into the intangibles and capabilities in established tertiary hospitals using the RBV approach could help improve CBA and implementation programmes.

These supply and demand perspectives correspond to process or resource-based versus output/outcome-based views portrayed in *figure 4*. On the demand side, patient volumes provide a needs-based view without any adjustment for case-mix complexity. Given a DRG mapping and cost weights, patient volumes can be translated into case-weighted volumes. If DRGs can be classified by complexity then these can be further classified into secondary and tertiary.

On the supply side, physical resources comprise buildings and technology whose capacity determines patient volumes but not necessarily case severity. Capability is required at both secondary and tertiary levels but the skill component becomes critical for provision of tertiary services. This dovetails nicely with RBV where it is the way that resources are used that affects capability and capacity.

There are, however, problems. While buildings, diagnostic advances, therapeutic equipment and qualifications of medical/nursing staff are easy-to-define and "objective", they lack specificity with respect to the target group, tertiary patients. Tertiary centres can lose focus on their real clientele if they need to make a profit on secondary cases in order to provide tertiary medicine. The supply side perspective also provides little assistance in understanding and managing infrastructural costs.

Unfortunately on the demand side, there are considerable opportunities to game the system illustrated by the number of DRGs that continue to be procedure rather than diagnosis based. Consequently, any process oriented definition of tertiariness cannot be disentangled from organizational, governance and incentive issues. Nevertheless, we view this process based approach as the more promising because the supply side approaches' lack of specificity precludes any solution likely to work in reality.

4. A simple formal model of secondary/tertiary risk

As our results indicate, we envisage tertiariness to relate to the range of complexity of patients managed within a hospital. While a hospital may have some tertiary patients, this is not sufficient to be a tertiary hospital since tertiariness has different process and infrastructural arrangements. A hospital that has mainly noncomplex patient volumes should have different capacity and capabilities than a hospital with more complex volumes. If it is possible to agree on DRGs that are tertiary, rules can be constructed specifying secondary or tertiary service provision. Only hospitals that provide the requisite levels of capacity and capability can be described as tertiary.

For hybrid DRGs. we argue there is a critical probability that equates the expected cost in a secondary and tertiary hospital. If we define S_{NC} as non-complex and S_C as complex, we can define P^* as the probability that equates the conditional cost of a non-complex and complex case between a tertiary and non-tertiary hospital. *Table 3* sets out a simple illustration for two hospitals with varying costs under two states of non-complex and complex. In the first state, the secondary hospital processes the patient at lower cost than the tertiary which has a higher level of testing and a more holistic approach. In the second state (complex), the tertiary hospital processes the patient at a lower cost than the secondary. Given these costs, the critical probability $P^* = 66⅔$ percent equates the expected costs between the two hospitals. From a policy perspective, a patient assessed as having a higher probability (say 70%) of non-complications should be admitted to a secondary hospital. If the probability is 50/50 then clearly they should be admitted to a tertiary hospital.

	Cost if Not Complex	Cost if Complex	Expected Cost
Secondary Hospital	\$10	\$100	$10P + 100\ (1\text{-}P)$
Tertiary Hospital	\$20	\$80	$20P + 80\ (1\text{-}P)$
	P	*1-P*	

Table 2: Costs for Secondary and Tertiary Hospital under States Not Complex and Complex

Of course the model is a simple illustration. In reality, complexity is unlikely to be captured by a single variable such as "patient processing cost", requiring other variables such as 24 hour ICU surveillance, extant co-morbidities, etc.

In this context, it is helpful to distinguish between the decision facilitating and the decision influencing role of accounting information developed by *Demski* (1973, 1994). The former interprets a system such as a health care system purely from a decision oriented approach whereas the later explicitly takes asymmetric information, conflict of interest and the resulting possibility of strategic behaviour into account.

In a decision facilitating world, the simple illustrative model we used above can nowadays conceivably be rendered practical by sophisticated so-called predictive modelling and impactibility techniques (*Cousins et al.* 2002; *Curry et al.* 2004; *Lewis* 2010; Freund et al. 2010, 2011, 2012). Using data mining concepts and the increasing availability of integrated "big data" in health care (electronic patient records containing past utilization, hospital episodes and/or complications, tens of thousand of ICD codes and central pharmaceutical numbers, quality data on hospitals etc. etc.), threshold values in the sense of the above probabilities or critical expected treatment costs could be determined and fed into a prescriptive system that states what type of patient is likely to benefit from tertiary care and who should remain in secondary care. For the prediction of avoidable hospital admissions for patients suffering from chronic conditions in German disease management programs (*Freund et al.* 2010, 2011, 2012) these models have consistently outperformed ones based merely on physician expert opinion and could easily be modified for use with the hybrid DRGs discussed in the present paper.

The true implementation problem, however, is likely to occur in the context of a decision influencing world, even if such a prescriptive regime based on PM were available. The reason is that the model raises questions of governance and capacity management. How is the cut-off criterion (in a probability resulting from a multitude of input variables with considerable physician discretion) to be managed to ensure patients are assigned to the appropriate hospital? Given perceived funding incentives for tertiariness, a transfer may not be in the best interest of a secondary hospital. Utilisation of capacity through inappropriate patient mix can be a major cost driver with a high risk of poor outcomes from a mismatch of capability with service delivery. For tertiary hospitals there is the incentive to fill unused capacity with secondary volumes to fund the development of tertiary capabilities which appears to be happening as discussed earlier.

Figure 5 illustrates a formal model in process of development by the authors to illustrate some of the problems involved.

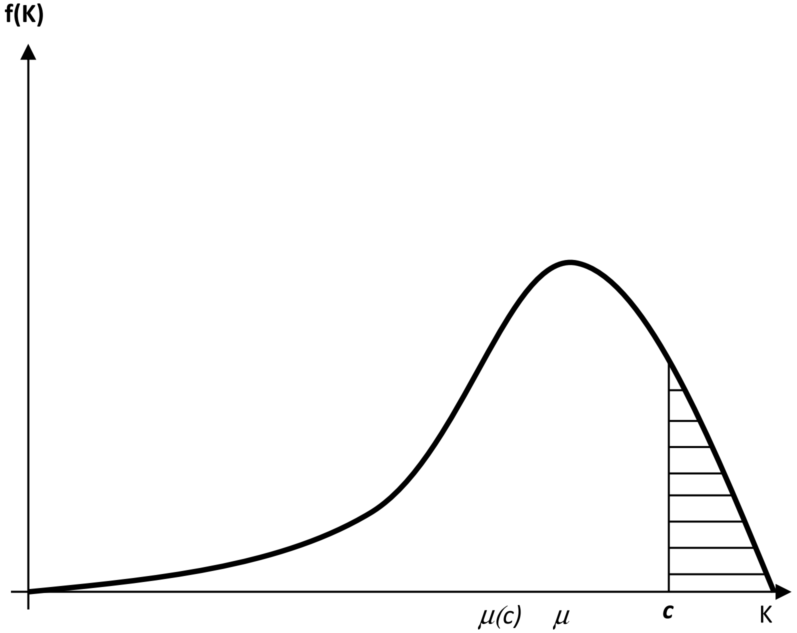

Figure 5: Severity-related cost for a hybrid DRG

The graph shows severity related cost for a hybrid (type B DRG) from the point of view of a secondary hospital. If DRGs reimburse national average costs per case μ, a secondary hospital can make a profit by *endogenously* setting a complexity-level c. This reduces its expected costs to $\mu(c) = E(K|K < c)$. Patients with a score above c are transferred to a tertiary institution where they will cause the case deficit described earlier.

Turning again to *table 2*, clearly Group A patients are more costly and complex at high tertiary levels (average CW PCCL 5) compared with Groups B and C (1,7 and 1,49). Group B have the potential to carry out high tertiary level work because they have this type of capability in other areas but they can also transfer these to Group A if they become too costly (i.e. a score above c). Group B have an incentive to cherry pick as shown by the data where the CW PCCL is closer to Group C (although higher) but well below Group A.

In the context of this paper, the finding implies that any operative concept of tertiariness denoted c^o c^o must take into account that this needs to be reconciled with the c resulting from an economic calculus on the part of the lower level hospital. Ideally, reimbursement incentives for hybrids would have to be set so that $c = c^o$. Ageing populations and medical innovations make this is a daunting task.

A further complication arises if hospitals adopt a portfolio view of DRGs they treat because it is hard for hospitals to withdraw from providing particular DRGs. Instead the withdrawal of entire unprofitable service lines might occur. Applying this concept of complexity to a portfolio view remains an open question.

The above model is general in nature. Apart from the reimbursement regime, the internal incentive and organizational structure plays a crucial role for the endogenous cut-off value *c* (*Pauly* 1974) i.e., how well hospital management succeeds in translating external economic rewards into appropriate internal incentives for medical decision makers. Questions of physician autonomy (salaried vs. staff privileges), financial incentives (bonuses, quality based reimbursement) further complicate a workable concept of process-based tertiariness. Nevertheless, a look at the whole picture allows us to evaluate specific incentive arrangements from a tertiary objective. Incentive schemes that reward low complication rates at secondary hospitals could provide a better matching between severity/complexity. However, this might be detrimental for tertiary care because they provide incentives to avoid tertiary patients.[15]

5. Conclusion

Although a vague concept of tertiariness figures prominently in most health care systems, it lacks a clear and operational definition for preventing severely ill patients being treated at secondary hospitals or light cases being unnecessarily treated at maximal care facilities. We show from our survey that despite the research reported in the literature, there remain unresolved issues around incentives and reimbursement. There has been a growing recognition that a supply oriented tertiary view needs to be supplemented by a demand perspective based around output products (e.g. DRGs). Resources such as elaborate diagnostic capacity, special care wards and highly trained staff lack tertiary specificity. Supply-oriented government or policy definitions of tertiariness lead to investments in buildings and technology that are of limited tertiary specificity and, because these facilities lack specificity, they can be used to treat both tertiary *and* secondary. In fact, tertiary hospitals may depend on these light cases cross-subsidizing severe cases transferred to them.

A demand-oriented approach that focuses on clinical processes, organisational form and bottom-up cost calculations for tertiary cases seems more promising to obtain a workable definition of tertiariness that can cope with issues of hospital governance as well as regulatory (inter hospital), intra-hospital incentive structures. However, this view must be tempered by the fact that capability must be established before demand can be met. Nonetheless, we argue that more focus is needed on the demand perspective.

This research aimed to answer the question "what makes a tertiary hospital different from a secondary one?" We have reported the results from a study using Cardiac DRGs showing differences in PCCL between tertiary and secondary providers which provide an avenue for classifying DRGs as well as hospitals. We have also described how funding variability can arise among DRGs which can be dramatically affected by prospective payment systems based around capitation. Such variability combined with incentives around careers and specific revenue streams can lead to dysfunctionality in decisions to transfer between both secondary and tertiary hospitals.

The resource-based view of the firm suggests research into differences in resource use and configurations across hospitals e.g., do tertiary hospitals employ a holistic approach in their process management and rely on team-work? Are infrastructural arrangements in tertiary hospitals different from secondary? Can differences in capabilities be identified and measured across hospitals?

This leads to resource considerations over whether costs for secondary DRGs are higher in tertiary hospitals than secondary and conversely whether costs for tertiary DRGs are

15 For the real world relevance of this statement, see *Dranove et al.* (2003).

higher in secondary hospitals than tertiary? Our preliminary results provide some empirical support for the first supposition but the second remains open to debate.

From a product perspective, more work is needed to identify complexity groupings across DRGs. Those familiar with the health sector will know that outpatient, community health and disability volumes have lacked an accepted classification and coding system. Measuring cost variability in these categories is wide open and urgently needs researchers' attention as well as service delineation and product specification.

Our simplified model provides a first step towards building policy from modelling health processes. More sophisticated risk predictive and resource consumption models are obvious candidates for providing a better understanding of hospital resource management processes and their impact on cost structures.

In conclusion, research into health and in this paper, into tertiary distinctions, has a win-win connotation. More efficient and effective health management benefits all citizens while providing a valuable resource for researchers. In this paper we have tried to demonstrate the nature of the problem, its international dimension, and a theoretical framework on which to build research into tertiariness. Hopefully this will attract management accounting and other researchers into this area.

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