

# Utilizing Allied Health Activity Data to Investigate Concordance/Discrepancy Between AHP Cost and DRG Payment

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## **Abstract**

*Health care labour costs account for a large proportion of hospital operating costs. For hospitals to run efficiently it is important that the cost of providing health care is acutely collected and applied to patients. Diagnostic related groups (DRG) were developed to help funders quantify the various outputs of health services to improve efficiencies within health care and are influenced by length of stay. They provide relatively good indicators of total costs and are accessible for analysis. Although allied health staff provide 15-20% of all patient care services within hospitals they may not routinely have the opportunity to inform funding decision. However allied health staff could review the services they provide to different DRG groups, in terms of their service weight for each DRG, to help identify potential trends and cost savings. In this paper DRG groups with high allied health input are identified and analysed using a regression model and current service weights to see if allied health patient contact cost increases over length of stay for a specific DRG. Analysis reveals significant difference between actual and allied health cost over duration of stay and highlights the potential need for further research and refinement of cost weights in place.*

## **1. Introduction**

In a recent survey of the current health system in New Zealand it was stated that:

*“Demand for healthcare keeps growing and there are not sufficient resources –workforce, beds, or money, to keep pace. Some hard calls need to be made in the future to keep the system afloat and make sure care goes to those with the greatest need and ability to benefit.”[1(p3)]*

In order to ensure that there will be enough staff and resources available to meet growing needs it is important that health professionals review the delivery of common treatments and try to develop cost effective treatment pathways for their patients. To help achieve this there is a need for a better working relationship between clinicians and hospital administrators to make information available to help identify potential cost savings [1].

Health care is labour intensive, and the cost of labour accounts for 60-80% of operating costs, sufficient staffing is therefore a critical component of successful and efficient health care delivery [2]. Accurate estimation of the costs of specific health care services and the cost of care for individual patients is critical to the efficient administration of health care's systems, to prevent inappropriate payment incentives [3].

Allied health staff groups routinely collect administrative information about the patients they see and the amount of time spent caring for them. This care constitutes a large proportion of the care patients receive in hospital. Boyce [4] stated that between 15 to 20% of all patient care service in hospitals is provided by allied health practitioners. However despite this large contribution to care of patients allied health do not routinely have the opportunity to provide substantial input into hospital reform or cost saving exercises [5].

## 1.1. Costing in health care

Under the traditional organizational structure of the hospital there are normally two accounting systems in operation, managerial and financial. The finance system provides the basic financial description of the hospital in terms of its balance sheet, income statement and funds flow, while the management accounting system provides financial information orientated at the department level (e.g. nursing, laboratory, medical records) for internal management purposes [6]. As a result these systems have not been able to provide a unified view of the financial consequences of the care delivered to individual patient groups or casemix.

The casemix approach to the classification of patient care episodes allows episodes to be grouped into one category which can then be matched with measures such as resource usage, quality and other standard product definitions like the average length of stay. The basic principle of Casemix is that hospital costs can be allocated to direct products produced by that hospital. In product costing, a direct product is defined as a product which emerges from the end of the production line. The idea behind casemix is to break down total hospital expenditure into product units so that cost per product statistics can be analysed [7].

One of the first systems to effectively make use of the casemix concept was the diagnosis related groups (DRG) classification system. This was developed by Professor Bob Fetter at Yale University. The DRG system was designed to group together acute in patients who are similar clinically and who have a similar pattern of resource use. They provide a clinically meaningful way of relating the number and types of patients treated to the resource provided. They are developed from diagnostic, procedure, and demographic information routinely available from a hospital inpatient medical record on discharge [8].

Since DRGs form a classification of the patient population into classes with similar expected output utilisation, they can provide a definition of the services provided by a hospital. As such they allow the resources consumed and costs incurred to be related directly to the types of patients or casemix that the hospital treats [6]. US authorities quickly perceived the potential of DRG as a payment tool and in 1980 New Jersey State introduced the first casemix funding system [8]. Since its introduction in the U.S there have been a variety of DRG classification systems developed. DRG's have become the most widely known and implemented method for inpatient episode grouping and are now widely used for costing allocation and payment [9].

Each DRG is allocated a 'weight', which is dependent on the average cost of resources (e.g. nursing, diagnostic services, allied health, procedures) required to achieve the appropriate patient outcome [10].

Considerable research has been undertaken in Australia and overseas to estimate these relative cost values. Most research, however, has had to use data on surrogates for the cost of patient care; some using length of hospital stay, others using charges rendered for care (or charges discounted by a profit factor), and some have modelled patient care costs on the basis of care patterns and relativities from the Yale cost model in the United States. This costing method uses a series of indicators to allocate all costs, including overhead costs, to the set of DRGs [11].

The most important of the indicators in the model are the cost weights. These DRG cost weights are derived from data obtained from a different set of hospitals from those participating in the costing study. These are measures of the relative cost of specific service inputs to each DRG, which are applied to apportion the total cost of each service in each hospital in the costing study to each casemix group [12]. The cost weights are then adjusted for length of stay and a number of other specialist procedures to yield a final reimbursement rate.

## 2. Clinical problem/ requirements

In New Zealand DRG codes are calculated by the Ministry of Health. The current DRG grouper is based on the Australian Refined Diagnostic related group (AR-DRG) version 5.0, which uses up to 30 diagnoses and up to 30 procedures in its calculations. External cause codes such as allied health input are not used by the grouper [13].

However there seems to be lingering suspicions that case-mix data does not capture allied health work that well even in the acute care setting since much allied health work is often determined by reasons not directly related to the principal cause for admission [14]. For instance, treatment of malnutrition by dieticians could be 'secondarily' associated with many DRGs.

There is wide acknowledgement that the procedure-based system of DRGs are grounded on a medical/illness perspective and is unsatisfactory in describing and predicting the activity of allied health professions in health care service delivery [15].

Unlike many other professions time spent seeing patients is captured more regularly to determine staffing requirements however the variation in amount of time spent with patients is not captured as the cost is assigned on a unit level only. This is similar to the issues with DRG funding; allocation of cost to DRG level implies that each patient consumes the same amount of time and interpatient variability is not captured

The aim of this investigation is to calculate the actual allied health staff cost based on time spent with patients for each episode of care for several DRG groups. This staff cost will then be compared to the total hospital based cost, obtained by totalling the unit costs for all services provided during an episode of care, to see both allied health input and hospital cost are influenced by length of stay as modelled by DRG casemix weighting.

### **3. Implementation/design**

Ethics approval of the research protocol as conforming to ethical guidelines was to conduct this research was sought and obtained from the Northern X Regional ethics committee for New Zealand (Ethics ref: NTX/11/EXP/026).

#### **3.1. Data definition**

Data was obtained by working with the decision support team at Waitemata District Health Board to formulate data queries from the data warehouse. Data was obtained from all the inpatient episodes for both North Shore hospital and Waitakere hospital for the 08 to 09 financial year.

Data was obtained from two sources: Firstly from the hospital based inpatient medical record abstract, this consists of the information from the national minimum data set that is used to calculate DRG weights. The second part was from each of the respective allied health professional activity databases for comparison.

The inpatients medical record abstract included demographic data, administrative data (admitting ward and mode of separation (i.e. discharge/transfer) and clinical data (diagnosis and procedures). However the data that was relevant and used for this analysis was:

- Episode number
- Admission and Discharge date (Used to calculate actual length of stay)
- Patient identifier number
- Age
- DRG code applied to the episode
- WIES weighting (used to calculate DRG funding)
- Actual cost (from hospital billing system)

The allied health activity database would provide the date, times and duration of direct patient contact and allow for the total amount of allied health time per episode for each profession to be determined.

#### **3.2. Methodology**

The first step was to identify the DRG groups that have a high allied health input at Waitemata District Health Board. Once episodes of care within the DRG's with high allied health had been identified the next step was to obtain the allied health activity data, or contact time for each episode. The staff cost per unit time for each staff group was then calculated and this cost applied to the contact time for each staff group and totalled for each episode to give total allied health cost. This staff cost was then compared with the actual cost obtained from the hospital costing system and the amount funded by the DRG methodology.

### 3.2.1. Objectives

The methodology above hopes to address the following objectives.

- a) To identify the top ten DRG groups that receive the most allied health input at Waitemata DHB
- b) To identify cases from the episode numbers for each of these DRG codes for the 2008-2009 financial year
- c) To calculate the allied health cost (AHC) by utilizing the activity data used by management for work force planning
- d) To compare the DRG, Actual cost and Allied health cost distributions for a DRG group including/excluding outliers.
- e) For the DRG identified to, analyze the possible relationship between cost (dependent variable) and LOS (independent variable) for both AC and AHPC costs using simple regression. To test the hypothesis that AHP and Actual cost both vary over length of stay for a specific DRG

During the collection of data there were a number of issues that had to be addressed in the survey. These problems and steps taken to address the are grouped into the respective phases and discussed below.

#### a) Identifying DRG's with high allied health input

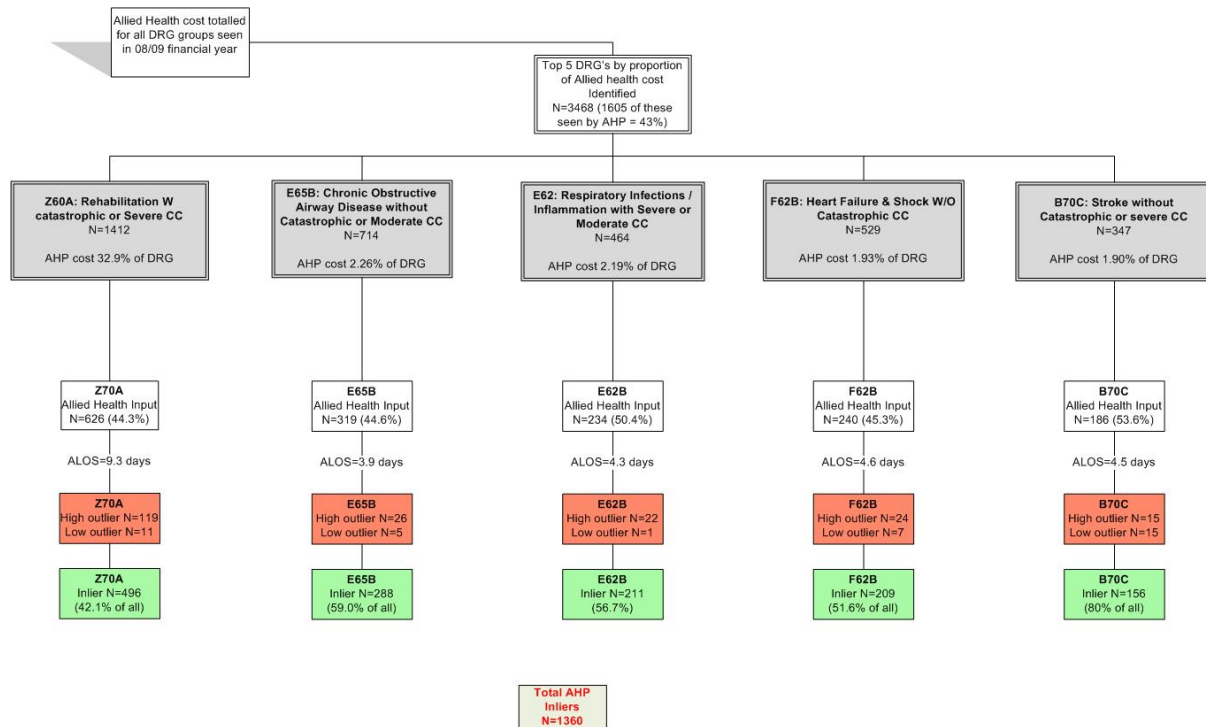
In order to identify the allied health intensive DRG the hospital costing system was used to identify groups that had the largest allied health cost attributed to them for the 2008-2009 financial year. Because the discharges from both hospitals were included there were cost centres for allied health at both hospitals. These were all identified by liaising with the associate director of allied health. These cost centres were then used to allocate the total allied health cost to each DRG group and are discussed in more detail in section c). The DRG groups were then ranked by the total allied health product cost for each group to highlight the top ten DRG's and can be seen below in Table 1.

#### b) Identifying cases

The episode numbers for the top ten DRG's were used to highlight identify episodes of care for the 2008-2009 financial year and are shown below in Figure 1. These episode numbers were linked to patient identifier numbers also used to obtain the frequency and total contact time for each allied health group. In line with the allied health costing data collected for case weight calculation within DRG groups the only allied health professions included in this analysis were Physiotherapists, Speech and Language therapists, Occupational therapists, Social workers and Dietitians.

**Table 1 - Top 10 DRGs by Allied Health Cost**

| Rank | DRG  | DRG Description   | Total cost of DRG | Product Cost Total cost of AHP products | %of AHP cost of total cost of DRG |
|------|------|---|-------------------|---|-----------------------------------|
| 1    | Z60A | Rehabilitation W Catastrophic or Severe CC                        | \$345,971.78      | \$113,828.49                            | 32.90%                            |
| 2    | E65A | Chronic Obstructive Airways Disease W Catastrophic or Severe CC   | \$3,485,953.10    | \$39,447.26                             | 1.13%                             |
| 3    | B70A | Stroke W Catastrophic CC  | \$6,328,351.85    | \$39,270.26                             | 0.62%                             |
| 4    | B70C | Stroke W/O Catastrophic or Severe CC                              | \$1,242,004.65    | \$23,624.61                             | 1.90%                             |
| 5    | E65B | Chronic Obstructive Airways Disease W/O Catastrophic or Severe CC | \$943,474.24      | \$21,276.97                             | 2.26%                             |
| 6    | L63B | Kidney and Urinary Tract Infections Age >69 or W Severe CC        | \$1,064,969.83    | \$20,247.43                             | 1.90%                             |
| 7    | B70B | Stroke W Severe CC  | \$1,225,756.79    | \$19,960.06                             | 1.63%                             |
| 8    | E62A | Respiratory Infections/Inflammations W Catastrophic CC            | \$1,381,008.46    | \$17,585.53                             | 1.27%                             |
| 9    | F62B | Heart Failure and Shock W/O Catastrophic CC                       | \$878,695.86      | \$16,929.13                             | 1.93%                             |
| 10   | E62B | Respiratory Infections/Inflammations W Severe or Moderate CC      | \$639,014.21      | \$13,966.35                             | 2.19%                             |



**Figure 1 - Consort style diagram showing cases identified from the top five DRG groups at Waitemata**

Each DRG group within figure 1 is broken down further to highlight outlier cut offs which are defined by the national average length of stay according to the New Zealand Casemix framework [13]. Low outliers are defined as DRG episodes where the length of stay is less than 1/3 the national average for the DRG group and high outliers defined by DRG groups that have a length of stay greater than three times the national average length of stay.

As the sample for the 2008-2009 financial year included patients that were not seen by allied health and excluded from analysis the percentage of episodes with allied health input is also clearly defined. E.g. for DRG group F62B 45.3% (240 of the 529 episodes) were seen by allied health and of all the inliers (i.e. episodes with length of stay between higher and lower cut offs) for this DRG group 51.6% of all F62B inliers were seen by allied health.

### c) Calculating allied health staff cost

The original plan for calculating the allied health cost per profession per minute was to make use of the costing data and staffing numbers for each staff group using time driven activity costing. This was initially developed by Kaplan & Anderson [16], and a step by step process for calculating unit cost per profession within the time driven activity based costing framework was put forward by Everaert, et al [17], (2008, cited and summarised by Demeere et al, 2009, [18(p297)]):

1. Identify the various resource groups (allied health departments for analysis)
2. Estimate the total cost of each resource group (the cost for all staff from that department)
3. Estimate the practical capacity of each resource group (e.g. available working hours, excluding vacation, meeting and training hours)
4. Calculate the unit cost of each resource group by dividing the total cost of the resource group by the practical capacity
5. Determine the time estimation for each event, based upon the time equation for the activity and the characteristics of the event
6. Multiply the unit cost of each resource group by the time estimate for the event.

**Table 2 - Details of allied health cost per minute for each of the individual cost centres: combined to give the mean cost per minute for each professional group**

|   | <b>Physio Therapy</b> | <b>Respiratory</b> | <b>Occupational Therapy</b> | <b>Speech Therapy</b> | <b>Social Work</b> | <b>Diet</b>    |
|---|-----------------------|--------------------|-----------------------------|-----------------------|--------------------|----------------|
| North Shore Hospital new                    | \$3.653               | \$3.448            | \$3.530                     | \$3.714               | \$3.411            | \$1.373        |
| North Shore Hospital Fup                    | \$4.004               | \$3.773            | \$3.806                     | \$3.552               | \$3.600            | \$1.644        |
| Dietetic Education                          | -                     | -                  | -                           | -                     |                    | \$1.417        |
| North Shore Hospital Rehabilitation Therapy | \$1.970               | -                  | \$2.770                     | \$2.270               | \$3.280            | -              |
| Waitakere Hospital new                      | \$3.236               | \$3.043            | \$3.120                     | \$2.906               | \$3.009            | -              |
| Waitakere Hospital Fup                      | \$3.566               | \$3.349            | \$3.380                     | \$3.142               | \$3.187            | -              |
| Waitakere Hospital Rehabilitation therapy   | \$2.220               | -                  | \$1.950                     | \$2.040               | \$2.860            | -              |
| <b>Total</b>                                | <b>\$18.649</b>       | <b>\$13.612</b>    | <b>\$18.557</b>             | <b>\$17.624</b>       | <b>\$19.347</b>    | <b>\$4.434</b> |
| Resp + Physio                               | <b>\$32.261</b>       |                    |                             |                       |                    |                |
| Number of values                            | 10                    |                    | 6                           | 6                     | 6                  | 3              |
| <b>Mean Cost per minute</b>                 | <b>\$3.226</b>        |                    | <b>\$3.093</b>              | <b>\$2.937</b>        | <b>\$3.225</b>     | <b>\$1.478</b> |

There was a major organizational restructure at Waitemata DHB in October of 2009. Prior to this restructure the organizational structure at Waitemata DHB was fairly fragmented, and there was a duplication of effort between allied health. Due to a clear indication from government that the ongoing trend of increasing levels of health funding was not sustainable, an organizational restructure process was commenced, to try and improve efficiencies. The net effect of this restructure made it difficult to obtain accurate data about the amount of staff working at each hospital and within the different divisions and provide the necessary data to facilitate the activity based costing method proposed by Everaert, et al [17].

This was a drawback as one of the underlying objectives was to compare allied health activity cost to DRG costs, to see if there was a relationship between the two. After lengthy discussions with the decision support team at Waitemata and some of the financial analysts it was decided that, as it was not possible to obtain accurate data available on the amount of salaried staff for the financial year of the study as a result of the restructure. The only potential way for calculating the actual cost for each professions time was by making use of the relative values used in allocating costs with the accounting system.

Each relative values for allied health staff inputs had a time associated to it and this was used to calculate the cost per minute for each cost centre and then combined to obtain a mean cost per minute per professional group. The various costs for each cost centre can be seen below in Table 2.

These costs were then applied to the total contact time in minutes for each profession, identified in step b) to give allied health cost per episode of care.

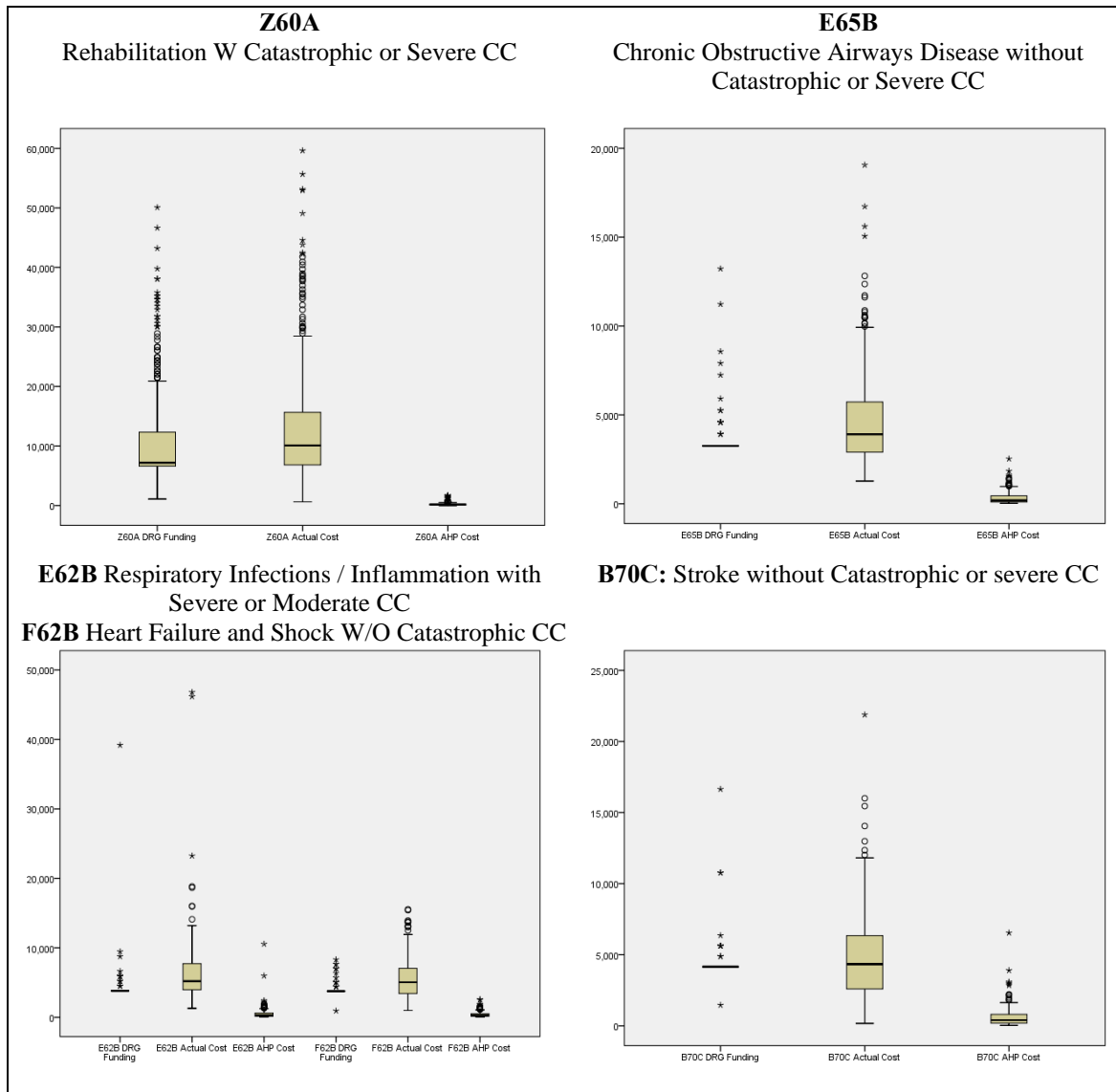
#### **4. Evaluation**

Analysis of the mean and median cost for the top five each DRG group (see Table 3) highlighted that the data was not parametric so box plots were used to show the differences between these graphs.

Figure 2 shows the effect of excluding outliers and highlights that as each DRG is weighted there is not much variation in the amount received for a DRG group with only a few outliers. This DRG funding appears to be fairly accurate as it appears relatively close to the median for actual cost. However Mann Whitney U tests indicated a statistically significant difference between these two figures. Because several statistical tests were being performed simultaneously on each DRG group, in order to avoid a lot of spurious positives Bonferroni correction was used to calculate adjusted p values for the Mann Whitney U test. Even with the adjusted p values there was a significant difference between the DRG funding and both actual and allied health cost. This may be as a result of the large sample sizes, the results of this analysis can be seen in Table 4.

**Table 3 - Descriptive statistics for the top 5 DRG groups with a high proportion of allied health cost identified (from table 1) for both in and outliers**

| DRG  | Details        | Outlier |          |          |            | % of AHP cost of total cost | Inlier |         |         |            |
|------|----------------|---------|----------|----------|------------|-----------------------------|--------|---------|---------|------------|
|      |                | n       | Mean     | median   | Difference |                             | n      | Mean    | median  | Difference |
| Z60A | DRG Funding    | 626     | \$10,575 | \$7,185  | \$3,391    | 32.9%                       | 496    | \$7,986 | \$6,613 | \$1,373    |
|      | Actual cost    | 626     | \$12,597 | \$10,097 | \$2,500    |                             | 496    | \$9,448 | \$8,933 | \$514      |
|      | AHP cost       | 626     | \$210    | \$148    | \$63       |                             | 496    | \$179   | \$133   | \$45       |
|      | Length of Stay | 626     | 19.5     | 15.2     | 4.3        |                             | 496    | 14.5    | 14.1    | 0.5        |
|      | Age            | 626     | 82.5     | 83.0     | 0.5        |                             | 496    | 83.1    | 84.0    | 0.9        |
| E65B | DRG Funding    | 319     | \$3,400  | \$3,256  | \$144      | 2.3%                        | 288    | \$3,256 | \$3,256 | \$0        |
|      | Actual cost    | 319     | \$4,734  | \$3,945  | \$789      |                             | 288    | \$4,226 | \$3,740 | \$486      |
|      | AHP cost       | 319     | \$335    | \$199    | \$136      |                             | 288    | \$302   | \$194   | \$108      |
|      | Length of Stay | 319     | 5.8      | 4.9      | 0.9        |                             | 288    | 5.1     | 4.6     | 0.5        |
|      | Age            | 319     | 72.1     | 74.0     | 2.0        |                             | 288    | 72.1    | 74.0    | 1.9        |
| E62B | DRG Funding    | 234     | \$4,080  | \$3,808  | \$272      | 2.2%                        | 211    | \$3,808 | \$3,808 | \$0        |
|      | Actual cost    | 234     | \$6,430  | \$5,216  | \$1,214    |                             | 211    | \$5,586 | \$5,074 | \$512      |
|      | AHP cost       | 234     | \$497    | \$284    | \$213      |                             | 211    | \$379   | \$258   | \$121      |
|      | Length of Stay | 234     | 7.5      | 6.4      | 1.1        |                             | 211    | 6.4     | 5.9     | 0.6        |
|      | Age            | 234     | 70.9     | 76.0     | 5.1        |                             | 211    | 70.4    | 76.0    | 5.6        |
| F62B | DRG Funding    | 240     | \$4,060  | \$3,766  | \$294      | 1.9%                        | 209    | \$3,766 | \$3,766 | \$0        |
|      | Actual cost    | 240     | \$5,904  | \$5,113  | \$791      |                             | 209    | \$5,173 | \$4,902 | \$271      |
|      | AHP cost       | 240     | \$415    | \$273    | \$142      |                             | 209    | \$364   | \$245   | \$119      |
|      | Length of Stay | 240     | 7.4      | 6.1      | 1.3        |                             | 209    | 6.3     | 6.0     | 0.3        |
|      | Age            | 240     | 82.4     | 84.0     | 1.6        |                             | 209    | 82.3    | 84.0    | 1.7        |
| B70C | DRG Funding    | 186     | \$4,329  | \$4,154  | \$175      | 1.9%                        | 156    | \$4,154 | \$4,154 | \$0        |
|      | Actual cost    | 186     | \$5,044  | \$4,346  | \$698      |                             | 156    | \$4,654 | \$4,340 | \$314      |
|      | AHP cost       | 186     | \$653    | \$410    | \$243      |                             | 156    | \$575   | \$414   | \$162      |
|      | Length of Stay | 186     | 6.0      | 4.8      | 1.2        |                             | 156    | 5.4     | 4.8     | 0.6        |
|      | Age            | 186     | 71.6     | 76.0     | 4.4        |                             | 156    | 72.2    | 76.0    | 3.8        |



**Figure 2 - Box plots for each of the top five DRG groups showing the cost between the amount of DRG funding received, the Actual cost incurred and the Allied health Cost calculated outlier groups only**

**Table 4 - Mann Witney U analysis comparing DRG funding to Actual cost, and Allied health cost for top 5 DRGs selected**

| <i>DRG</i> | <i>In and Outliers</i>           |   |                                    |   |
|------------|----------------------------------|---|------------------------------------|---|
|            | <b>Mann Witney DRG vs Actual</b> | <b>Bonferroni Correction <math>\alpha/n</math> (<math>\alpha=0.05</math>)</b> | <b>Mann Witney DRG vs AHP cost</b> | <b>Bonferroni Correction <math>\alpha/n</math> (<math>\alpha=0.05</math>)</b> |
| Z60A       | 0.000000                         | 0.005000  | 0.000000                           | 0.005000  |
| E65B       | 0.000000                         | 0.005000  | 0.000000                           | 0.005000  |
| E62B       | 0.000000                         | 0.005000  | 0.000000                           | 0.005000  |
| F62B       | 0.000000                         | 0.005000  | 0.000000                           | 0.005000  |
| B70C       | 0.035968                         | 0.040968  | 0.000000                           | 0.005000  |

To investigate whether or not there is a similar relationship between the allied health cost and the actual incurred health cost simple regression model was used. Regression analysis was conducted, for both the inliers and outliers of each DRG group, using actual cost and AHP costs as independent variables with the length of stay being the dependant variable to see if there was a relationship between the two (i.e. Cost ~ Allied Health cost +Actual length of stay). See Table 5. This model was significant and the length of stay accounted for significant variation within the model. However as this regression model was looking at the simultaneous influence of two variables (allied health cost and Actual cost) on a third (length of stay) it was decided to check for an interaction term to check if the influence of two variables on a third is not additive [19].

To check whether this was the for best fit additional analysis was conducted utilising an interaction term (i.e. Cost ~ Allied Health cost +Actual +Allied Health cost:Actual length of stay). Results of the enhanced regression model with the interaction term between AC and DRG\_cost. Demonstrated a highly statistically significant interaction term, therefore the main effects (costing variables) were kept in the model as well as the interaction term this accounted for 82-97% (adjusted R squared) in the model variability for both in and outliers.

The relationship between Allied health cost and Actual cost over length of stay for both in and outliers can be seen below in Figure 3. The regression lines highlight how the amount of variance between the different costs and length of stay are not equal (or parallel), i.e. actual cost increases at a greater rate over length of stay then allied health cost which could be for a number of reasons. This difference may be attributed to an error in the allied health pricing methodology and service weights that were used to calculate allied health cost earlier. This highlights the potential need the need to potentially re evaluate the present service weight costing that is presently used by the hospital costing system as it may not be accurately capturing allied health cost. Alternatively allied health input and cost may genuinely only vary slightly with length of stay in comparison to the high day rate for doctor nurse and ward costs. This would then highlight the potential benefit of making use of allied health DRG activity costing to describe and define levels of care provided and help facilitate budget setting in certain areas.

It is also interesting to note that DRG Z70A did not have as much of an allied health activity cost as was expected from the high proportion of allied health cost to total cost (Table 1 earlier). This may be as a result of distortion caused by the expense of rehabilitation equipment provided for patients within this group and warrants further investigation to see if this is the case.

**Table 5 - P values for relationship coefficient for top five DRG groups (both in and outliers)**

|              | DRG  | Adjusted r <sup>2</sup> from regression including interaction term | Overall F value (model fit) | Standardised Beta for ALOS (gradient of line) | P value for AHP cost | Standardised Beta for Interaction term (difference to gradient of line) | P value for Interaction |
|--------------|------|--|-----------------------------|---|----------------------|---|-------------------------|
| Outliers     | Z70A | .967   | .000000                     | .973  | .907                 | -.001   | .000000                 |
|              | E65B | .962   | .000000                     | .889  | .000000              | -.103   | .000000                 |
|              | E62B | .802   | .000000                     | .867  | .000332              | -.129   | .000000                 |
|              | F62B | .961   | .000000                     | .906  | .000000              | -.097   | .000000                 |
|              | B70C | .958   | .000000                     | .986  | .000000              | -.148   | .000000                 |
| Inliers only | Z70A | .919   | .000000                     | .697  | .250319              | .028  | .000000                 |
|              | E65B | .946   | .000000                     | .723  | .000001              | -.113   | .000000                 |
|              | E62B | .823   | .000000                     | .599  | .008501              | -.140   | .000000                 |
|              | F62B | .937   | .000000                     | .707  | .000147              | -.111   | .000000                 |
|              | B70C | .955   | .000000                     | .810  | .000000              | -.137   | .000000                 |

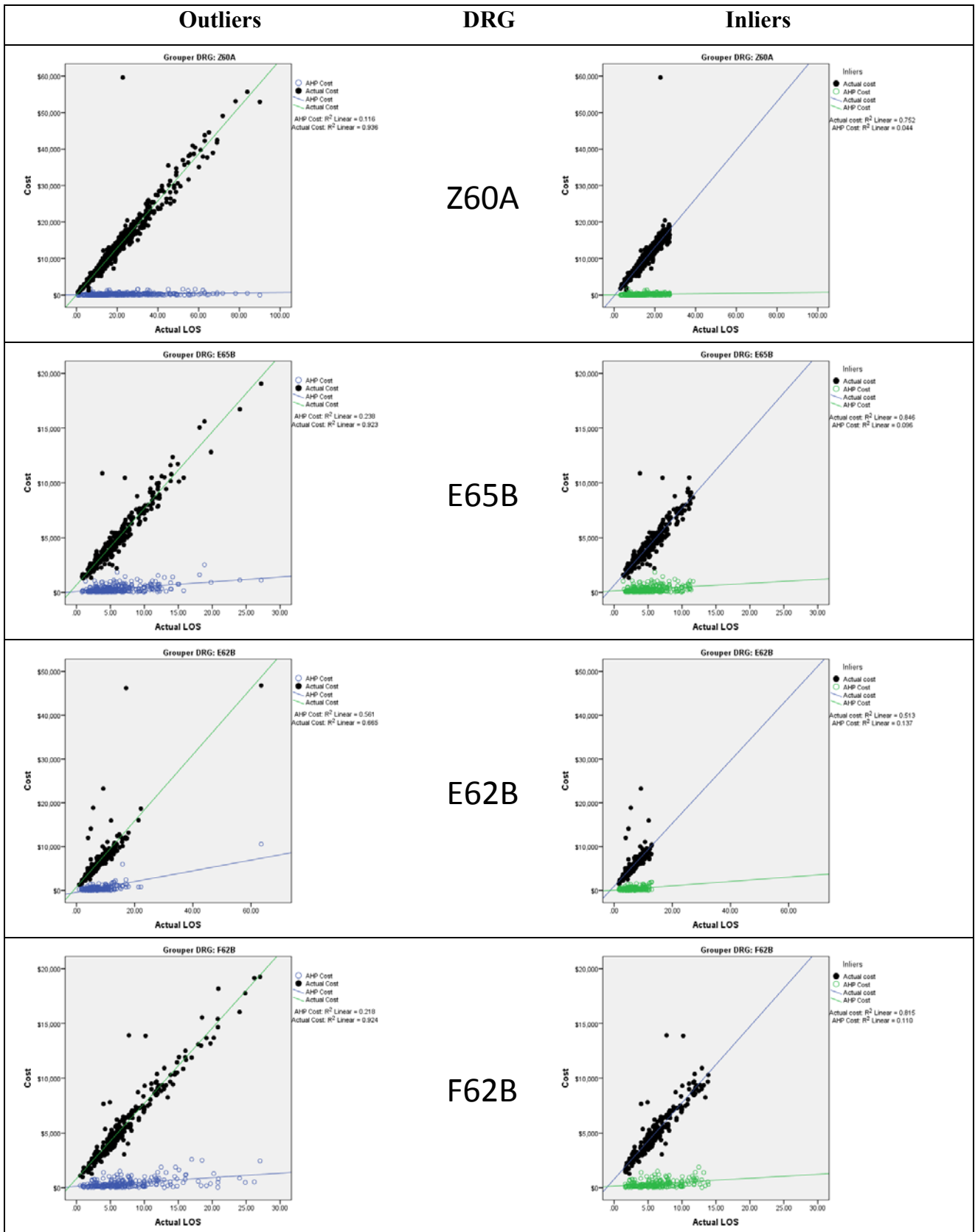


Figure 3 - Results of complex regression analysis for top five DRG group showing results of both in and outliers

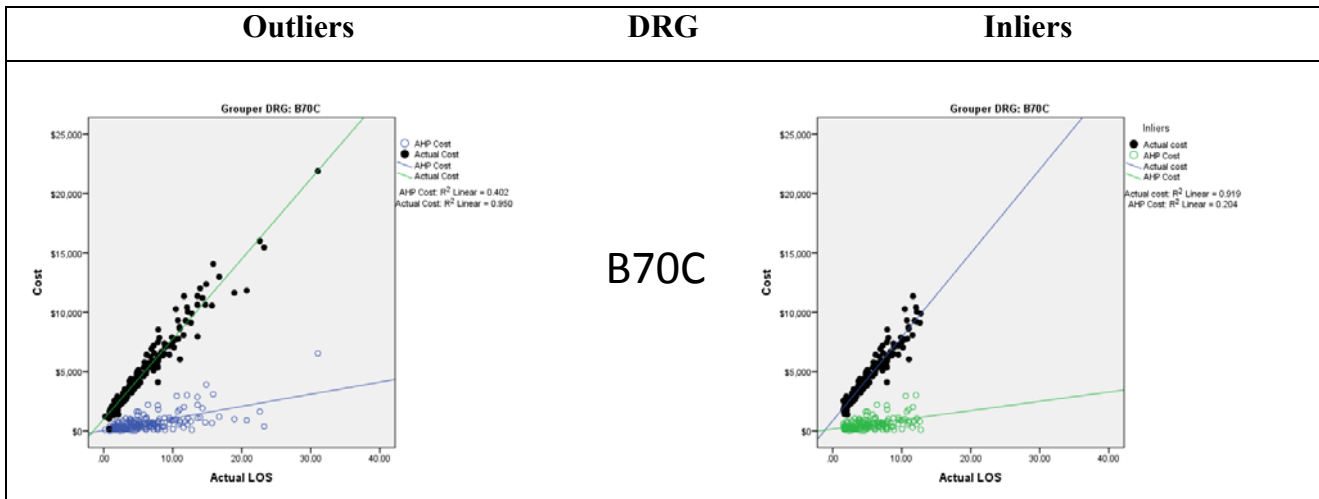


Figure 4 cont'd - Results of complex regression analysis for top five DRG group showing results of both in and outliers

### 5. Comparison with other approaches

Most of the literature looking into allied health input within DRG groups has focused solely on the total amount of allied health time spent with each DRG group and has not looked at comparing the cost of this allied health activity with actual cost. In a review of the amount of allied health input time spent on individual DRG groups in hours across 35 hospitals within Australia and New Zealand there were similar findings for DRG's with high allied health resource use. Seven of the top ten identified by total allied health cost were in the top 20 of this sample, as can be seen below in Table 6.

Similar studies using regression analysis to compare component costs have highlighted both the expense of obtaining accurate costing information and the use of regression to compare costs, even in a small sample of 9 patients [21]. This method of multiple regression analysis was also utilised recently to demonstrate how there was a bias within the more complex DRG groups funding in tertiary referral centres [22], with 6% of patients within this group accounting for more than 20% of the costs due to their increased complexity. A number of additional risk factors were highlighted that could serve to adjust risk in this highly complex DRG group

Table 6 - Showing the top 20 DRGs for allied health input by time in hours across the 35 hospitals in Australia and New Zealand that submitted their allied health data for analysis (Health Roundtable[20]).

| ANDRG                                    | HOSPITAL |           |           |           |        |        |         |          |        |        |       |         |        |      |        |       |       |       |      |       |       |        |       |      |         |         |         |          |        |         |         |         |         |      |        |     |
|--|----------|-----------|-----------|-----------|--------|--------|---------|----------|--------|--------|-------|---------|--------|------|--------|-------|-------|-------|------|-------|-------|--------|-------|------|---------|---------|---------|----------|--------|---------|---------|---------|---------|------|--------|-----|
|  | Achilles | Achilles2 | Achilles4 | Aphrodite | Apollo | Athene | Cerbera | Centauri | Condor | Cougar | Eagle | Electra | Falcon | Fury | Gemini | Hawk1 | Hawk2 | Hawk3 | Hera | Hera2 | Hera3 | Hermes | Jason | Lynx | Polaris | Regulus | Scorpio | Scorpio2 | Sirius | Sirius2 | Sirius3 | Sirius4 | Tornado | Vega | Vulcan |     |
| A06B : TRACH+VENT+CCC OR TRACH+VENT+95   | 114      | 38        | 0         | 78        | 35     | 55     | 0       | 63       | 121    | 205    | 176   | 30      | 112    | 18   | 76     | 6     | 0     | 10    | 15   | 0     | 21    | 9      | 24    | 1    | 118     | 19      | 35      | 0        | 89     | 1       | 51      | 36      | 128     | 38   | 114    |     |
| A06A : TRACH+VENT > 95HRS +CCC           | 48       | 25        | 0         | 94        | 23     | 21     | 0       | 70       | 100    | 234    | 183   | 18      | 94     | 11   | 84     | 0     | 0     | 9     | 11   | 0     | 5     | 24     | 14    | 3    | 169     | 33      | 46      | 0        | 77     | 0       | 89      | 46      | 66      | 57   | 154    |     |
| B70A : STROKE+CCC                        | 92       | 28        | 8         | 50        | 56     | 12     | 0       | 80       | 32     | 89     | 38    | 20      | 71     | 34   | 30     | 11    | 2     | 9     | 15   | 0     | 1     | 24     | 15    | 7    | 61      | 65      | 52      | 4        | 17     | 5       | 33      | 42      | 63      | 46   | 93     |     |
| B2A : RESPIRATORY INFECTION/INFLAMM+CCC  | 59       | 33        | 18        | 28        | 28     | 12     | 0       | 32       | 18     | 38     | 37    | 20      | 32     | 18   | 10     | 7     | 6     | 14    | 12   | 0     | 2     | 17     | 13    | 3    | 64      | 23      | 32      | 21       | 19     | 6       | 21      | 33      | 17      | 11   | 37     |     |
| B70B : STROKE+S/C                        | 22       | 8         | 4         | 14        | 25     | 14     | 0       | 43       | 21     | 16     | 22    | 18      | 42     | 44   | 30     | 6     | 3     | 2     | 9    | 0     | 1     | 10     | 7     | 7    | 35      | 29      | 24      | 1        | 22     | 7       | 25      | 41      | 32      | 8    | 21     |     |
| B5B : CHRONIC OBSTRUCT AIRWAY DIS- C/SC  | 21       | 24        | 10        | 19        | 31     | 8      | 0       | 25       | 14     | 32     | 27    | 27      | 16     | 35   | 34     | 3     | 4     | 8     | 13   | 0     | 1     | 14     | 3     | 7    | 23      | 28      | 17      | 11       | 14     | 12      | 29      | 40      | 15      | 8    | 15     |     |
| B02A : CRANOTOMY + CCC                   | 35       | 0         | 0         | 40        | 0      | 8      | 0       | 17       | 54     | 60     | 41    | 19      | 51     | 0    | 20     | 0     | 0     | 0     | 0    | 0     | 5     | 8      | 7     | 0    | 26      | 0       | 0       | 0        | 10     | 0       | 11      | 0       | 25      | 13   | 92     |     |
| D3B : HIP REPLACEMENT -CCC               | 0        | 19        | 0         | 76        | 12     | 8      | 0       | 9        | 12     | 13     | 14    | 25      | 30     | 29   | 23     | 1     | 0     | 4     | 7    | 0     | 0     | 26     | 3     | 20   | 24      | 31      | 17      | 3        | 8      | 0       | 20      | 24      | 40      | 7    | 21     |     |
| D8B : OTHER HIP & FEMUR PR - CCC         | 9        | 22        | 0         | 21        | 7      | 8      | 0       | 16       | 24     | 23     | 27    | 17      | 28     | 29   | 24     | 2     | 0     | 6     | 6    | 0     | 8     | 9      | 2     | 7    | 17      | 22      | 17      | 7        | 18     | 0       | 28      | 13      | 48      | 13   | 23     |     |
| B02C : CRANOTOMY - CC                    | 18       | 0         | 0         | 40        | 0      | 10     | 0       | 10       | 14     | 12     | 31    | 17      | 19     | 0    | 14     | 0     | 0     | 0     | 0    | 0     | 170   | 2      | 1     | 0    | 7       | 0       | 0       | 0        | 17     | 0       | 5       | 0       | 14      | 6    | 22     |     |
| G02A : M/R SMALL & LARGE BOWEL PR+CCC    | 19       | 18        | 0         | 19        | 13     | 2      | 0       | 15       | 15     | 22     | 25    | 19      | 18     | 27   | 13     | 2     | 1     | 9     | 7    | 0     | 2     | 15     | 2     | 6    | 17      | 17      | 16      | 0        | 9      | 2       | 22      | 8       | 23      | 15   | 27     |     |
| D8A : OTHER HIP & FEMUR PROC + CCC       | 4        | 21        | 0         | 21        | 9      | 9      | 0       | 16       | 17     | 24     | 31    | 6       | 30     | 15   | 7      | 2     | 0     | 7     | 4    | 0     | 1     | 8      | 4     | 2    | 20      | 13      | 12      | 1        | 11     | 0       | 15      | 9       | 52      | 12   | 23     |     |
| F62A : HEART FAILURE & SHOCK + CCC       | 26       | 18        | 6         | 12        | 11     | 4      | 0       | 13       | 10     | 30     | 20    | 11      | 11     | 10   | 8      | 4     | 2     | 7     | 8    | 0     | 0     | 7      | 3     | 2    | 26      | 16      | 26      | 5        | 8      | 5       | 12      | 17      | 17      | 8    | 39     |     |
| D4B : KNEE REPLACEMENT -C/SC             | 0        | 18        | 0         | 66        | 8      | 4      | 0       | 0        | 7      | 9      | 5     | 17      | 15     | 27   | 13     | 1     | 0     | 2     | 5    | 0     | 0     | 12     | 1     | 13   | 18      | 11      | 10      | 3        | 1      | 0       | 8       | 23      | 45      | 9    | 15     |     |
| G02Z : VAGINAL DELIVERY                  | 29       | 15        | 6         | 0         | 15     | 0      | 0       | 8        | 13     | 0      | 0     | 7       | 0      | 16   | 29     | 1     | 20    | 0     | 0    | 81    | 0     | 1      | 0     | 0    | 1       | 6       | 0       | 8        | 27     | 11      | 16      | 18      | 25      | 12   | 0      |     |
| B70C : STROKE - C/SC                     | 9        | 5         | 2         | 13        | 6      | 9      | 0       | 28       | 11     | 9      | 11    | 18      | 29     | 24   | 31     | 4     | 1     | 3     | 3    | 0     | 0     | 7      | 3     | 4    | 19      | 16      | 19      | 1        | 10     | 4       | 15      | 16      | 11      | 3    | 13     |     |
| B2B : RESPIRATORY INFECTION/INFLAM+SM/CC | 17       | 7         | 6         | 9         | 15     | 7      | 0       | 16       | 10     | 7      | 13    | 15      | 10     | 22   | 18     | 2     | 4     | 6     | 6    | 0     | 2     | 8      | 7     | 3    | 22      | 13      | 11      | 8        | 11     | 8       | 14      | 21      | 8       | 4    | 7      |     |
| B5A : CHRONIC OBSTRUCT AIRWAY DIS+C/SC   | 15       | 16        | 6         | 9         | 18     | 2      | 0       | 15       | 7      | 22     | 19    | 7       | 10     | 10   | 9      | 1     | 2     | 6     | 7    | 0     | 0     | 9      | 6     | 2    | 21      | 12      | 17      | 3        | 4      | 4       | 9       | 23      | 13      | 7    | 15     |     |
| I13B : HUMERUS/BIAC/FIBULA/ANKL PR-CC    | 2        | 13        | 0         | 13        | 3      | 13     | 0       | 8        | 15     | 17     | 13    | 16      | 21     | 23   | 14     | 0     | 0     | 8     | 3    | 0     | 1     | 14     | 2     | 5    | 11      | 17      | 10      | 9        | 17     | 0       | 11      | 9       | 25      | 5    | 13     |     |
| B63Z : DM/INTA&CHRONIC DISTURB CRBL FN   | 9        | 6         | 4         | 5         | 20     | 11     | 0       | 16       | 6      | 6      | 11    | 10      | 31     | 3    | 16     | 2     | 1     | 4     | 7    | 0     | 0     | 2      | 4     | 1    | 23      | 11      | 3       | 26       | 7      | 2       | 18      | 11      | 14      | 5    | 30     |     |
| Percent of Total Time                    | 21%      | 14%       | 25%       | 27%       | 24%    | 24%    | ##      | 16%      | 25%    | 28%    | 23%   | 21%     | 25%    | 27%  | 21%    | 18%   | 25%   | 28%   | 24%  | 14%   | 24%   | 24%    | 25%   | 44%  | 25%     | 23%     | 23%     | 17%      | 28%    | 27%     | 24%     | 15%     | 21%     | 21%  | 28%    | 17% |

## 6. Lessons learned

Diagnostic related group costing information is readily available and can have a role to play in helping identify potential cost saving measures for allied health. In this study we found that by using the individual cost codes for allied health departments and totalling these costs for DRG groups we could identify groups of patients that have high allied health input.

Researchers need to be wary of the potential delays in obtaining data from different feeder systems within hospitals. Many of these systems are silos and do not interact well with each other it took a considerable number of consultations with the decision support team to help identify and extract the information required.

Service weights are used to calculate relativities of allied health cost across the DRG range and provide useful information for service planning [23]. The service weights for allied health staff at Waitemata DHB may need to be measured and recalibrated as they may not appear to represent actual cost of allied health input. Measuring the actual cost of allied health would require a more detailed approach of observing actual activities for patients. Alternatively a less expensive method could be making use of detailed activity based costing to better quantify the cost per unit time in a year.

The interaction term used in our regression model to highlight this had extremely significant results and shows a very strong correlation in describing the variance in the model. Not many other researchers have made use of this interaction term within their regression analysis and it is something that could be investigated further.

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