Health Issues and Services, A Complex Socio-Cognitive-Technical System

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***Abstract*—This paper investigates the additional resources needed to care for patients with chronic conditions in Australian hospitals. A number of different methods are used to define chronic conditions, based on previous work. The analysis shows that within each Diagnosis Related Group (DRG) patients with chronic conditions utilize significant more resources than patients without. Since admissions within the same DRG are reimbursed at the same level, these results point to potential inefficiencies in the hospital reimbursement system.**

***Index Terms*—Chronic illness, DRGs, economic cost, inefficiency, inequity.**

I. Introduction

With the improvement of medical interventions, the population has been ageing over the last century and is predicted to age further in the future [1]. The ageing of the population, combined with additional factors such as the introduction of new technologies, has contributed to a steady increase in health expenditures, raising sustainability issues. Prominent in this landscape is the issue of chronic diseases, which have replaced infectious diseases to be the leading cause of ill health and death in Australia and account for about 85% of the total burden of disease. Based on self-reported data 11 million Australian had at least one of the following eight chronic conditions: arthritis, asthma, back problems, cancer, chronic obstructive pulmonary disease, cardiovascular disease, diabetes mellitus, mental or behavioral conditions [2]. Additionally, the problem is getting worse with time, and the proportion of people with three or more long term chronic conditions rose from 38% in 2007-08 to 44% in 2014-15.

The presence of one or more chronic conditions makes taking care of a patient more complex and possibly expensive [3]. For example, a patient with stroke who also has diabetes and arthritis is much more complex to care for than a patient with stroke only.

In order to ensure that an adequate amount of resources is dedicated to patients with chronic conditions it is important to have an estimate of the cost associated with it. In particular, it is useful to know how much more resources are needed to care for a patient with one or more chronic conditions.

This is particularly important in the hospital setting, with hospitals that have adopted the increasingly common prospective payment system based on Diagnosis Related Groups (DRGs). Under such a system hospitals are paid the same amount for each hospitalization "type", where the type is described by one of the (approximately) 700 DRG codes. If the admissions of patients with and without one or more chronic conditions get coded with the same DRG code the hospital gets reimbursed the same amount, even if the patient with chronic conditions may cost much more than the one without. The DRG system is designed in such a way that *on average* hospitals get reimbursed the correct total amount. However, hospitals that treat disproportionately high numbers of admissions of chronic patients will be allocated insufficient resources, possibly impacting the overall quality of care [4]. Since chronic conditions correlate to varying degrees with low socio-economic status (SES) [5] hospitals servicing areas with high concentration of patients of low SES can be put at disadvantage, creating equity issues.

In this paper we address the following question: *keeping all else equal, how much more resources are needed to treat a patient with one or more chronic conditions, compared to a patient with no chronic conditions?* We also go further, and quantify the additional resources needed to treat patients with specific conditions, such as hypertension, heart disease or diabetes.

The plan of the paper is as follows: in Section II we summarize basic facts about the DRG system, in Section III we describe the data and methods used for the analysis, in Section IV we describe the results and in Section V we discuss the findings and the limitations of the analysis.

II. Diagnosis Related Groups (DRGS)

The Diagnosis Related Groups were adopted by the United States Congress in 1983 for the use of prospective payment to hospitals [6], [7]. The prospective payment system was an attempt to control to expanding costs of hospital care and to move away from a reimbursement system based on retrospective cost, which rewarded hospitals for long lengths of stay and for providing large number of procedures. Under the prospective system hospitals are payed on the expected cost of an admission, independently of the actual resources used to care for the patient. Many adjustments are allowed, for example to account for unusually long stays and other factors, but we will ignore them here for the sake of simplicity. The expected cost is computed by assigning to each admission a DRG code, and each DRG carries a different level of reimbursement. DRG codes are computed as a function of the diagnosis of the patients and the procedures performed in the hospital, which are themselves coded according to the

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International Classification of Diseases (ICD).

Australia uses a particular version of the DRG system [8], the Australian Refined DRGs (AR-DRGs). The AR-DRGs system is under constant revision and it is continuously improved using clinical experts as well as data analytics modifications. The most current version is AR-DRGs Version 8, but since it has been released relatively recently the data analysis was performed on Version 7.

III. Data And Methods

A large number of hospitals across Australia and New Zealand have participated in a service improvement program for many years. They have provided data for this project, consisting of approximately 25 million inpatient episodes over a period of six years. Ethics approval for the analysis of these data was obtained through Western Sydney University Human Research Ethics Committee (approval #H11065). For each admission a number of variables are recorded, including age and gender of the patient the length of stay and the type of admission/discharge, the ICD codes describing diagnosis and procedures for the episode and the final DRG code. For about 4 million episodes the data also contains the patient level cost determined by the costing methodology at the local hospital or health service area, and this is the data set used in this analysis.

The estimation strategy is very simple and consists of few steps:

- A set of ICD codes denoting a number *N* of chronic conditions is identified;
- A set of *N* binary indicators is created at individual level, to denote the presence or absence of each of the *N* chronic conditions.
- The cost of admission is regressed as a function of the DRG codes and the chronic conditions indicators.

Since we are controlling for DRGs the coefficients of the chronic indicators represent the additional resources required to care for patient with that specific chronic condition. The limitation of this approach is that it assumes that the contribution of each chronic condition is additive, so we do not analyze the interactions among chronic conditions, something that will be done in future work.

There is no common agreement on the definition of chronic conditions and how they can be identified in hospital admission data. Therefore, we have looked at the literature and performed the analysis with three different definitions, which are outlined below.

A. Method 1

We used six chronic conditions identified in a paper [9] on the accuracy of reporting of morbid conditions in administrative data: diabetes, heart disease, hypertension, obesity, smoking and stroke. These conditions were identified using the following ICD-10-AM diagnosis codes: E10–E14 for diabetes, I20–I52 for heart disease, I60–I69, G45, G46 for stroke, I10–I15 and R03.0 for hypertension, F17.2 or Z72.0 for smoking and E66 for obesity. Notice that here we label obesity and smoking as chronic conditions, although they are more commonly labelled as risk factors, since they highly correlate with chronic conditions and can be independent determinants of additional costs.

B. Method 2

We used the ICD-10-AM codes U78 to U88, that were designed specifically for the purpose of identifying chronic conditions [10]. They include, among others, disease of the nervous, circulatory, digestive and respiratory systems, endocrine and metabolic diseases, and mental and behavioral disorders.

C. Method 3

We used a subset of chronic diseases that are listed in the National Healthcare Agreement as associated with potentially avoidable admissions [11]. These include Asthma, Congestive cardiac failure, Diabetes complications, COPD, Bronchiectasis, Angina, Iron deficiency anaemia, Hypertension, Nutritional deficiencies and Rheumatic heart diseases.

IV. Results

For each of the three definitions of chronic disease we have run a regression of cost against DRG and chronic disease indicators. In Fig. 1 we have aggregated the results to show how much more resources are needed, on average, to care for a patient with *any* chronic condition, compared to a patient without. Despite the differences among the three definitions the outcome is remarkably clear: chronic patients tend to use 2.6-2.7 more resources than their non-chronic counterpart. Stated differently, admission of patients with chronic conditions tend to cost somewhere between $5,700 and $6,700 more than admissions of patients without chronic conditions. This implies that a hospital that has a proportion of chronic patients that is 10 percentage points more than the average faces costs which are approximately 12% larger than the average, and therefore 12% more than what they get reimbursed. These differences are large and can have significant impact on the finances of a hospital, raising questions not only of efficiency but also of equity, since there are significant correlations between chronic conditions and low SES status.

For each of the methods used to define "chronic" the linear regression provides the coefficients of each of the chronic condition indicators. For example, in method 1 we have defined 6 chronic conditions, and therefore there is 6 regression coefficients, each representing the additional resources needed to care for a patient with that chronic conditions. The results of the analysis are reported in Tables I, II, and III. In each table we report the additional resources associated with a chronic condition as well as the proportion of admissions that include that chronic conditions. The proportions are important because they help to see the results in context: certain conditions, such as bronchiectasis in definition 3 or congenital abnormalities in definition 2, require significant additional resources, but they are also quite rare and therefore do not have large impact overall.

The different definitions of "chronic illness" used in each of the different models have a different effect on what extra resources are attributed to the chronic conditions. However,

when the definitions of the chronic conditions are comparable the additional resources and the proportion of patients tend to be consistent. For example, the definitions that include diabetes as a separate chronic condition end up with approximately 6.1% of episodes affected by this condition and the extra cost associated with the condition to be around $400.

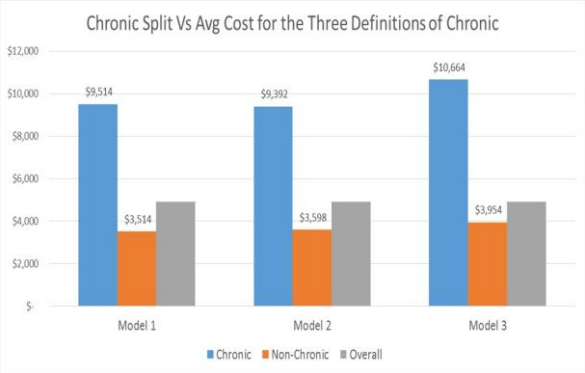

Fig. 1. The additional resources needed to care for patient with and without chronic conditions for each of the three methods of defining chronic conditions.

Overall one of the largest contributions to the chronic/no-chronic split is the group of diseases of the circulatory system, including heart disease, stroke and hypertension. For example, according to definition 1, in 7.6% of all admissions the patient had an additional, separate diagnosis of heart disease, and these patients costed $2,384 more than the patient without this diagnosis. Interestingly only one of the definitions (definition 2) included mental and behavioral problems as a separate chronic issue, despite carrying a large additional cost ($3,700) as well as affecting a significant proportion of admission (2.9%).

TABLE I: ADDITIONAL COST FOR CHRONIC CONDITIONS DEFINED IN METHOD 1

CONDITION	EXTRA COST	STD. DEV	% CASES
Diabetes	$418	$44	6.1%
Heart Disease	$2,385	$61	7.7%
Stroke	$3,618	$175	1.7%
Hypertension	$1,132	$100	6.1%
Smoking	$334	$81	9.9%
Obesity	$3,720	$299	0.5%

TABLE II: ADDITIONAL COST FOR CHRONIC CONDITIONS DEFINED IN METHOD 2

CONDITION	EXTRA COST	STD. DEV	% CASES
Endocrine, nutritional and metabolic diseases	$3,991	$286	0.6%
Mental and behavioural disorders	$3,704	$132	0.3%
Diseases of the nervous system	$3,489	$160	2.2%
Diseases of the circulatory system	$1,819	$70	2.9%
Diseases of the respiratory system	$1,422	$163	2.7%
Diseases of the digestive system	$4,735	$399	0.6%
Musculoskeletal system and connective tissue	$747	$81	5.9%
Diseases of the genitourinary system	$515	$140	4.5%
Congenital and chromosomal abnormalities	$4,007	$875	0.1%

TABLE III: ADDITIONAL COST FOR CHRONIC CONDITIONS DEFINED IN METHOD 3

CONDITION	EXTRA COST	STD. DEV	% CASES
Asthma	$1,658	$384	0.9%
Congestive cardiac failure	$4,076	$164	2.0%
Diabetes complications	$411	$43	6.1%
COPD	$1,014	$193	1.7%
Bronchiectasis	$3,681	$388	0.3%
Angina	$634	$279	1.0%
Iron deficiency anaemia	$2,387	$251	0.9%
Hypertension	$1,798	$96	5.9%
Nutritional deficiencies	$6,323	$344	0.3%
Rheumatic heart disease	$4,428	$458	0.2%

V. CONCLUSIONS

The advantages and efficiencies brought by a prospective payment systems based on DRGs are realized under some important conditions: that all the admissions within a specific DRG require similar amount of hospital resources and that the variation in resource use is truly random. In this paper we have shown that some of the variation in cost of admission is not random and can be explained by whether the patient has additional diagnosis of chronic disease. For example, patients who have a diagnosis of hypertension, in addition to whatever diagnosis led them to the hospital, will cost $1,000-$1,800 more than patients without normal blood pressure.

When the variation in resource use is not random, but predictably dictated by observable factors, the following observations apply:

- There may be space for improvement in the DRG system, meaning that it may be possible to refine it and produce DRG classes that are more homogeneous, with less variation in cost. The DRG system is continuously updated and improved, and this study suggests that a possible direction for improvement is to develop DRGs that better capture the presence of chronic conditions.
- If the factors predicting the variation in resource use affect disproportionally certain sub-groups of the population, and if hospitals vary in how much they serve those population sub-groups, equity issues may arise.

Since the correlation between chronic condition risk and low SES is quite well documented [12] there are reasons for concern. Individuals with low SES are not randomly distributed across the country, and are likely to attend some hospitals more than others. This implies that hospitals in low SES areas may attend to a population with higher than average burden of chronic disease. The results of this paper imply that those hospitals are likely not be sufficiently compensated, inducing a shortage of resources that may affect the quality of care of all patients in the hospital catchment area. Therefore it is possible that the current payment system places an unfair burden on individuals with low SES status. This paper does not quantify the extent to which this is the case, but it shows that the difference between chronic and non-chronic patients can be very large and prevalent, suggesting that there is potential for inequity.

This paper has both strengths and limitations. One of its strength is the data it relies on, which is collected across a large number of public hospitals at different locations and of different sizes, likely to be well representative of the Australian landscape. While few New Zealand hospitals are included in the data, and cannot be excluded because hospitals are not identified, it is not likely that this inclusion would significantly change the results. Access to this type of data is highly restricted under the current regulatory environment, and therefore studies of this type are not easily conducted.

A limitation of the paper is that we have analysed chronic conditions separately from each other, without interactions [13]. The cost of an additional diagnosis of hypertension and stroke could easily add up to more than the sum of the two contributions. The only reason for which we have not studied the interactions is simplicity: while this is possible within the current data set it is also much more difficult to interpret. The problem is compounded by the fact that there are different definitions of chronic conditions, which would most likely influence the structure of the interactions. Therefore we have postponed this component to later work. Another limitation of the study is that it was conducted using AR-DRG version 7, and it is possible that under the AR-DRG version 8 the results could be somewhat different, although it seems unlikely that the conclusions would be different.

To summarize, we have demonstrated that additional diagnosis of chronic conditions can greatly affect the resource use in the hospital setting and may result in misallocation of resources, possibly leading to inefficiencies as well as inequities.

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Michael Hart has a masters of applied science (clinical measurement), University of Technology, Sydney in 1997, a bachelor of applied science (biomedical science) from the University of Technology in 1990, an electronics engineering certificate from North Sydney Technical College in 1985 and an electronics trades certificate from Sydney Technical College in 1983.

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Mr. Hart is a board member of a Child Protection charity organization, the Australian Legislative Ethics Committee, and has given a number of presentations about the child protection systems and its performance measures as well as provided a number of submission to government for improvement in the area.

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He is currently developing a microsimulation model for policy analysis in NSW, Australia, he is working on analysis of geographic and temporal patterns of utilization of care and he is responsible for the cost-effectiveness analysis in two NHMRC funded RCTs. While at RAND he developed the COMPARE microsimulation model, that was used to anticipate the effect of the health care reform commonly known as Obamacare.

Dr. Girosi in 2007 was awarded the Longuet-Higgins Prize for Fundamental Contributions in Computer Vision (with E. Osuna and R. Freund), is a member of the Editorial Board of the Journal of Eating Disorders, and act as Knowledge Broker in the Knowledge Exchange Program at the Sax Institute (Sydney, Australia).