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Evaluating the relevance of disability weights for adjusting disease-cost and comorbidity calculations at the Kigali University Teaching Hospital

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Abstract

Evaluating the burden of diseases treated in hospitals in terms of (co)morbidity and financial impact is a long standing problem. Proposed solutions often rely on very sophisticated medical registration systems that are less suitable for developing countries. The authors have developed a simple prototype method for calculating financial impact and comorbidity of clinical conditions treated in a Sub-Saharan hospital environment (CALCO method) using disability weights. The developed method has been tested for 4 major clinical entities (tuberculosis, nutritional deficiencies, perinatal complications and malaria) on a dataset of 8.309 electronically registered admissions between Februari 1st 2009 and September 1st 2009 at the Kigali University Teaching Hospital. Results suggest that the method consists an acceptable instrument for estimating the financial burden of diseases treated in the hospital and that the proposed algorithms provide a useful formal method for quantifying hospital-bound comorbidity. The CALCO method might find its use in future implementations of Performance Based Financing (PBF) programs in Africa.

Keywords:

Cost of Illness, Comorbidity, Financing, International Classification of Diseases

Introduction

In 2009, the Kigali Health Informatics Research Institute (KHIRI), a department of the Kigali University Teaching Hospital (CHUK), began working out a set of pathology grouping codes in an attempt to enable efficient evaluation of clinical activity in a typical sub-Saharan hospital. This collection of grouping codes [1] was called the KHIRI Pathology Grouping Set (KPGS) and is a bi-classified grouping system, based on ICD-10 [2,4] and ICPC-2 [3] classification standards, completed with a clinical thesaurus [6]. The code structure has been derived from ICD-10 chapters. KPGS is somehow similar to the well known concept of Diagnosis Related Groups (DRG), which has proven to be useful for health management mainly in the Western world. However, the usability of these sophisticated, expensive and complex systems in developing countries with different cultural, demographic and health environments [5], is at least questionable. The KPGS classification can therefore be considered a simplified African implementation of DRG's, addressing clinical conditions that better match local African health management requirements. [1,5,6]

The CHUK is using today the KPGS classification of clinical conditions for documenting a number of important health facility management parameters: length of stay, episode of care based co-morbidity, care delivery costs related to specificic clinical conditions etc. The Kigali University Teaching Hospital is a national reference hospital; a large number of patients are being admitted at the health facility with complex health conditions involving multiple diseases or clinical concepts. At present, no formal structured registration has been put in place to qualify the actual burden of different clinical conditions linked to one and the same episode of care. Therefore, every documented clinical condition for an episode of care is being considered of equal severity by the actual hospital information system. This means that if the hospital management wants to calculate disease related costs based on care deliveries linked to a specific episode of care, the only method being available today is to distribute costs equally over all diseases linked to the considered episode of care. Such an approach appears of doubtful use in approximating the real financial burden of disease and can therefore not be used for practical (disease related) management needs (e.g. predicting cost/income evolution related to major changes in incidence of specific diseases and modulating human resources assignment to hospital departments based on the typical disease profiles of the patients treated in those departements)

Being able to quantify the average (financial) burden of diseases would greatly improve the way care delivery costs can be distributed over different diagnoses that have been associated to one and the same episode of care. In that approach, severe diseases would get more admission days, care delivery costs (drugs, consumables, clinical acts) and overhead costs attributed to than mild or even insignificant diseases, reflecting much better the real cost distribution in complex multi-pathology clinical situations.

Materials and Methods

Purpose of the study

The purpose of this study was to:

1. Assign weight-scores to clinical conditions reflecting their importance in terms of financial burden and comorbidty.
2. Evaluate the usability of the assigned weight-scores for quantifying comorbidity related to clinical conditions
3. Evaluate the usability of the assigned weigt-scores for enabling realistic distribution of care delivery costs over associated diagnoses for hospital admissions

Study concept

This is a comparative retrospective study in which disease related cost of care information is studied including episode of care identification, length of stay (LOS), cost of provided care deliveries and diagnostic codes under ICD-10, ICPC-2 and KPGS classifications.

Materials

Since the 3th quarter of 2008, discharge diagnoses and detailed information about provided care deliveries are being systematically encoded for every in-patient in the CHUK hospital information management system (OpenClinic®). For the purpose of this study, we will use a dataset extracted from the hospital information system covering all hospital admissions between February 1st 2009 and September 1st 2009 (n = 8.309).

Methods

Step 1: Elaborate a method for attributing weight scores to all 167 KPGS codes in use at the hospital site. A weight score should ideally reflect the (financial) burden of a particular disease or clinical condition

Step 2: Develop a method for distributing care delivery costs/income proportionally over all clinical conditions linked to an episode of care based on corresponding weight scores (estimation of direct disease-related costs)

Step 3: Develop a method for distributing overhead costs proportionally over all clinical conditions linked to an episode of care based on corresponding weight scores (estimation of indirect disease costs)

Step 4: Develop a method for calculating the (financial) burden of diseases treated at the health facilty in a defined period of time

Step 5: Compare the results of financial burden of disease calculations based on a sufficiently large dataset using 3 different methods (evaluation of the developed method)

1. The method of equal distribution of care delivery costs over all clinical conditions linked to an episode of care
2. The newly developed CALCO method of weight score based care delivery cost distribution
3. The method of manually distributing care delivery costs over all clinical conditions linked to an episode of care. This is done by a clinician and is referred to as the 'golden standard'.

Results

Step1: development of a weight-scoring method

This method has been based on elements of the work of Murray and Lopez on the concept of Disability Adjusted Life Years (DALY's). The DALY is a metric that is used to quantify the burden of diseases, injuries and health risk factors in a single measure. It is based on years of life lost from premature death and years of life lived in less than full health:

$$DALY_x = YLL_x + YLD_x \quad (1)$$

Where:

$DALY_x$ = DALY for clinical condition x

YLL_x = Years of Life Lost due to premature death caused by clinical condition x

YLD_x = Years Lived with Disability caused by clinical condition x

= [Incidence$_x$] x [Average disability duration$_x$] x [weight$_x$]

The weight reflects the seriousness of the clinical condition on a scale from 0 (perfect health) to 1 (death) and therefore has been considered an excellent candidate for weight-scoring KPGS clinical conditions. The concept has been introduced by Murray and Lopez for the purpose of their Global Burden of Disease (GBD) study in 1990 and was reused in the WHO GBD study in 2004 [7] assigning a score to a total of 107 GBD-clinical conditions (diseases and injuries). For every concerned GBD-clinical condition, a link has been made to corresponding ICD10 codes, enabling mapping on KPGS-clinical conditions used at the Kigali University Teaching Hospital:

- 76 of the 167 KPGS codes could be directly mapped onto a GBD clinical condition. In these cases, the GBD weight-score was transferred to the corresponding KPGS code.
- 21 KPGS codes cover symptoms or circumstances influencing health and have not been assigned a weight-score
- The remaining 70 KPGS clinical conditions had no equivalent in the GBD study. They have been assigned weight scores by clinicians referring to a table of sample-scores as shown in Table 1.

Table 1 – Sample scores table

Score	Sample clinical conditions
0,00	Mild anemia, mild hearing loss
0,05	Upper respiratory infection, migraine, skin diseases
0,10	Sleeping disorders, moderate hearing loss, low back pain
0,20	Serious hearing loss, reumatoid arthritis
0,30	Tuberculosis
0,40	Neuropsychiatric disorders
0,50	HIV, mental retardation
0,60	Meningitis
0,70	Major depression, metastatic cancer
0,80	Terminal cancer, major neurologic handicap
0,90	Complicated CVA

Step 2: develop a method for distributing care delivery costs

The purpose of this method is to distribute care delivery costs/income proportionally over all clinical conditions linked to an episode of care based on corresponding weight scores. In order to do so, we have first developed the concept of *Comorbidity Index of a diagnosis d* (I_d). The index I_d expresses the importance of a diagnosis within the context of an episode of care and is calculated as follows:

$$I_d = \Sigma W / W_d \quad (2)$$

Where:

- I_d = Comorbidity index of clinical condition *d* for an episode of care.
- ΣW = Sum of all weight scores of all clinical conditions associated to the episode of care
- W_d = Weight score for clinical condition *d*

As a consequence, the value of I_d is at least equal to 1 (e.g. when diagnosis *d* is the sole diagnosis linked to the episode of care), greater values indicating a lower weight of the diagnosis within the global clinical picture of the admission.

Care delivery costs can then be assigned to particular diagnoses using the following formula:

$$C_d = \Sigma C / I_d \quad (3)$$

Where:

- C_d = Care delivery costs/income associated to a clinical condition *d* for an episode of care
- ΣC = Sum of all care delivery costs/income for the episode of care
- I_d = Comorbidity index of clinical condition *d* for the episode of care.

Step 3: develop a method for distributing overhead costs

The purpose of this method is to distribute overhead costs proportionally over all clinical conditions linked to an episode of care based on corresponding weight scores:

$$O_d = \frac{\Sigma O}{\Sigma \delta} \times \frac{\delta}{I_d} \quad (4)$$

Where:

- O_d = overhead costs associated to a clinical condition *d* for an episode of care
- ΣO = the total overhead costs of the health facility for the studied period of time
- $\Sigma \delta$ = the total number of admission days at the health facility in the studied period of time
- δ = duration in days of the episode of care
- I_d = Comorbidity index of clinical condition *d* for the episode of care.

Step 4: calculating the (financial) burden of disease treated at the health facilty in a defined period of time

The total financial burden of a diagnosis *d* at a health facility can then be described by the sum of direct disease-related costs (care deliveries) and indirect disease costs (overhead):

$$F_d = \Sigma C_d + \Sigma O_d \quad (5)$$

Where:

- F_d = the total financial burden of disease for diagnosis *d* over the studied period
- ΣC_d = direct disease-related costs, represented by the sum of all care delivery costs/income associated to a clinical condition *d* for all episodes of care in the studied period
- ΣO_d = indirect disease costs, represented by the sum of all overhead costs associated to a clinical condition *d* for all episodes of care in the studied period

The average financial burden per episode of care for a diagnosis *d* at a health facility would then be:

$$F_{da} = F_d / n_d \quad (6)$$

Where:

- F_{da} = the average financial burden of disease for diagnosis *d* per episode of care over the studied period
- F_d = the total financial burden of disease for diagnosis *d* over the studied period
- n_d = the total number of episodes of care with diagnosis *d* in the study period

Then we also calculate the average comorbidity index for a diagnosis *d* (I_{da}):

$$I_{da} = \Sigma I_d / n_d \quad (7)$$

Where:

I_{da} = the average comorbidity index for diagnosis *d* per episode of care over the studied period

ΣI_d = the sum of all comorbidity indexes for all diagnosis *d*-related episodes of care over the study period

n_d = the total number of episodes of care related to diagnosis *d* in the study period

Step 5: evaluation of the methods developed in steps 1 to 4

The main objective of this evaluation step was to compare the results obtained with the newly developed CALCO method to:

1. A 'golden standard' provided by manual analysis of the same dataset by a hospital physician, calculating F_d and F_{da} based on clinical analysis of every episode of care by manual assignment of care deliveries to individual diagnoses
2. The actual method of equal distribution of care delivery costs over all diagnoses linked to an episode of care (equal weight-score for all diagnoses)

Because no reliable data on care delivery costs was registered in the hospital database, only care delivery income has been taken into account for the evaluation. The comparison was performed for all cases of 4 major clinical conditions treated at the hospital in the period between February 1st and May 1st 2009. The results are shown in Table 2.

Table 2 shows that the total care delivery cost F_d and the average cost per episode of care F_{da} related to 4 important clinical conditions could be estimated by the CALCO method within an acceptable margin of error. The deviations from the results obtained by the 'golden standard' method vary from -8,7% to +8,4%. This certainly presents an important improvement compared to the method of equal distribution of costs over all episode of care-related clinical conditions where deviations vary between -22,1% and +78,4%. However, the improvement seems to be minimal for 'KPGS code 160: Perinatal complications'. This is primarily due to the fact that in the large majority of the related episodes of care, 'Perinatal complications' represented the sole diagnosed clinical condition. This fact is also documented by the low I_{da} score for the 'Equal distribution method', where I_{da} equals to the average number of diagnoses per episode of care related to 'Perinatal complications'.

In a second stage, we have calculated F_d and F_{da} for all clinical conditions treated at the CHUK in the period from February 1st and September 1st 2009 (8.309 episodes of care). Table 3 shows the top 10 of clinical conditions responsible for the highest accumulated costs in the study period (F_d). Table 4 ranks the top 10 clinical conditions according to the average cost of an episode of care (F_{da}).

Table 2 – F_d, F_{da} and I_{da} calculation method comparison

Method	F_d	F_{da}	I_{da}	deviation
KPGS code 01B: Tuberculosis (n=31)				
GS	$4.349,87	$140,32	-	-
CALCO	$4.214,60	$135,95	1,340	-3,1%
ED	$3.461,89	$111,67	1,730	-20,4%
KPGS code 01V: Malaria (n=42)				
GS	$3.338,90	$79,50	-	-
CALCO	$3.046,79	$72,54	1,250	-8,7%
ED	$2.601,26	$61,93	1,610	-22,1%
KPGS code 04D: Nutritional deficiencies (n=29)				
GS	$1.088,97	$37,55	-	-
CALCO	$1.180,11	$40,69	7,860	+8,4%
ED	$1.942,79	$66,99	2,220	+78,4%
KPGS code 160: Perinatal complications (n=93)				
GS	$9.922,18	$106,69	-	-
CALCO	$10.268,56	$110,41	1,360	+3,5%
ED	$10.377,26	$111,58	1,250	+4,6%

GS = Golden standard

ED = Equal distribution of care delivery costs over all diagnoses linked to an episode of care

Table 3 – Top 10 clinical conditions sorted by F_d

Clinical condition	F_d	F_{da}
15B: Pregnancy complications	**$86.819,06**	$122,97
19A: Fractures	**$66.431,48**	$254,53
140: Genito-urinary diseases	**$39.581,10**	$122,54
190: Other trauma / intoxication	**$31.439,31**	$236,39
160: Perinatal complications	**$23.213,62**	$87,93
02F: Benign neoplasms	**$20.403,62**	$153,41
02A: Malignant neoplasms	**$19.835,44**	$146,93
11G: Peritoneal diseases	**$19.553,61**	$376,03
04B: Diabetes mellitus	**$16.470,61**	$249,55
10C: Pneumonia	**$14.635,57**	$114,34

Table 4 – Top 10 clinical conditions sorted by F_{da}

Clinical condition	F_d	F_{da}
19B: Burns and corrosions	$14.035,99	**$467,87**
11G: Peritoneal diseases	$19.553,61	**$376,03**
19A: Soft tissue disorders	$1.879,72	**$375,94**
07D: Diseases of iris & cil bord	$363,82	**$363,82**
06H: Polyneuropathia	$2035,94	**$339,32**
11P: Intussusception	$5.244,12	**$308,48**
09L: Intracranial haemorrhage	$4.220,70	**$281,38**
13C: Spine disorders	$1.117,67	**$279,42**
11G: Appendix diseases	$5.021,61	**$278,98**
11R: Hepatic failure	$1.319,05	**$263,81**

Discussion

The study provides evidence that the CALCO method enables calculation within acceptable margins of error of the financial burden of diseases in a hospital environment in Sub-Saharan Africa. CALCO has been completely integrated in the OpenClinic® hospital information system used at the CHUK health facility. All necessary calculations can be performed based on information registered in daily routine procedures and require no extra data-entry from hospital staff.

The method documents the distribution of hospital-bound income and costs over 167 clinical entities covering all ICD10 codes. This information can be used for multiple purposes:

- Detecting the clinical conditions that weigh most on the health facility budget. The actual study taught us that the top 3 clinical conditions in Table 3 account for more than 10% of the total hospital income.
- Estimating income/cost evolution related to disease incidence changes
- Comparing episode of care based costs for specific clinical conditions between health facilities
- Monitoring episode of care based costs for specific clinical conditions over time within a health facility

In the near future, the CALCO algorithms will be reused in a number of PBF implementations in Rwanda, notably for the health district of the City of Kigali. However, the actual CALCO method makes no use of international coding standards for procedures and care deliveries, limiting to some extent comparability of health facilities. Future developments will have to focus on this aspect.

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