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A case-mix classification system for explaining healthcare costs using administrative data in Italy

Maria Chiara Corti[a], Francesco Avossa[a], Elena Schievano[a], Pietro Gallina[b], Eliana Ferroni[a,*], Natalia Alba[c], Matilde Dotto[a], Cristina Basso[d], Silvia Tiozzo Netti[b], Ugo Fedeli[a], Domenico Mantoan[e]

[a] Epidemiological System of the Veneto Region, Padua, Italy
[b] Local Health Unit no 6, Padua, Italy
[c] Local Health Unit no 9, Verona, Italy
[d] Intermediate Care Unit of The Veneto Region, Venice, Italy
[e] Health and Social Services of the Veneto Region, Venice, Italy

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ABSTRACT

Background: The Italian National Health Service (NHS) provides universal coverage to all citizens, granting primary and hospital care with a copayment system for outpatient and drug services. Financing of Local Health Trusts (LHTs) is based on a capitation system adjusted only for age, gender and area of residence. We applied a risk-adjustment system (Johns Hopkins Adjusted Clinical Groups System, ACG® System) in order to explain health care costs using routinely collected administrative data in the Veneto Region (North-eastern Italy).

Methods: All residents in the Veneto Region were included in the study. The ACG system was applied to classify the regional population based on the following information sources for the year 2015: Hospital Discharges, Emergency Room visits, Chronic disease registry for copayment exemptions, ambulatory visits, medications, the Home care database, and drug prescriptions. Simple linear regressions were used to contrast an age-gender model to models incorporating more comprehensive risk measures aimed at predicting health care costs.

Results: A simple age-gender model explained only 8% of the variance of 2015 total costs. Adding diagnoses-related variables provided a 23% increase, while pharmacy based variables provided an additional 17% increase in explained variance. The adjusted R-squared of the comprehensive model was 6 times that of the simple age-gender model.

Conclusions: ACG System provides substantial improvement in predicting health care costs when compared to simple age-gender adjustments. Aging itself is not the main determinant of the increase of health care costs, which is better explained by the accumulation of chronic conditions and the resulting multimorbidity.

1. Introduction

The Italian National Health Service (NHS) provides universal coverage to all residents, granting primary, outpatient and hospital care with a copayment for outpatient and drug services.

The NHS is organized at central, regional and local level. At national level, the Ministry of Health allocates national funds to the Regions which are responsible for organizing and delivering health care. At local level, geographically based Local Health Care Trusts (LHTs) directly deliver public health, community health services and primary care, and secondary and specialist care directly or through public hospitals or accredited private providers. Each LHT is financed through a capitation system adjusted for age, gender and geographic area of residence, in the assumption that these variables adequately adjust for the health care resource use and needs of a given population [1].

Progressive aging of the population in Western countries together with the increase of the burden of chronic diseases represent a challenge for health care systems, which are still largely configured for individual diseases rather than multimorbidity [2,3]. Multimorbidity is associated with high mortality, reduced functional status and increased use of health care resources [4,5]. There is the need for public health organizations to better understand the population's morbidity burden and its relationship to actual resource needs, use and allocation [6].

Several methods have been applied in order to evaluate health care costs. The Charlson index was demonstrated to be effective in predicting costs in primary care and other multimorbidity classification

* Corresponding author at: Epidemiological System of Veneto Region, Passaggio Gaudenzio 1, Padua, Italy.
E-mail address: eliana.ferroni@regione.veneto.it (E. Ferroni).

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systems are currently available [7,8].

Johns Hopkins Adjusted Clinical Group (ACG®) System measures the morbidity burden of patient populations based on disease patterns, age and gender relying on the diagnostic and/or pharmaceutical code information found in other electronic medical records, providing an accurate representation of the morbidity burden of populations. The ACG System has been used in commercial and research settings and has been validated in many European and non-European countries, including several countries with health care systems based on universal coverage [9–18].

Compared to other performance models, ACG System was found to better explain the variability of health care costs [19]. In Italy it was recently used to analyzed direct costs for a single chronic condition in a LHT [20]. The aim of this study is to apply ACG system to explain the overall health care costs in the Veneto Region (around 5 million inhabitants).

2. Methods

2.1. Data collection

The study was carried out in the Veneto Region, including all residents (n 4,958,539) in 2015. For each individual registered in the Veneto Health Care Population Registry (a compulsory registry for receiving universal coverage), data on diagnoses, drugs, procedures and costs for calendar year 2015 were retrieved from the administrative health care databases routinely available in the Veneto Region and were analyzed using the Johns Hopkins University Adjusted Clinical Groups System (ACG® v.10.0.1) [6]. Sources of data included routinely available administrative databases (Hospital Discharge Abstracts, Emergency Room visits, Chronic disease registry for copayment exemptions, ambulatory visits and medications, and the Home care database). In order to assure data completeness, chronic diagnoses codes from the last 5 years were also collected from the Hospital Discharge Database. Depending on where the diagnosis came from, the code could be either ICD-9-CM [21], ICD-10 [22] or ICPC [23]. With regard to drug expenditure and usage, only drugs reimbursed by the Regional Health Service were considered, as over-the-counter drug data were not available. Costs were calculated on the basis of a medications' actual costs and of inpatient/outpatients fees related to hospital admissions or outpatient services received during year 2015.

2.2. ACG system

The ACG System provides several risk assessment measures. Using diagnosis codes, the ACG actuarial cells assign individuals to one of 93 mutually exclusive combinations of conditions based on the number of different types of illnesses occurring in individuals over one year of observation combined with age and gender [6]. A simple collapsing of these categories allows easy stratification of the population into Healthy, Low, Moderate, High and Very High risk categories, also defined as Resource Utilization Bands (RUBs). Another component of the ACG System uses diagnoses to assign disease or condition categories, Expanded Diagnosis Clusters (EDCs). EDCs provide a useful metric for statistically testing if disease prevalence of a population sub-group is different than the overall average. Pharmacy codes are categorized into morbidity groups known as Rx-MGs: drugs coded according to the Anatomical Therapeutic Chemical (ATC) classification were assigned to disease or condition categories based on morbidity type, duration, stability, route of administration and therapeutic goal. The ACG System accepts ICD-9 and ICD-10 (including clinical modification or CM versions), ICPC, ATC, and other codes. If “type” of code is properly identified, the program can handle multiple code sets simultaneously [24].

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Table 1
Population distribution by age and sex, Veneto Region, 2015.

Age class	Sex				Total		
	Males		Females				
	N	%	N	%	N	%	%
0–13	324,303	51.4	307,105	48.6	631,408	100,0	12.7
14–34	513,134	50.7	499,704	49.3	1,012,838	100,0	20.4
35–64	1,093,512	50.1	1,090,431	49.9	2,183,943	100,0	44.0
65–74	259,027	47.7	284,046	52.3	543,073	100,0	11.0
75–84	171,140	42.9	227,599	57.1	398,739	100,0	8.0
85+	56,875	30.2	131,663	69.8	188,538	100,0	3.8
Total	2,417,991	48.8	2,540,548	51.2	4,958,539	100,0	100.0

2.3. Statistical analysis

Simple ordinary least squares regression analysis was performed to assess the linkage between health care costs and risk assessment variables assigned by the ACG System using NHS data. The basic form of the models was $y = X\beta + \varepsilon$ where y = cost in 2015 and β included: 1) age gender; 2) age, gender and healthy, low, moderate, high, and very high morbidity indicators; 3) age, gender and ACG actuarial cells; 4) age, gender, ACG actuarial cells and Rx-MGs. With the exception of Rx-MGs, which were not mutually exclusive, every variable included in the model was a categorical variable. Adjusted R-squared were computed. As our interest was in assessing the linkage between costs and risk assessment variables, individuals who did not experience health care expenses during the observation period were excluded as were individuals with extremely high cost (outlier cases beyond the 97.5 percentile in the cost distribution).

3. Results

The age and sex distribution of the study population reflects the northern-Italian general population distribution [25,26] (Table 1). As shown in Fig. 1, in which are described population and costs by risk categorization, only 4.3% of subjects in the study population were classified in the High and Very High risk categories, that accounts for 33.2% of total public health costs, while Healthy Users, who represent 37.1% of the population, explain only 7.8% of the costs. This high proportion of healthy users (costs without diagnoses) is explained by the lack of diagnoses in the ambulatory care setting, where only costs and not diagnoses of outpatient services were recorded. Overall, 23.3% of the population classified as higher risk (moderate, high and very high risk) accounts for 77.8% of the costs (Fig. 1).

Part of the population (19.7%) had no diagnoses and no costs and persons in this risk category were classified as non-users (Fig. 1). Hypertension with or without major complications (171.6/1000), type 2 diabetes w/o complication (39.1/1000), arrhythmias, other endocrine disorders, and malignancies are the most frequently documented conditions, as shown in Table 2, where the 20 most frequent conditions' prevalence is presented. During 2015, 62.9% of the population used one or more drugs. The most frequently filled prescriptions were for Acute Minor Infections (332.6/1000), Hypertension (228.8/1000), and Peptic Disease (151.3/1000). The mean cost of every risk category, calculated on the dataset used to fit the models (total costs ≤97.5°pctl) is 201.10€ for RUB = 1 (Healthy Users), 627.40€ for RUB = 2 (Low), 1377.34€ for RUB = 3 (Moderate), 3007.19€ for RUB = 4 (High), 4562.65€ for RUB = 5 (Very High). Overall costs in the whole population were accounted by hospital care (49%), drug prescriptions (25%), ambulatory care, imaging, and laboratory tests (21%), emergency room visits (2%), other settings of care (including rehabilitation, hospice, home care, 3%).

In linear regression analyses, a simple “Age-Gender” model explained only 8% of the variance of total health care costs (Fig. 2).