



**Adaptive capacity of the Adjusted Clinical Groups Case-Mix System to the cost of primary health care in Catalonia (Spain): A Observational Study**

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**TITLE PAGE****Adaptive capacity of the Adjusted Clinical Groups Case-Mix System to the cost of primary health care in Catalonia (Spain): A Observational Study****Authors**

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## ABSTRACT

*Objectives:* To describe the adaptive capacity of the Adjusted Clinical Groups (ACG) system to the cost of care in primary healthcare (PHC) centers in Catalonia (Spain).

*Design:* Retrospective study (multicenters) conducted using computerized medical records

*Setting:* 13 primary care teams in 2008 were included.

*Participants:* All patients registered in the study centers who required care between January 1 and December 31, 2008 were finally studied. Patients not registered in the study centers during the study period were excluded.

*Outcome measures:* demographic (age and sex), dependent (cost of care) and case mix variables were studied. The cost model for each patient was established by differentiating the fixed and variable costs. To evaluate the adaptive capacity of the ACG system, Pearson's coefficient of variation (CV) and the percentage of outliers were calculated. Multiple linear regression analysis was used for predictive models.

*Results:* The number of patients studied was 227,235 (frequency: 5.9 visits per person per year), with a mean of 4.5 (3.2) episodes and 8.1 (8.2) visits per patient per year. The mean total cost was €654.2. The explanatory power of the ACG system was 36.9% for costs (56.9% without outliers). Ten ACG categories accounted for 60.1% of all cases and 19 for 80.9%. Five categories represented 71% of poor performance (N = 78,887, 34.7%), particularly category 0300 -Acute Minor, Age 6+ (N = 26,909; 11.8%), which had a CV = 139% and 6.6% of outliers.

*Conclusions:* The ACG system is suitable for the classification of PHC patients in Catalonia. Their adaptive capacity would be improved by desegregating some categories, especially in pediatric patients.

**Keywords:** Adjusted Clinical Groups. Poor performance. Use of resources. Primary care. Health care costs.

## ARTICLE SUMMARY

### *Article focus*

- In health management, separating financing, purchasing and the provision of services requires more precise instruments and measurement of healthcare activity.
- The Adjusted Clinical Groups (ACG) Case-Mix System is a system of risk adjustment that classifies persons according to the diseases they present over a given period.

### *Key messages*

- The ACG system is an appropriate manner of classifying patients in routine clinical practice in PHC centers in Catalonia.
- Although improvements to the adaptive capacity through disaggregation of some categories according to age groups and, especially, the number of acute episodes in pediatric patients, would be necessary to reduce intra-group variation.

### *Strengths and limitations of this study*

- The greatest limitations of the study are related to the quality of the records and information systems.
- Without standardization of methodologies in terms of patient characteristics and the number and measurement of variables, the results and their generalizability should be interpreted with caution.

## INTRODUCTION

In health management, separating financing, purchasing and the provision of services requires more precise instruments and measurement of healthcare activity<sup>1-2</sup>. Various countries are developing methods of per capita funding as a mechanism for allocating health care resources in a given region<sup>3</sup>. The Adjusted Clinical Groups (ACG) Case-Mix System is a system of risk adjustment that classifies persons according to the diseases they present over a given period. The main objective is to measure the degree of disease in patient populations according to different levels of morbidity<sup>4-5</sup>.

Classification systems for ambulatory patients, especially primary healthcare (PHC) patients, have not been widely used even in the USA, where they mainly originated. In addition, there is some uncertainty about the adaptive capacity of these instruments in health fields other than that for which they were designed. These classification systems relate the burden of disease, consumption of resources and the real costs of care<sup>6-11</sup>. Therefore, studies aimed at improving knowledge of the relationships between these factors can provide valuable evidence.

In general, ACG are accepted as useful in our setting and their use is increasing in various areas. However, some ACG categories seem to have excess variability and therefore we decided to study the performance of each ACG category in PHC centers in Catalonia<sup>6,12-13</sup>.

The aim of this study was to identify the retrospective adaptive capacity and poorly-performing categories of the ACG system according to the cost of care in various PHC centers in Catalonia (Spain) in daily clinical practice.

## METHODS

### *Design and study population*

We conducted a retrospective, multicenter study based on computerized medical records of PHC patients. All records were dissociated to ensure the confidentiality of the data. The study population consisted of all patients (N=310,235) assigned to thirteen PHC centers in Catalonia belonging to four service providers. The patient population was predominantly urban, lower-middle class, with industrial occupations. All centers included provide universal free-at-the-point-of care healthcare with private provision of services in concert with the Catalan Health Service. All patients registered in the study centers who required care between January 1 and December 31, 2008 were finally studied. Patients not registered in the study centers during the study period were excluded.

### *Data retrieval and processing*

Dependent variables were defined as the mean number of episodes and the direct costs of PHC. The independent variables analyzed were: age, sex, care provider and clinical service (family medicine [age  $\geq 15$  years] and pediatrics [age 0-14 years]). An episode or reason for consultation was considered as a care process equivalent to a diagnosis. The health problems diagnosed were coded using the International Classification for Primary Care (ICPC-2)<sup>14</sup>. A conversion (mapping) from ICPC-2 codes to ICD-9-CM was made by a working group (one documentalist, two clinicians and two technical consultants). Relationships between the ICPC-2 and ICD-9-CM were divided into three groups: 1) no relationship (ICPC-2 code with no equivalent in ICD-9-CM), 2) one-way relationship (one ICPC-2 code with a single equivalent in ICD-9-CM, the optimal situation) and 3) multiple relationships (one ICPC-2 code with several possible equivalents in ICD-9-CM).

The following measures were used to calculate overall morbidity: a) the Charlson comorbidity index<sup>15</sup> as an approximation of severity, and b) the individual case mix index, obtained using the ACG. The operating algorithm of the ACG Grouper version 8.2 (<http://www.acg.jhsph.edu>)<sup>16</sup> consists of a series of consecutive steps that result in 106 ACG, which are mutually-exclusive groups for each patient treated.

To construct an ACG, the age, sex and the reasons for consultation or diagnosis according to ICD-9-CM are required. The first stage groups the diagnoses of the ICD-9-CM in 32 Ambulatory Diagnostic Groups (ADG) (a patient may have one or more ADG), the second step groups the ADG into 12 Collapsed Ambulatory Diagnostic Groups (CADG), the third step transforms these into 25 Major Ambulatory Categories (MAC), and finally these are transformed into an ACG category. At the end of the process, each patient is assigned to a single group with similar resource consumption. The application provides resource utilization bands (RUB), with each patient being grouped into one of five mutually-exclusive categories according to their morbidity (1: healthy users, 2: low morbidity, 3: moderate morbidity, 4: high morbidity and 5: very high morbidity)<sup>4-5</sup>.

To measure the performance or adaptive capacity of each ACG category (intra-group variability of the total cost of care) we used: a) the Pearson coefficient of variation (CV), in which a coefficient greater than 100% was considered poor performance, b) the percentage of outliers obtained through data refining of variables. The cutoff point (T) for outliers was established using the formula:  $T=Q_3+1.5(Q_3-Q_1)$ , where  $Q_3$  and  $Q_1$  are the third and first quartile of the distribution, respectively.

### *Use of resources and cost model*

The design of the system of costs took into account the information requirements and degree of development of available information systems. The unit of care product used as the basis for the final calculation was the cost per patient treated during the study period. For each patient, we differentiated fixed costs and variable costs. The main fixed costs were: staff (salaries and wages), purchases (drugs, medical supplies, etc.), outsourced services (building repair and maintenance, professional services, etc.), and a set of costs relating to structural services and center management according to the General Accounting Plan for Health Care Centers. Fixed costs were allocated per visit (mean/unit: fixed costs/total number of visits). Variable costs per patient were calculated according to diagnostic petitions (laboratory, radiology, diagnostic or therapeutic, referrals to specialists and drug prescriptions). The tariffs used to calculate costs came from analytical cost-accounting studies (see Table 1). Finally, the cost per patient was calculated as:  $C_p = (\text{mean cost per visit} \times \text{number of visits} [\text{fixed costs}]) + (\text{variable costs})$ .

### *Data confidentiality*

The confidentiality of records according to the Organic Law on Data Protection (15/1999, December 13) was respected by dissociating the data.

### *Data quality and statistical analysis*

In a preliminary analysis we carefully reviewed the medical records to observe their frequency and distribution and to search for possible errors in recording or coding.

We performed a descriptive univariate analysis including mean values, standard deviation (SD), proportions and percentiles. The normal distribution of variables was confirmed using the Kolmogorov-Smirnov test. In the bivariate analysis, we used the chi-square test, the Student t test, ANOVA, Pearson's linear correlation and the Mann-Whitney Wilcoxon nonparametric test. To evaluate the explanatory power of the ACG System we used the coefficient of determination ( $R^2$ ) obtained from the ratio intra-group variability/ total variability (ANOVA). Multiple linear regression analysis (method: stepwise, dependent variable: total cost) was used to determine the variables that best explained the cost of PHC. The analysis was made using the SPSS for Windows v. 18 statistical package. Statistical significance was established as  $p < 0.05$ .

## RESULTS

A total of 227,235 patients were registered in the study centers in 2008 (86.5% in family medicine and 13.5% in pediatrics). Table 2 details the general characteristics of the patient population, the co-morbidity and the total costs. Patients had a mean of 4.5 (3.2) episodes and 8.1 (8.2) visits per year. The percentage of males (51.1% vs. 43.3%,  $p < 0.001$ ) and visits (9.7 versus 7.8  $p < 0.001$ ) were higher in pediatric patients. The mean age of women was higher than that of men, 39.2 versus 37.8 ( $p < 0.001$ ). The total cost was 148.7 million euros (93.3% for family medicine). Drugs were prescribed to 80.1% of patients. Fixed costs accounted for 29.1% of total costs and variable costs for 70.9% (including 47.5% on drug prescriptions). Therefore, the mean total cost per patient per year was € 654.2 (851.7), € 702.5 in Family Medicine and Pediatric € 344.6,  $p < 0.001$ . A total of 6.2% of patients were considered outliers, and after data refining the mean unitary cost per year was € 556.7.

In the regression model (Table 3,  $N=227,235$ ), the cost of drugs and episodes explained 94% of total costs. The results of the model using cleansed data ( $N = 213,169$ ) were similar, although there was a greater beta coefficient for the episodes in comparison with the ADG (75.139 versus 10.023) although this did not modify the percentages of the coefficient of determination (0.917 versus 0.918). The association between the mean/unit cost according to age is shown in Figure 1.

The performance (patient distribution) and adaptive capacity (intra-group variation in categories) of the ACG classification are shown in Table 4. All patients were grouped in a category. However, no patients were grouped in 37 of the 106 categories, meaning that all patients were grouped in the remaining 69 categories. Furthermore, 61% of all patients were grouped in 10 categories and 80.9% in 19 ( $N = 183,721$ , Table 4). This distribution showed no significant differences according to the service provider. In 10 ACG categories, a poor performance (poor adaptive capacity) was observed ( $CV > 100\%$ ,  $N = 110,917$ , 48.8% of patients, Table 4 and Figure 2). The two categories with the highest CV were 1600-Preventive/Administrative ( $N = 8,527$ , 3.8%, outliers: 12.5%) and 1300-Psychosocial, w/o Psychosocial Unstable ( $N = 3,653$ , 1.6%, outliers: 10.7%).

We carried out a more-detailed analysis according to poor performance and the number of patients in each category. Table 5 shows the distribution of five ACG categories (making up 71% of poorly-performing categories,  $N = 78,887$ ). Compared with the total of 69 categories ( $N = 227,235$ ) these five categories had a lower explanatory power (coefficient of determination,  $R^2$ ) in episodes (44.3% versus 77.4%) and total costs (18.8% versus 36.9%),  $p < 0.001$ . For refined data, the results were 46.4% versus 78.4% for episodes and 36.5% versus 56.9% for total costs,  $p < 0.001$ . Category 0300-Acute Minor, Age 6 + ( $N = 26,909$ ; 11.8%) had a  $CV = 139\%$  and 6.6% of outliers and showed



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3 significant differences before and after data refining. Categories 0400-Acute Major (N = 8160) and  
4 1800-Acute Minor/Acute Major (N = 9077) performed similarly. Category 4100-2-3 Other ADG  
5 Combinations, Age 35 +, had the highest number of patients (N = 28,864, 12.7%), with a high mean  
6 number of episodes (3.9 of total cases, compared to 4.5 in outliers,  $p < 0.001$ ), resulting in increased  
7 costs in these patients. The  $R^2$  of the five poorly-performing categories was 34.7%.  
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## 10 11 12 13 14 **DISCUSSION**

15 This study determined the retrospective adaptive capacity of the ACG classification system according  
16 to the cost of PHC in Catalonia (Spain) in daily clinical practice, identifying 10 categories that  
17 performed poorly in the Catalan health system. In Catalonia, the use of capitation-based funding is  
18 still in its infancy compared to other European healthcare systems. The focus is on incorporating risk  
19 adjustment indicators in order to provide unbiased estimates of the expected costs of an individual  
20 patient in each health plan<sup>2-17</sup>.  
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27 There is abundant published evidence on the use and overall performance of the ACG classification,  
28 but evidence on categories that perform poorly is very limited<sup>4-7,9,12,18-23</sup>. It is expected that persons  
29 with similar morbidity and demographic characteristics will have a similar use of resources. In this  
30 respect, the available empirical evidence shows that it is technically possible to find an adjustment  
31 formula to predict at least a portion of the variation in health expenditure per person, and also that the  
32 highest predictive values are achieved by systems that incorporate diagnostic information<sup>6,21,25</sup>. This  
33 has been proven in our study, since the number of episodes showed a greater explanatory power  
34 with respect to ACG categories than the total costs. Furthermore, data refining may lessen the weight  
35 of random factors in predicting expenditure, although it is known that no system of classification of  
36 patients into RUB explains all the variation in the use of resources<sup>6-7,10,26</sup>.  
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45 In general, the Grouper requires a limited number of variables for each patient: age, sex and  
46 diagnosis (not necessarily correlated in time). This simplicity of use is compatible with the needs of  
47 PHC, which must work with large daily volumes of information, limited time for each patient,  
48 professional cooperation (doctors, nurses, social workers, etc.) and repeated visits from the same  
49 patient. However, a greater degree of computerization of PHC and the establishment of mechanisms  
50 for consensus between health professionals would be required to increase data quality and the  
51 consistency of records, especially in the identification of diagnoses<sup>11,23</sup>.  
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3 The general results of the study (demographic variables [age and sex], case mix [morbidity] and  
4 resource use levels [RUB]), fall within the parameters expected in PHC in Spain. Furthermore, the  
5 distribution of patients within ACG categories is similar to the results obtained in other studies (60% of  
6 patients are grouped in 10 ACG categories), and stable over time<sup>4,6,8-9,12,18-23,25-28</sup>. In the different  
7 regression models analyzed, the number of episodes had a greater explanatory power than the ADG  
8 (dependent variable: cost of care), although there was a high correlation between the two variables  
9 (Tables 3 and 4).  
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15 This may be because the grouping works by binary combinations of ADG, regardless of the number  
16 of recurrences and the type of disorder<sup>4,5</sup>. For example, a patient with one or more episodes of upper  
17 respiratory tract infection over time, with or without concomitant pharyngitis, may remain grouped in  
18 the same ACG category, resulting in widely-differing use of resources and degree of variation in  
19 costs. This point has been suggested by some authors as a limitation of the ACG system, although  
20 recent years have seen an expansion of categories from 51 to 103 to avoid such problems<sup>23</sup>.  
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27 Poor performance or adaptive capacity was observed in 10 ACG categories (N = 110,917, 48.8% of  
28 patients). The two categories with the highest CV were: Preventive/Administrative and Psychosocial,  
29 w/o Psychosocial Unstable. These results are difficult to compare for several reasons: a) These  
30 categories include many different circumstances and conditions (administrative processes, preventive  
31 actions and health promotion, unstable conditions with an unpredictable risk of recurrence, etc.), b)  
32 These conditions tend to be associated with poor-quality medical records (prescriptions not linked to  
33 a diagnosis, etc.), and c) The presence of different organizational models between centers (patient  
34 circuits, etc.) as a result of health policies, causing a high degree of variability that affects the use of  
35 resources and their costs.  
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43 We found that five categories accounted for 71% of poor performance. In general, acute disease  
44 (0300-Acute Minor, Age 6 +, 0400-Acute Major and 1800-Acute Minor/Acute Major), representing a  
45 large number of pediatric patients, had a poor adaptive capacity. The ACG classification in Catalonia  
46 might be improved by expanding some of these categories according to age groups and, especially,  
47 by quantifying the number of episodes occurring during the study period. However, in the categories  
48 4100-2-3 Other ADG Combinations, Age 35 + and 3900-2-3 Other ADG Combinations, Males Age 18  
49 to 34, the performance with respect to classification into RUB could be improved by separating  
50 different ranges of episodes or ADG.  
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3 Therefore, a possible scenario for the debate on the funding model for PHC teams could be  
4 developed using a combination of factors: a) the weighting of structural costs related to accessibility,  
5 b) the variable costs according to the case-mix (ACG) and patient complexity, adapting the  
6 classification to the country, and c) quality targets derived from the policy sought by the purchaser  
7 and expected by the customer. In this aspect, the adaptive capacity of the ACG system to the Catalan  
8 setting could be bettered by improving the definition of some categories. This would facilitate policy  
9 making using benchmarking with respect to the complexity (case mix) and efficiency of PHC centers  
10 with the population served, enabling capitation payments (risk adjustment)<sup>4,26</sup>.

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17 The greatest limitations of the study are related to the quality of the records and information systems.  
18 Without standardization of methodologies in terms of patient characteristics and the number and  
19 measurement of variables, the results and their generalizability should be interpreted with caution<sup>24</sup>.  
20 In addition, possible differences between health professionals in the selection of diagnoses may  
21 contaminate the comparison of costs between groups. However, strength of the study is that the large  
22 sample size could minimize these drawbacks. The ACG system was designed to measure the health  
23 status and medical resources consumed in a set of patients and, therefore, population-based studies  
24 of risk-adjusted capitation payments and the clinical management of PHC centers may be of  
25 considerable interest in Catalonia<sup>23, 29</sup>.

## 35 CONCLUSIONS

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37 The ACG system is an appropriate manner of classifying patients in routine clinical practice in PHC  
38 centers in Catalonia, although improvements to the adaptive capacity through disaggregation of some  
39 categories according to age groups and, especially, the number of acute episodes in pediatric  
40 patients, would be necessary to reduce intra-group variation.

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47  
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49  
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51 Gol Clinical Research Institute (IDIAP Jordi Gol).

52  
53 **Contributors:** AS, SV, RN, CV, AP and MV planned the study. AS, RN and SV supervised the campaign  
54 registration, data entry and follow-up. AS was responsible for the statistical analysis with help from SV. AS  
55 wrote the first draft of the paper and has the primary responsibility for the final content. All authors contributed to  
56 and approved the final manuscript. AS is the head of the Catalan study.

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Table 1: Mean unit costs in 2008

Health resources	Unit cost (€)
Health visit	23.62
Laboratory tests	22.70
Conventional radiology	18.84
Diagnostic tests/therapy	37.85
Referral to reference specialist	106.29
Drug prescriptions	RRPvat

Source: analytical accounting conducted for this study, RRPvat: recommended retail price including Value Added Tax.

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Table 2: General characteristics of study: co-morbidity and cost model

Characteristics	Total	
Patients	N = 227,235	
<i>General</i>		
Number of physicians	224	
Number of episodes	1,020,606	
Number of visits	1,834,326	
Mean age, years	44.1 (23.7)	
- 25 Percentile	27.0	
- 50 Percentile	43.0	
- 75 Percentile	67.0	
Sex (female)	55.6%	
<i>General co-morbidity</i>		
Mean ADG	3.7 (2.2)	
- 25 Percentile	2.0	
- 50 Percentile	3.0	
- 75 Percentile	5.0	
Mean episodes	4.5 (3.2)	
Mean Charlson index	0.2 (0.6)	
RUB	2.4 (0.8)	
1	16.9%	
2	31.0%	
3	47.9%	
4	3.8	
5	0.5	
Outliers (N = 14,066)	6.2%	
<i>Cost model (in euros) per year</i>		
	Mean/unit	%
- Fixed costs	190.7 (193.3)	29.1%
- Laboratory	51.9 (73.8)	7.9%
- Conventional radiology	21.4 (34.1)	3.3
- Complementary tests	6.2 (19.6)	1.0%
- Referrals to specialists	73.1 (117.3)	11.2%
- Drug prescriptions	310.8 (681.2)	47.5%
Total cost of PHC	654.2 (851.7)	100.0%
- Cost of family medicine	92.9%	
- Cost of pediatric medicine(0-14years)	7.1.	

Values expressed as mean (SD: standard deviation) or percentage; RUB: resource utilization bands, ADG: Ambulatory Diagnostic Groups, PHC: Primary Health Care.

Table 3: Final result of multiple linear regression model.

Final model	Beta	95% CI		R <sup>2</sup>	t	p	Collinearity statistics	
		Li	Ls				Tolerance	Factor
<i>Without data refining, N = 227235</i>								
Pharmacy cost	1.000	0.998	1.002	0.879	1204.095	<0.001	0.539	1.856
Episodes	80.878	79.290	82.466	0.944	99.810	<0.001	0.025	40.051
RUB	22.631	21.263	23.999	0.946	32.426	<0.001	0.512	1.953
Age	0.393	0.352	0.433	0.946	18.997	<0.001	0.715	1.399
ADG	-12.146	-13.904	-10.388	0.946	-13.540	<0.001	0.024	41.647
Sex	-8.402	-10.064	-6.741	0.946	-9.912	<0.001	0.972	1.029
<i>With data refining, N = 213169</i>								
Pharmacy cost	1.031	1.029	1.033	0.826	893.708	<0.001	0.584	1.713
Episodes	75.139	73.566	76.712	0.917	93.624	<0.001	0.024	42.008
RUB	21.727	20.413	23.041	0.918	32.410	<0.001	0.512	1.954
Age	0.387	0.346	0.428	0.918	18.613	<0.001	0.667	1.500
ADG	-10.023	-11.755	-8.291	0.918	-11.340	<0.001	0.023	43.539
Sex	-7.367	-8.960	-5.773	0.918	-9.062	<0.001	0.973	1.028

Dependent variable: total cost, input method: stepwise, CI: confidence intervals; Li: lower limit; Ls: upper limit; p: statistical significance, t: Student test; R<sup>2</sup>: coefficient of determination; RUB: resource utilization bands, ADG: Ambulatory Diagnostic Groups. The cutoff (T) for data refining of outliers was established using the formula:  $T = Q_3 + 1.5(Q_3 - Q_1)$  where  $Q_3$  and  $Q_1$  are the third and first quartiles of the distribution, respectively.



Table 4: Distribution of ACG categories with the most patients: variability of categories

ACG	ACG Description	N	%	Cost <sup>(1)</sup>	CV	Outliers <sup>(2)</sup>
4100	2-3 Other ADG Combinations, Age 35+	28864	12.7%	776.3	107%	6.5%
0300	Acute Minor, Age 6+	26909	11.8%	169.6	139%	6.6%
4910	6-9 Other ADG Combinations, Age 35+, 0-1 Major ADGs	14876	6.5%	1,624.4	67%	4.5%
2100	Acute Minor/Likely to Recur, Age 6+, w/o Allergy	11867	5.2%	304.7	91%	5.3%
4410	4-5 Other ADG Combinations, Age 45+, no Major ADGs	10551	4.6%	1,025.4	74%	5.3%
4420	4-5 Other ADG Combinations, Age 45+, 1 Major ADGs	10137	4.5%	1,336.2	79%	4.6%
0500	Likely to Recur, w/o Allergies	9872	4.3%	187.2	140%	6.6%
1800	Acute Minor/Acute Major	9077	4.0%	353.2	104%	5.9%
1600	Preventive/Administrative	8527	3.8%	229.5	215%	12.5%
0400	Acute Major	8160	3.6%	237.3	160%	8.1%
0900	Chronic Medical: Stable	6319	2.8%	506.7	114%	6.2%
3900	2-3 Other ADG Combinations, Males Age 18 to 34	5877	2.6%	341.7	117%	6.0%
3200	Acute Minor/Acute Major/Likely to Recur, Age 12+, w/o Allergy	5785	2.5%	525.0	89%	6.3%
2300	Acute Minor/Chronic Medical: Stable	5756	2.5%	612.6	95%	6.3%
3600	Acute Minor/Acute Major/Likely to Recur/Chronic Medical: Stable	5575	2.5%	1,022.1	72%	5.0%
4310	4-5 Other ADG Combinations, Age 18 to 44, no Major ADGs	4168	1.8%	554.8	86%	6.4%
4920	6-9 Other ADG Combinations, Age 35+, 2 Major ADGs	4089	1.8%	2,102.5	67%	3.5%
2800	Acute Major/Likely to Recur	3659	1.6%	351.0	102%	6.9%
1300	Psychosocial, w/o Psychosocial Unstable	3653	1.6%	340.4	175%	10.7%

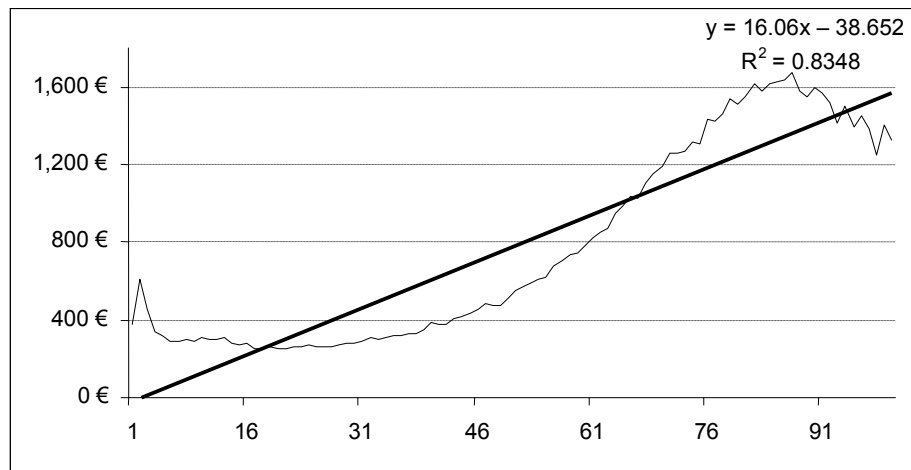
Nineteen ACG categories contain 80.9% of patients (N = 183,721). No patient was grouped in 37 ACG categories; ACG, Adjusted Clinical Groups (Code)<sup>(1)</sup>: Gross cost (mean/unit in euros), CV: Pearson's Coefficient of Variation,<sup>(2)</sup>:outliers: percentage of patients, cut-off:  $T = Q_3 + 1.5(Q_3 - Q_1)$  where  $Q_3$  and  $Q_1$  are the third and first quartiles of the distribution, respectively. Total sample: N = 227235, CV = 130.0%, outliers: 6.2%.

Table 5: Distribution of five poorly-performing ACG categories according to age, episodes and cost

ACG categories (coding and description)	Total	No outliers	Outliers			
Variables	N	Mean	N	Mean	N	Mean
<i>4100: 2-3 Other ADG Combinations, Age 35+</i>	28864		26992		1872	
Age		60.5 (14.8)		59.7 (14.6)		70.9 (12.8)
Episodes		3.9 (1.3)		3.9 (1.2)		4.5 (1.5)
Total cost		776.3 (828.2)		620.3 (448.7)		3026.1 (1504.4)
<i>0300: Acute Minor, Age 6+</i>	26909		25142		1767	
Age		33.1 (16.5)		31.9 (15.4)		50.5 (22.1)
Episodes		1.7 (1.1)		1.7 (0.9)		2.5 (1.4)
Total cost		169.5 (236.5)		125.2 (91.7)		800.0 (554.3)
<i>1800: Acute Minor/Acute Major</i>	9077		8538		539	
Age		32.1 (19.8)		30.8 (18.5)		51.6 (27.1)
Episodes		3.6 (1.5)		3.6 (1.4)		4.8 (2.3)
Total cost		353.2 (366.2)		288.7 (166.5)		1374.2 (843.8)
<i>0400: Acute Major</i>	8160		7503		657	
Age		38.5 (18.2)		36.6 (16.7)		59.9 (20.6)
Episodes		1.6 (0.8)		1.5 (0.7)		2.1 (1.1)
Total cost		237.3 (379.5)		158.3 (108.7)		1139.1 (877.8)
<i>3900: 2-3 Other ADG Combinations, Males Age 18 to 34</i>	5877		5523		354	
Age		28.1 (4.5)		28.0 (4.5)		28.7 (4.2)
Episodes		3.3 (1.0)		3.3 (1.1)		3.8 (1.2)
Total cost		341.6 (399.1)		273.7 (154.1)		1401.2 (1040.1)

Contrast statistic: Chi<sup>2</sup> test or Mann-Whitney Wilcoxon test; p<0.001 in all cases, ADG: Ambulatory Diagnostic Groups; coefficient of determination (R<sup>2</sup>): intra-group/total variability (ANOVA).

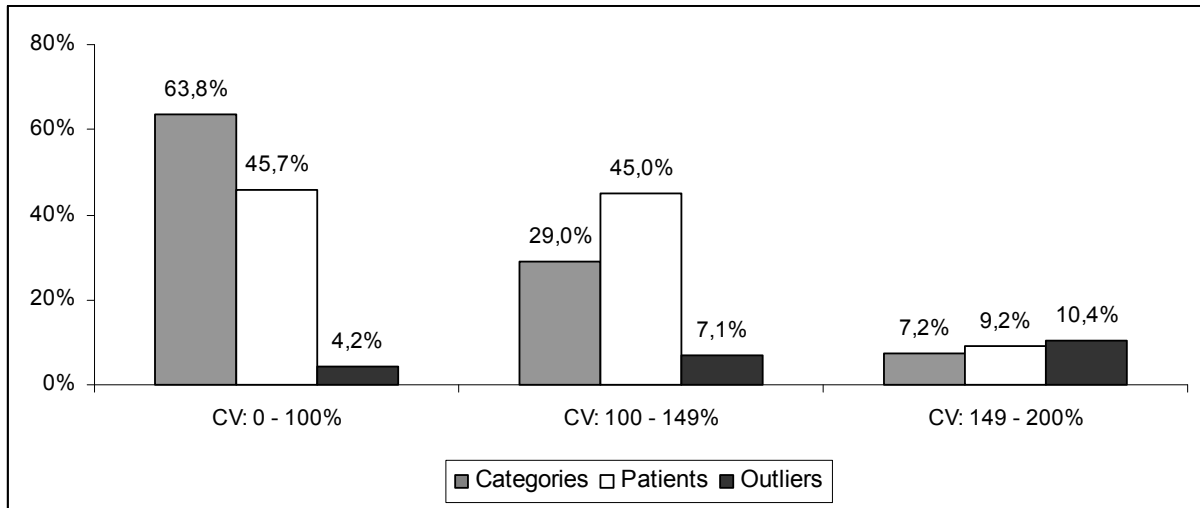
Figure 1: Correlation of the cost of care according to age.



R<sup>2</sup>: Coefficient of determination; model adjusted by linear regression

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Figure 2: Percentage distribution of coefficients of variation according to the number of categories, patients and outliers



CV: Pearson's coefficient of variation; contrast statistic:  $\chi^2$ ,  $p < 0.001$  for all categories.

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**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology\***  
**Checklist for cohort, case-control, and cross-sectional studies (combined)**

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	X
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	X
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	X
Objectives	3	State specific objectives, including any pre-specified hypotheses	X
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	X
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	X
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	X
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	X
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	X
Bias	9	Describe any efforts to address potential sources of bias	X
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	X
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	X
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	X
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	X

		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	X
		(b) Give reasons for non-participation at each stage	X
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	X
		(b) Indicate number of participants with missing data for each variable of interest	X
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	X
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	X
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	X
		(b) Report category boundaries when continuous variables were categorized	X
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	X
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	X
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	X
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	X
Generalisability	21	Discuss the generalisability (external validity) of the study results	X
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	X

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.  
**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).



**Adaptive capacity of the Adjusted Clinical Groups Case-Mix System to the cost of primary health care in Catalonia (Spain): A Observational Study**

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**TITLE PAGE****Adaptive capacity of the Adjusted Clinical Groups Case-Mix System to the cost of primary health care in Catalonia (Spain): A Observational Study****Authors**

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## ABSTRACT

*Objectives:* To describe the adaptive capacity of the Adjusted Clinical Groups (ACG) system to the cost of care in primary healthcare (PHC) centers in Catalonia (Spain).

*Design:* Retrospective study (multicenters) conducted using computerized medical records

*Setting:* 13 primary care teams in 2008 were included.

*Participants:* All patients registered in the study centers who required care between January 1 and December 31, 2008 were finally studied. Patients not registered in the study centers during the study period were excluded.

*Outcome measures:* demographic (age and sex), dependent (cost of care) and case mix variables were studied. The cost model for each patient was established by differentiating the fixed and variable costs. To evaluate the adaptive capacity of the ACG system, Pearson's coefficient of variation (CV) and the percentage of outliers were calculated. Multiple linear regression analysis was used for predictive models.

*Results:* The number of patients studied was 227,235 (frequency: 5.9 visits per person per year), with a mean of 4.5 (3.2) episodes and 8.1 (8.2) visits per patient per year. The mean total cost was €654.2. The explanatory power of the ACG system was 36.9% for costs (56.9% without outliers). Ten ACG categories accounted for 60.1% of all cases and 19 for 80.9%. Five categories represented 71% of poor performance (N = 78,887, 34.7%), particularly category 0300 -Acute Minor, Age 6+ (N = 26,909; 11.8%), which had a CV = 139% and 6.6% of outliers.

*Conclusions:* The ACG system is an appropriate manner of classifying patients in routine clinical practice in PHC centers in Catalonia, although improvements to the adaptive capacity through disaggregation of some categories according to age groups and, especially, the number of acute episodes in pediatric patients, would be necessary to reduce intra-group variation.

**Keywords:** Adjusted Clinical Groups. Poor performance. Use of resources. Primary care. Health care costs.

## ARTICLE SUMMARY

### *Article focus*

- In health management, separating financing, purchasing and the provision of services requires more precise instruments and measurement of healthcare activity.
- The Adjusted Clinical Groups (ACG) Case-Mix System is a system of risk adjustment that classifies persons according to the diseases they present over a given period.

### *Key messages*

- The ACG system is an appropriate manner of classifying patients in routine clinical practice in PHC centers in Catalonia.
- Although improvements to the adaptive capacity through disaggregation of some categories according to age groups and, especially, the number of acute episodes in pediatric patients, would be necessary to reduce intra-group variation.

### *Strengths and limitations of this study*

- The greatest limitations of the study are related to the quality of the records and information systems.
- Without standardization of methodologies in terms of patient characteristics and the number and measurement of variables, the results and their generalizability should be interpreted with caution.

## INTRODUCTION

In health management, separating financing, purchasing and the provision of services requires more precise instruments and measurement of healthcare activity<sup>1-2</sup>. Various countries are developing methods of per capita funding as a mechanism for allocating health care resources in a given region<sup>3</sup>. The Adjusted Clinical Groups (ACG) Case-Mix System is a system of risk adjustment that classifies persons according to the diseases they present over a given period. The main objective is to measure the degree of disease in patient populations according to different levels of morbidity<sup>4-5</sup>.

Classification systems for ambulatory patients, especially primary healthcare (PHC) patients, have not been widely used even in the USA, where they mainly originated. In addition, there is some uncertainty about the adaptive capacity of these instruments in health fields other than that for which they were designed. These classification systems relate the burden of disease, consumption of resources and the real costs of care<sup>6-11</sup>. Therefore, studies aimed at improving knowledge of the relationships between these factors can provide valuable evidence.

In general, ACG are accepted as useful in our setting and their use is increasing in various areas. However, some ACG categories seem to have excess variability and therefore we decided to study the performance of each ACG category in PHC centers in Catalonia<sup>6,12-13</sup>.

The aim of this study was to identify the retrospective adaptive capacity and poorly-performing categories of the ACG system according to the cost of care in various PHC centers in Catalonia (Spain) in daily clinical practice.

## METHODS

### *Design and study population*

We conducted a retrospective, multicenter study based on computerized medical records of PHC patients. All records were dissociated to ensure the confidentiality of the data. The study population consisted of all patients (N=310,235) assigned to thirteen PHC centers in Catalonia belonging to four service providers. The patient population was predominantly urban, lower-middle class, with industrial occupations. All centers included provide universal free-at-the-point-of care healthcare with private provision of services in concert with the Catalan Health Service. All patients registered in the study centers who required care between January 1 and December 31, 2008 were finally studied. Patients not registered in the study centers during the study period were excluded.

### *Data retrieval and processing*

Dependent variables were defined as the mean number of episodes and the direct costs of PHC. The independent variables analyzed were: age, sex, care provider and clinical service (family medicine [age  $\geq 15$  years] and pediatrics [age 0-14 years]). An episode or reason for consultation was considered as a care process equivalent to a diagnosis. The health problems diagnosed were coded using the International Classification for Primary Care (ICPC-2)<sup>14</sup>. A conversion (mapping) from ICPC-2 codes to ICD-9-CM was made by a working group (one documentalist, two clinicians and two technical consultants). Relationships between the ICPC-2 and ICD-9-CM were divided into three groups: 1) no relationship (ICPC-2 code with no equivalent in ICD-9-CM), 2) one-way relationship (one ICPC-2 code with a single equivalent in ICD-9-CM, the optimal situation) and 3) multiple relationships (one ICPC-2 code with several possible equivalents in ICD-9-CM).

The following measures were used to calculate overall morbidity: a) the Charlson comorbidity index<sup>15</sup> as an approximation of severity, and b) the individual case mix index, obtained using the ACG. The operating algorithm of the ACG Grouper version 8.2 (<http://www.acg.jhsph.edu>)<sup>16</sup> consists of a series of consecutive steps that result in 106 ACG, which are mutually-exclusive groups for each patient treated.

To construct an ACG, the age, sex and the reasons for consultation or diagnosis according to ICD-9-CM are required. The first stage groups the diagnoses of the ICD-9-CM in 32 Ambulatory Diagnostic Groups (ADG) (a patient may have one or more ADG), the second step groups the ADG into 12 Collapsed Ambulatory Diagnostic Groups (CADG), the third step transforms these into 25 Major Ambulatory Categories (MAC), and finally these are transformed into an ACG category. At the end of the process, each patient is assigned to a single group with similar resource consumption. The application provides resource utilization bands (RUB), with each patient being grouped into one of five mutually-exclusive categories according to their morbidity (1: healthy users, 2: low morbidity, 3: moderate morbidity, 4: high morbidity and 5: very high morbidity)<sup>4-5</sup>.

To measure the performance or adaptive capacity of each ACG category (intra-group variability of the total cost of care) we used: a) the Pearson coefficient of variation (CV), in which a coefficient greater than 100% was considered poor performance, b) the percentage of outliers obtained through data refining of variables. The cutoff point (T) for outliers was established using the formula:  $T=Q_3+1.5(Q_3-Q_1)$ , where  $Q_3$  and  $Q_1$  are the third and first quartile of the distribution, respectively.

### *Use of resources and cost model*

The design of the system of costs took into account the information requirements and degree of development of available information systems. The unit of care product used as the basis for the final calculation was the cost per patient treated during the study period. For each patient, we differentiated fixed costs and variable costs. The main fixed costs were: staff (salaries and wages), purchases (drugs, medical supplies, etc.), outsourced services (building repair and maintenance, professional services, etc.), and a set of costs relating to structural services and center management according to the General Accounting Plan for Health Care Centers. Fixed costs were allocated per visit (mean/unit: fixed costs/total number of visits). Variable costs per patient were calculated according to diagnostic petitions (laboratory, radiology, diagnostic or therapeutic, referrals to specialists and drug prescriptions). The tariffs used to calculate costs came from analytical cost-accounting studies (see Table 1). Finally, the cost per patient was calculated as:  $C_p = (\text{mean cost per visit} \times \text{number of visits} [\text{fixed costs}]) + (\text{variable costs})$ .

### *Data confidentiality*

According to Spanish law, being a retrospective design and because it is not investigated the effectiveness of any medicine, the study does not need specific approval from an IRB or the patient's consent, but instead required the dissociation of the data. The confidentiality of records according to the Organic Law on Data Protection (15/1999, December 13) was respected by dissociating the data.

### *Data quality and statistical analysis*

In a preliminary analysis we carefully reviewed the medical records to observe their frequency and distribution and to search for possible errors in recording or coding. We performed a descriptive univariate analysis including mean values, standard deviation (SD), proportions and percentiles. The normal distribution of variables was confirmed using the Kolmogorov-Smirnov test. In the bivariate analysis, we used the chi-square test, the Student t test, ANOVA, Pearson's linear correlation and the Mann-Whitney Wilcoxon nonparametric test. To evaluate the explanatory power of the ACG System we used the coefficient of determination ( $R^2$ ) obtained from the ratio intra-group variability/ total variability (ANOVA). Multiple linear regression analysis (method: stepwise, dependent variable: total cost) was used to determine the variables that best explained the cost of PHC (independents variables: age, sex, episodes, number ADG, RUB and pharmacy cost). The analysis was made using the SPSS for Windows v.18 statistical package. Statistical significance was established as  $p < 0.05$ .

## RESULTS

A total of 227,235 patients were registered in the study centers in 2008 (86.5% in family medicine and 13.5% in pediatrics). Table 2 details the general characteristics of the patient population, the co-morbidity and the total costs. Patients had a mean of 4.5 (3.2) episodes and 8.1 (8.2) visits per year. The percentage of males (51.1% vs. 43.3%,  $p < 0.001$ ) and visits (9.7 versus 7.8  $p < 0.001$ ) were higher in pediatric patients. The mean age of women was higher than that of men, 39.2 versus 37.8 ( $p < 0.001$ ). The total cost was 148.7 million euros (93.3% for family medicine). Drugs were prescribed to 80.1% of patients. Fixed costs accounted for 29.1% of total costs and variable costs for 70.9% (including 47.5% on drug prescriptions). Therefore, the mean total cost per patient per year was € 654.2 (851.7), € 702.5 in Family Medicine and Pediatric € 344.6,  $p < 0.001$ . A total of 6.2% of patients were considered outliers, and after data refining the mean unitary cost per year was € 556.7.

In the regression model (Table 3,  $N=227,235$ ), the cost of drugs and episodes explained 94% of total costs. The results of the model using cleansed data ( $N = 213,169$ ) were similar, although there was a greater beta coefficient for the episodes in comparison with the ADG (75.139 versus 10.023) although this did not modify the percentages of the coefficient of determination (0.917 versus 0.918). The association between the mean/unit cost according to age is shown in Figure 1. **In the multivariate analysis by including only the clinical variables age, sex and number of ADG, the  $R^2$  was 56.5%.**

The performance (patient distribution) and adaptive capacity (intra-group variation in categories) of the ACG classification are shown in Table 4. All patients were grouped in a category. However, no patients were grouped in 37 of the 106 categories, meaning that all patients were grouped in the remaining 69 categories. Furthermore, 61% of all patients were grouped in 10 categories and 80.9% in 19 ( $N = 183,721$ , Table 4). This distribution showed no significant differences according to the service provider. In 10 ACG categories, a poor performance (poor adaptive capacity) was observed ( $CV > 100\%$ ,  $N = 110,917$ , 48.8% of patients, Table 4 and Figure 2). The two categories with the highest CV were 1600-Preventive/Administrative ( $N = 8,527$ , 3.8%, outliers: 12.5%) and 1300-Psychosocial, w/o Psychosocial Unstable ( $N = 3,653$ , 1.6%, outliers: 10.7%).

We carried out a more-detailed analysis according to poor performance and the number of patients in each category. Table 5 shows the distribution of five ACG categories (making up 71% of poorly-performing categories,  $N = 78,887$ ). Compared with the total of 69 categories ( $N = 227,235$ ) these five categories had a lower explanatory power (coefficient of determination,  $R^2$ ) in episodes (44.3% versus 77.4%) **and total costs (18.8% versus 36.9%),  $p < 0.001$ .** For refined data, the results were 46.4% versus 78.4% for episodes and 36.5% versus 56.9% for total costs,  $p < 0.001$ . Category 0300-

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Acute Minor, Age 6 + (N = 26,909; 11.8%) had a CV = 139% and 6.6% of outliers and showed significant differences before and after data refining. Categories 0400-Acute Major (N = 8160) and 1800-Acute Minor/Acute Major (N = 9077) performed similarly. Category 4100-2-3 Other ADG Combinations, Age 35 +, had the highest number of patients (N = 28,864, 12.7%), with a high mean number of episodes (3.9 of total cases, compared to 4.5 in outliers,  $p < 0.001$ ), resulting in increased costs in these patients. The  $R^2$  of the five poorly-performing categories was 34.7%.

## DISCUSSION

This study determined the retrospective adaptive capacity of the ACG classification system according to the cost of PHC in Catalonia (Spain) in daily clinical practice, identifying 10 categories that performed poorly in the Catalan health system. In Catalonia, the use of capitation-based funding is still in its infancy compared to other European healthcare systems. The focus is on incorporating risk adjustment indicators in order to provide unbiased estimates of the expected costs of an individual patient in each health plan<sup>2-17</sup>.

There is abundant published evidence on the use and overall performance of the ACG classification, but evidence on categories that perform poorly is very limited<sup>4-7,9,12,18-23</sup>. It is expected that persons with similar morbidity and demographic characteristics will have a similar use of resources. In this respect, the available empirical evidence shows that it is technically possible to find an adjustment formula to predict at least a portion of the variation in health expenditure per person, and also that the highest predictive values are achieved by systems that incorporate diagnostic information<sup>6,21,25</sup>. This has been proven in our study, since the number of episodes showed a greater explanatory power with respect to ACG categories than the total costs. Furthermore, data refining may lessen the weight of random factors in predicting expenditure, although it is known that no system of classification of patients into RUB explains all the variation in the use of resources<sup>6-7,10,26</sup>.

In general, the Grouper requires a limited number of variables for each patient: age, sex and diagnosis (not necessarily correlated in time). This simplicity of use is compatible with the needs of PHC, which must work with large daily volumes of information, limited time for each patient, professional cooperation (doctors, nurses, social workers, etc.) and repeated visits from the same patient. However, a greater degree of computerization of PHC and the establishment of mechanisms for consensus between health professionals would be required to increase data quality and the consistency of records, especially in the identification of diagnoses<sup>11,23</sup>.

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The general results of the study (demographic variables [age and sex], case mix [morbidity] and resource use levels [RUB]), fall within the parameters expected in PHC in Spain. Furthermore, the distribution of patients within ACG categories is similar to the results obtained in other studies (60% of patients are grouped in 10 ACG categories), and stable over time<sup>4,6,8-9,12,18-23,25-28</sup>. In the different regression models analyzed, the number of episodes had a greater explanatory power than the ADG (dependent variable: cost of care), although there was a high correlation between the two variables (Tables 3 and 4).

This may be because the grouping works by binary combinations of ADG, regardless of the number of recurrences and the type of disorder<sup>4,5</sup>. For example, a patient with one or more episodes of upper respiratory tract infection over time, with or without concomitant pharyngitis, may remain grouped in the same ACG category, resulting in widely-differing use of resources and degree of variation in costs. This point has been suggested by some authors as a limitation of the ACG system, although recent years have seen an expansion of categories from 51 to 103 to avoid such problems<sup>23</sup>.

Poor performance or adaptive capacity was observed in 10 ACG categories (N = 110,917, 48.8% of patients). The two categories with the highest CV were: Preventive/Administrative and Psychosocial, w/o Psychosocial Unstable. These results are difficult to compare for several reasons: a) These categories include many different circumstances and conditions (administrative processes, preventive actions and health promotion, unstable conditions with an unpredictable risk of recurrence, etc.), b) These conditions tend to be associated with poor-quality medical records (prescriptions not linked to a diagnosis, etc.), and c) The presence of different organizational models between centers (patient circuits, etc.) as a result of health policies, causing a high degree of variability that affects the use of resources and their costs.

We found that five categories accounted for 71% of poor performance. In general, acute disease (0300-Acute Minor, Age 6 +, 0400-Acute Major and 1800-Acute Minor/Acute Major), representing a large number of pediatric patients, had a poor adaptive capacity. The ACG classification in Catalonia might be improved by expanding some of these categories according to age groups and, especially, by quantifying the number of episodes occurring during the study period. However, in the categories 4100-2-3 Other ADG Combinations, Age 35 + and 3900-2-3 Other ADG Combinations, Males Age 18 to 34, the performance with respect to classification into RUB could be improved by separating different ranges of episodes or ADG.



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3 Therefore, a possible scenario for the debate on the funding model for PHC teams could be  
4 developed using a combination of factors: a) the weighting of structural costs related to accessibility,  
5 b) the variable costs according to the case-mix (ACG) and patient complexity, adapting the  
6 classification to the country, and c) quality targets derived from the policy sought by the purchaser  
7 and expected by the customer. In this aspect, the adaptive capacity of the ACG system to the Catalan  
8 setting could be bettered by improving the definition of some categories. This would facilitate policy  
9 making using benchmarking with respect to the complexity (case mix) and efficiency of PHC centers  
10 with the population served, enabling capitation payments (risk adjustment)<sup>4,26</sup>.

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17 The greatest limitations of the study are related to the quality of the records and information systems.  
18 Without standardization of methodologies in terms of patient characteristics and the number and  
19 measurement of variables, the results and their generalizability should be interpreted with caution<sup>24</sup>.  
20 In addition, possible differences between health professionals in the selection of diagnoses may  
21 contaminate the comparison of costs between groups. However, strength of the study is that the large  
22 sample size could minimize these drawbacks. The ACG system was designed to measure the health  
23 status and medical resources consumed in a set of patients and, therefore, population-based studies  
24 of risk-adjusted capitation payments and the clinical management of PHC centers may be of  
25 considerable interest in Catalonia<sup>23, 29</sup>.

## 35 CONCLUSIONS

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37 The ACG system is an appropriate manner of classifying patients in routine clinical practice in PHC  
38 centers in Catalonia, although improvements to the adaptive capacity through disaggregation of some  
39 categories according to age groups and, especially, the number of acute episodes in pediatric  
40 patients, would be necessary to reduce intra-group variation.

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49  
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53 **Contributors:** AS, SV, RN, CV, AP and MV planned the study. AS, RN and SV supervised the campaign  
54 registration, data entry and follow-up. AS was responsible for the statistical analysis with help from SV. AS  
55 wrote the first draft of the paper and has the primary responsibility for the final content. All authors contributed to  
56 and approved the final manuscript. AS is the head of the Catalan study.

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Table 1: Mean unit costs in 2008

Health resources	Unit cost (€)
Health visit	23.62
Laboratory tests	22.70
Conventional radiology	18.84
Diagnostic tests/therapy	37.85
Referral to reference specialist	106.29
Drug prescriptions	RRPvat

Source: analytical accounting conducted for this study, RRPvat: recommended retail price including Value Added Tax.

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Table 2: General characteristics of study: co-morbidity and cost model

Characteristics	Total	
Patients	N = 227,235	
<i>General</i>		
Number of physicians	224	
Number of episodes	1,020,606	
Number of visits	1,834,326	
Mean age, years	44.1 (23.7)	
- 25 Percentile	27.0	
- 50 Percentile	43.0	
- 75 Percentile	67.0	
Sex (female)	55.6%	
<i>General co-morbidity</i>		
Mean ADG	3.7 (2.2)	
- 25 Percentile	2.0	
- 50 Percentile	3.0	
- 75 Percentile	5.0	
Mean episodes	4.5 (3.2)	
Mean Charlson index	0.2 (0.6)	
RUB	2.4 (0.8)	
1	16.9%	
2	31.0%	
3	47.9%	
4	3.8	
5	0.5	
Outliers (N = 14,066)	6.2%	
<i>Cost model (in euros) per year</i>		
	Mean/unit	%
- Fixed costs	190.7 (193.3)	29.1%
- Laboratory	51.9 (73.8)	7.9%
- Conventional radiology	21.4 (34.1)	3.3
- Complementary tests	6.2 (19.6)	1.0%
- Referrals to specialists	73.1 (117.3)	11.2%
- Drug prescriptions	310.8 (681.2)	47.5%
Total cost of PHC	654.2 (851.7)	100.0%
- Cost of family medicine	92.9%	
- Cost of pediatric medicine(0-14years)	7.1.	

Values expressed as mean (SD: standard deviation) or percentage; RUB: resource utilization bands, ADG: Ambulatory Diagnostic Groups, PHC: Primary Health Care.

Table 3: Final result of multiple linear regression model.

Final model	Beta	95% CI		R <sup>2</sup>	t	p	Collinearity statistics	
		Li	Ls				Tolerance	Factor
<i>Without data refining, N = 227235</i>								
Pharmacy cost	1.000	0.998	1.002	0.879	1204.095	<0.001	0.539	1.856
Episodes	80.878	79.290	82.466	0.944	99.810	<0.001	0.025	40.051
RUB	22.631	21.263	23.999	0.946	32.426	<0.001	0.512	1.953
Age	0.393	0.352	0.433	0.946	18.997	<0.001	0.715	1.399
ADG	-12.146	-13.904	-10.388	0.946	-13.540	<0.001	0.024	41.647
Sex	-8.402	-10.064	-6.741	0.946	-9.912	<0.001	0.972	1.029
<i>With data refining, N = 213169</i>								
Pharmacy cost	1.031	1.029	1.033	0.826	893.708	<0.001	0.584	1.713
Episodes	75.139	73.566	76.712	0.917	93.624	<0.001	0.024	42.008
RUB	21.727	20.413	23.041	0.918	32.410	<0.001	0.512	1.954
Age	0.387	0.346	0.428	0.918	18.613	<0.001	0.667	1.500
ADG	-10.023	-11.755	-8.291	0.918	-11.340	<0.001	0.023	43.539
Sex	-7.367	-8.960	-5.773	0.918	-9.062	<0.001	0.973	1.028

Dependent variable: total cost, input method: stepwise, CI: confidence intervals; Li: lower limit; Ls: upper limit; p: statistical significance, t: Student test; R<sup>2</sup>: coefficient of determination; RUB: resource utilization bands, ADG: Ambulatory Diagnostic Groups. The cutoff (T) for data refining of outliers was established using the formula:  $T = Q_3 + 1.5(Q_3 - Q_1)$  where  $Q_3$  and  $Q_1$  are the third and first quartiles of the distribution, respectively.

Table 4: Distribution of ACG categories with the most patients: variability of categories

ACG	ACG Description	N	%	Cost <sup>(1)</sup>	CV	Outliers <sup>(2)</sup>
4100	2-3 Other ADG Combinations, Age 35+	28864	12.7%	776.3	107%	6.5%
0300	Acute Minor, Age 6+	26909	11.8%	169.6	139%	6.6%
4910	6-9 Other ADG Combinations, Age 35+, 0-1 Major ADGs	14876	6.5%	1,624.4	67%	4.5%
2100	Acute Minor/Likely to Recur, Age 6+, w/o Allergy	11867	5.2%	304.7	91%	5.3%
4410	4-5 Other ADG Combinations, Age 45+, no Major ADGs	10551	4.6%	1,025.4	74%	5.3%
4420	4-5 Other ADG Combinations, Age 45+, 1 Major ADGs	10137	4.5%	1,336.2	79%	4.6%
0500	Likely to Recur, w/o Allergies	9872	4.3%	187.2	140%	6.6%
1800	Acute Minor/Acute Major	9077	4.0%	353.2	104%	5.9%
1600	Preventive/Administrative	8527	3.8%	229.5	215%	12.5%
0400	Acute Major	8160	3.6%	237.3	160%	8.1%
0900	Chronic Medical: Stable	6319	2.8%	506.7	114%	6.2%
3900	2-3 Other ADG Combinations, Males Age 18 to 34	5877	2.6%	341.7	117%	6.0%
3200	Acute Minor/Acute Major/Likely to Recur, Age 12+, w/o Allergy	5785	2.5%	525.0	89%	6.3%
2300	Acute Minor/Chronic Medical: Stable	5756	2.5%	612.6	95%	6.3%
3600	Acute Minor/Acute Major/Likely to Recur/Chronic Medical: Stable	5575	2.5%	1,022.1	72%	5.0%
4310	4-5 Other ADG Combinations, Age 18 to 44, no Major ADGs	4168	1.8%	554.8	86%	6.4%
4920	6-9 Other ADG Combinations, Age 35+, 2 Major ADGs	4089	1.8%	2,102.5	67%	3.5%
2800	Acute Major/Likely to Recur	3659	1.6%	351.0	102%	6.9%
1300	Psychosocial, w/o Psychosocial Unstable	3653	1.6%	340.4	175%	10.7%

Nineteen ACG categories contain 80.9% of patients (N = 183,721). No patient was grouped in 37 ACG categories; ACG, Adjusted Clinical Groups (Code)<sup>(1)</sup>: Gross cost (mean/unit in euros), CV: Pearson's Coefficient of Variation,<sup>(2)</sup>:outliers: percentage of patients, cut-off:  $T = Q_3 + 1.5(Q_3 - Q_1)$  where  $Q_3$  and  $Q_1$  are the third and first quartiles of the distribution, respectively. Total sample: N = 227235, CV = 130.0%, outliers: 6.2%.

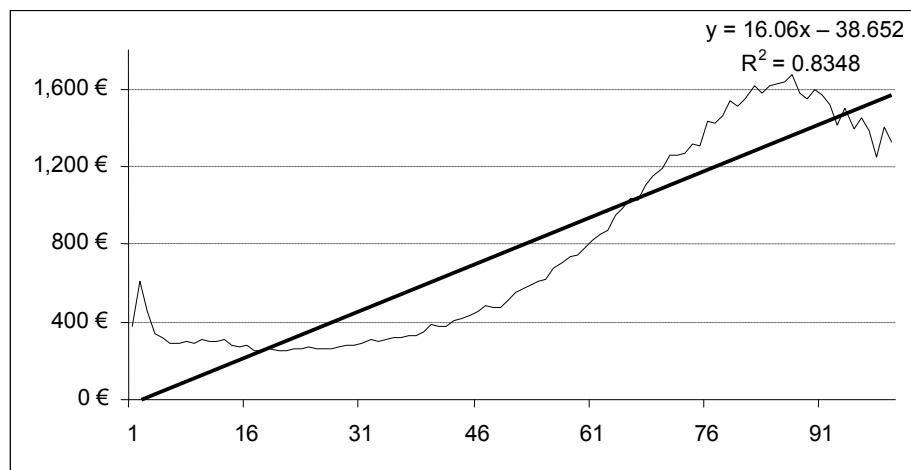
Table 5: Distribution of five poorly-performing ACG categories according to age, episodes and cost

ACG categories (coding and description)	Total	No outliers	Outliers			
Variables	N	Mean	N	Mean	N	Mean
<i>4100: 2-3 Other ADG Combinations, Age 35+</i>	28864		26992		1872	
Age		60.5 (14.8)		59.7 (14.6)		70.9 (12.8)
Episodes		3.9 (1.3)		3.9 (1.2)		4.5 (1.5)
Total cost		776.3 (828.2)		620.3 (448.7)		3026.1 (1504.4)
<i>0300: Acute Minor, Age 6+</i>	26909		25142		1767	
Age		33.1 (16.5)		31.9 (15.4)		50.5 (22.1)
Episodes		1.7 (1.1)		1.7 (0.9)		2.5 (1.4)
Total cost		169.5 (236.5)		125.2 (91.7)		800.0 (554.3)
<i>1800: Acute Minor/Acute Major</i>	9077		8538		539	
Age		32.1 (19.8)		30.8 (18.5)		51.6 (27.1)
Episodes		3.6 (1.5)		3.6 (1.4)		4.8 (2.3)
Total cost		353.2 (366.2)		288.7 (166.5)		1374.2 (843.8)
<i>0400: Acute Major</i>	8160		7503		657	
Age		38.5 (18.2)		36.6 (16.7)		59.9 (20.6)
Episodes		1.6 (0.8)		1.5 (0.7)		2.1 (1.1)
Total cost		237.3 (379.5)		158.3 (108.7)		1139.1 (877.8)
<i>3900: 2-3 Other ADG Combinations, Males Age 18 to 34</i>	5877		5523		354	
Age		28.1 (4.5)		28.0 (4.5)		28.7 (4.2)
Episodes		3.3 (1.0)		3.3 (1.1)		3.8 (1.2)
Total cost		341.6 (399.1)		273.7 (154.1)		1401.2 (1040.1)

Contrast statistic: Chi<sup>2</sup> test or Mann-Whitney Wilcoxon test; p<0.001 in all cases, ADG: Ambulatory Diagnostic Groups; coefficient of determination (R<sup>2</sup>): intra-group/total variability (ANOVA).



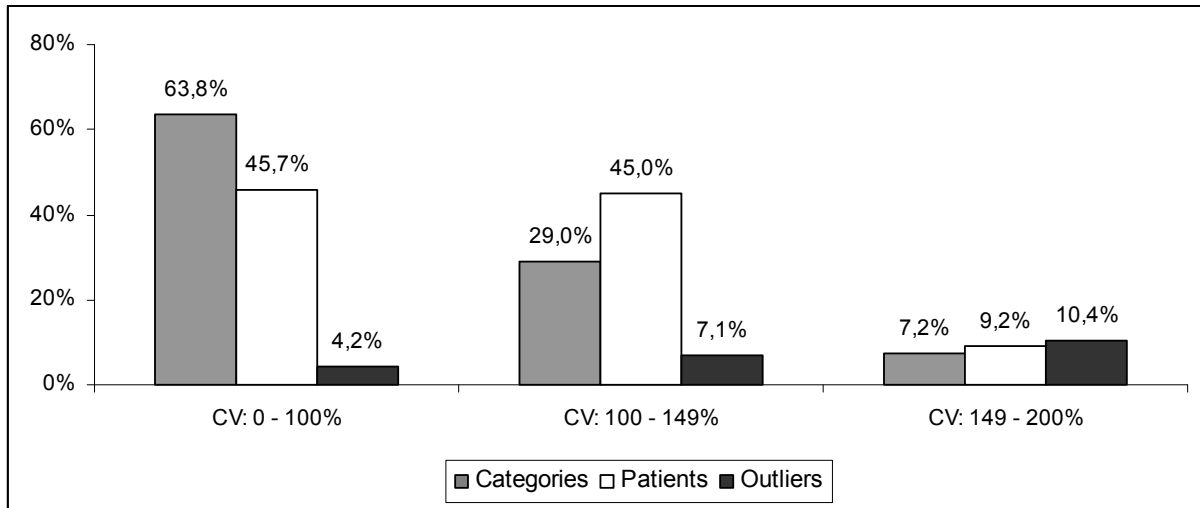
Figure 1: Correlation of the cost of care according to age.



R<sup>2</sup>: Coefficient of determination; model adjusted by linear regression

peer review only

Figure 2: Percentage distribution of coefficients of variation according to the number of categories, patients and outliers



CV: Pearson's coefficient of variation; contrast statistic:  $\chi^2$ ,  $p < 0.001$  for all categories.

Peer review only

**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology\***  
**Checklist for cohort, case-control, and cross-sectional studies (combined)**

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<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	X
Objectives	3	State specific objectives, including any pre-specified hypotheses	X
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	X
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	X
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	X
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Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	X
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	X
Bias	9	Describe any efforts to address potential sources of bias	X
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	X
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	X
		(b) Describe any methods used to examine subgroups and interactions	NA
		(c) Explain how missing data were addressed	X
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		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	
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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	X
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		(b) Report category boundaries when continuous variables were categorized	X
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Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	X
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<b>Other information</b>			
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\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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**Adaptive capacity of the Adjusted Clinical Groups Case-Mix System to the cost of primary health care in Catalonia (Spain): A Observational Study**

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology\*  
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**TITLE PAGE****Adaptive capacity of the Adjusted Clinical Groups Case-Mix System to the cost of primary health care in Catalonia (Spain): A Observational Study****Authors**

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## ABSTRACT

*Objectives:* To describe the adaptive capacity of the Adjusted Clinical Groups (ACG) system to the cost of care in primary healthcare (PHC) centers in Catalonia (Spain).

*Design:* Retrospective study (multicenters) conducted using computerized medical records

*Setting:* 13 primary care teams in 2008 were included.

*Participants:* All patients registered in the study centers who required care between January 1 and December 31, 2008 were finally studied. Patients not registered in the study centers during the study period were excluded.

*Outcome measures:* demographic (age and sex), dependent (cost of care) and case mix variables were studied. The cost model for each patient was established by differentiating the fixed and variable costs. To evaluate the adaptive capacity of the ACG system, Pearson's coefficient of variation (CV) and the percentage of outliers were calculated. **To evaluate the explanatory power of the ACG System we used the coefficient of determination ( $R^2$ ).**

*Results:* The number of patients studied was 227,235 (frequency: 5.9 visits per person per year), with a mean of 4.5 (3.2) episodes and 8.1 (8.2) visits per patient per year. The mean total cost was €654.2. The explanatory power of the ACG system was 36.9% for costs (**56.5% without outliers**). Ten ACG categories accounted for 60.1% of all cases and 19 for 80.9%. Five categories represented 71% of poor performance (N = 78,887, 34.7%), particularly category 0300 -Acute Minor, Age 6+ (N = 26,909; 11.8%), which had a CV = 139% and 6.6% of outliers.

*Conclusions:* The ACG system is an appropriate manner of classifying patients in routine clinical practice in PHC centers in Catalonia, although improvements to the adaptive capacity through disaggregation of some categories according to age groups and, especially, the number of acute episodes in pediatric patients, would be necessary to reduce intra-group variation.

**Keywords:** Adjusted Clinical Groups. Poor performance. Use of resources. Primary care. Health care costs.

## ARTICLE SUMMARY

### *Article focus*

- In health management, separating financing, purchasing and the provision of services requires more precise instruments and measurement of healthcare activity.
- The Adjusted Clinical Groups (ACG) Case-Mix System is a system of risk adjustment that classifies persons according to the diseases they present over a given period.

### *Key messages*

- The ACG system is an appropriate manner of classifying patients in routine clinical practice in PHC centers in Catalonia.
- Although improvements to the adaptive capacity through disaggregation of some categories according to age groups and, especially, the number of acute episodes in pediatric patients, would be necessary to reduce intra-group variation.

### *Strengths and limitations of this study*

- The greatest limitations of the study are related to the quality of the records and information systems.
- Without standardization of methodologies in terms of patient characteristics and the number and measurement of variables, the results and their generalizability should be interpreted with caution.

## INTRODUCTION

In health management, separating financing, purchasing and the provision of services requires more precise instruments and measurement of healthcare activity<sup>1-2</sup>. Various countries are developing methods of per capita funding as a mechanism for allocating health care resources in a given region<sup>3</sup>. The Adjusted Clinical Groups (ACG) Case-Mix System is a system of risk adjustment that classifies persons according to the diseases they present over a given period. The main objective is to measure the degree of disease in patient populations according to different levels of morbidity<sup>4-5</sup>.

Classification systems for ambulatory patients, especially primary healthcare (PHC) patients, have not been widely used even in the USA, where they mainly originated. In addition, there is some uncertainty about the adaptive capacity of these instruments in health fields other than that for which they were designed. These classification systems relate the burden of disease, consumption of resources and the real costs of care<sup>6-11</sup>. Therefore, studies aimed at improving knowledge of the relationships between these factors can provide valuable evidence.

In general, ACG are accepted as useful in our setting and their use is increasing in various areas. However, some ACG categories seem to have excess variability and therefore we decided to study the performance of each ACG category in PHC centers in Catalonia<sup>6,12-13</sup>.

The aim of this study was to identify the retrospective adaptive capacity and poorly-performing categories of the ACG system according to the cost of care in various PHC centers in Catalonia (Spain) in daily clinical practice.

## METHODS

### *Design and study population*

We conducted a retrospective, multicenter study based on computerized medical records of PHC patients. All records were dissociated to ensure the confidentiality of the data. The study population consisted of all patients (N=310,235) assigned to thirteen PHC centers in Catalonia belonging to four service providers. The patient population was predominantly urban, lower-middle class, with industrial occupations. All centers included provide universal free-at-the-point-of care healthcare with private provision of services in concert with the Catalan Health Service. All patients registered in the study centers who required care between January 1 and December 31, 2008 were finally studied. Patients not registered in the study centers during the study period were excluded.

### *Data retrieval and processing*

Dependent variables were defined as the mean number of episodes and the direct costs of PHC. The independent variables analyzed were: age, sex, care provider and clinical service (family medicine [age  $\geq 15$  years] and pediatrics [age 0-14 years]). An episode or reason for consultation was considered as a care process equivalent to a diagnosis. The health problems diagnosed were coded using the International Classification for Primary Care (ICPC-2)<sup>14</sup>. A conversion (mapping) from ICPC-2 codes to ICD-9-CM was made by a working group (one documentalist, two clinicians and two technical consultants). Relationships between the ICPC-2 and ICD-9-CM were divided into three groups: 1) no relationship (ICPC-2 code with no equivalent in ICD-9-CM), 2) one-way relationship (one ICPC-2 code with a single equivalent in ICD-9-CM, the optimal situation) and 3) multiple relationships (one ICPC-2 code with several possible equivalents in ICD-9-CM).

The following measures were used to calculate overall morbidity: a) the Charlson comorbidity index<sup>15</sup> as an approximation of severity, and b) the individual case mix index, obtained using the ACG. The operating algorithm of the ACG Grouper version 8.2 (<http://www.acg.jhsph.edu>)<sup>16</sup> consists of a series of consecutive steps that result in 106 ACG, which are mutually-exclusive groups for each patient treated.

To construct an ACG, the age, sex and the reasons for consultation or diagnosis according to ICD-9-CM are required. The first stage groups the diagnoses of the ICD-9-CM in 32 Ambulatory Diagnostic Groups (ADG) (a patient may have one or more ADG), the second step groups the ADG into 12 Collapsed Ambulatory Diagnostic Groups (CADG), the third step transforms these into 25 Major Ambulatory Categories (MAC), and finally these are transformed into an ACG category. At the end of the process, each patient is assigned to a single group with similar resource consumption. The application provides resource utilization bands (RUB), with each patient being grouped into one of five mutually-exclusive categories according to their morbidity (1: healthy users, 2: low morbidity, 3: moderate morbidity, 4: high morbidity and 5: very high morbidity)<sup>4-5</sup>.

To measure the performance or adaptive capacity of each ACG category (intra-group variability of the total cost of care) we used: a) the Pearson coefficient of variation (CV), in which a coefficient greater than 100% was considered poor performance, b) the percentage of outliers obtained through data refining of variables. The cutoff point (T) for outliers was established using the formula:  $T=Q_3+1.5(Q_3-Q_1)$ , where  $Q_3$  and  $Q_1$  are the third and first quartile of the distribution, respectively.

### *Use of resources and cost model*

The design of the system of costs took into account the information requirements and degree of development of available information systems. The unit of care product used as the basis for the final calculation was the cost per patient treated during the study period. For each patient, we differentiated fixed costs and variable costs. The main fixed costs were: staff (salaries and wages), purchases (drugs, medical supplies, etc.), outsourced services (building repair and maintenance, professional services, etc.), and a set of costs relating to structural services and center management according to the General Accounting Plan for Health Care Centers. Fixed costs were allocated per visit (mean/unit: fixed costs/total number of visits). Variable costs per patient were calculated according to diagnostic petitions (laboratory, radiology, diagnostic or therapeutic, referrals to specialists and drug prescriptions). The tariffs used to calculate costs came from analytical cost-accounting studies (see Table 1). Finally, the cost per patient was calculated as:  $C_p = (\text{mean cost per visit} \times \text{number of visits [fixed costs]}) + (\text{variable costs})$ .

### *Data confidentiality*

According to Spanish law, being a retrospective design and because it is not investigated the effectiveness of any medicine, the study does not need specific approval from an IRB or the patient's consent, but instead required the dissociation of the data. The confidentiality of records according to the Organic Law on Data Protection (15/1999, December 13) was respected by dissociating the data.

### *Data quality and statistical analysis*

In a preliminary analysis we carefully reviewed the medical records to observe their frequency and distribution and to search for possible errors in recording or coding. We performed a descriptive univariate analysis including mean values, standard deviation (SD), proportions and percentiles. The normal distribution of variables was confirmed using the Kolmogorov-Smirnov test. In the bivariate analysis, we used the chi-square test, the Student t test, ANOVA, Pearson's linear correlation and the Mann-Whitney Wilcoxon nonparametric test. [To evaluate the explanatory power of the ACG System we used the coefficient of determination \( \$R^2\$ \) obtained from the ratio intra-group variability/total variability \(ANOVA\).](#) The analysis was made using the SPSS for Windows v.18 statistical package. Statistical significance was established as  $p < 0.05$ .

## RESULTS

A total of 227,235 patients were registered in the study centers in 2008 (86.5% in family medicine and 13.5% in pediatrics). Table 2 details the general characteristics of the patient population, the comorbidity and the total costs. Patients had a mean of 4.5 (3.2) episodes and 8.1 (8.2) visits per year. The percentage of males (51.1% vs. 43.3%,  $p < 0.001$ ) and visits (9.7 versus 7.8  $p < 0.001$ ) were higher in pediatric patients. The mean age of women was higher than that of men, 39.2 versus 37.8 ( $p < 0.001$ ). The total cost was 148.7 million euros (93.3% for family medicine). Drugs were prescribed to 80.1% of patients. Fixed costs accounted for 29.1% of total costs and variable costs for 70.9% (including 47.5% on drug prescriptions). Therefore, the mean total cost per patient per year was € 654.2 (851.7), € 702.5 in Family Medicine and Pediatric € 344.6,  $p < 0.001$ . A total of 6.2% of patients were considered outliers, and after data refining the mean unitary cost per year was € 556.7. The association between the mean/unit cost according to age is shown in Figure 1.

The performance (patient distribution) and adaptive capacity (intra-group variation in categories) of the ACG classification are shown in Table 3. All patients were grouped in a category. However, no patients were grouped in 37 of the 106 categories, meaning that all patients were grouped in the remaining 69 categories. Furthermore, 61% of all patients were grouped in 10 categories and 80.9% in 19 ( $N = 183,721$ , Table 3). This distribution showed no significant differences according to the service provider. In 10 ACG categories, a poor performance (poor adaptive capacity) was observed ( $CV > 100\%$ ,  $N = 110,917$ , 48.8% of patients, Table 3 and Figure 2). The two categories with the highest CV were 1600-Preventive/Administrative ( $N = 8,527$ , 3.8%, outliers: 12.5%) and 1300-Psychosocial, w/o Psychosocial Unstable ( $N = 3,653$ , 1.6%, outliers: 10.7%).

We carried out a more-detailed analysis according to poor performance and the number of patients in each category. Table 4 shows the distribution of five ACG categories (making up 71% of poorly-performing categories,  $N = 78,887$ ). Compared with the total of 69 categories ( $N = 227,235$ ) these five categories had a lower explanatory power (coefficient of determination,  $R^2$ ) in episodes (44.3% versus 77.4%) and total costs (18.8% versus 36.9%),  $p < 0.001$ . For refined data, the results were 46.4% versus 78.4% for episodes and 36.5% versus 56.5% for total costs,  $p < 0.001$ . Category 0300-Acute Minor, Age 6 + ( $N = 26,909$ ; 11.8%) had a  $CV = 139\%$  and 6.6% of outliers and showed significant differences before and after data refining. Categories 0400-Acute Major ( $N = 8160$ ) and 1800-Acute Minor/Acute Major ( $N = 9077$ ) performed similarly. Category 4100-2-3 Other ADG Combinations, Age 35 +, had the highest number of patients ( $N = 28,864$ , 12.7%), with a high mean number of episodes (3.9 of total cases, compared to 4.5 in outliers,  $p < 0.001$ ), resulting in increased costs in these patients. The  $R^2$  of the five poorly-performing categories was 34.7%.

## DISCUSSION

This study determined the retrospective adaptive capacity of the ACG classification system according to the cost of PHC in Catalonia (Spain) in daily clinical practice, identifying 10 categories that performed poorly in the Catalan health system. In Catalonia, the use of capitation-based funding is still in its infancy compared to other European healthcare systems. The focus is on incorporating risk adjustment indicators in order to provide unbiased estimates of the expected costs of an individual patient in each health plan<sup>2-17</sup>.

There is abundant published evidence on the use and overall performance of the ACG classification, but evidence on categories that perform poorly is very limited<sup>4-7,9,12,18-23</sup>. It is expected that persons with similar morbidity and demographic characteristics will have a similar use of resources. In this respect, the available empirical evidence shows that it is technically possible to find an adjustment formula to predict at least a portion of the variation in health expenditure per person, and also that the highest predictive values are achieved by systems that incorporate diagnostic information<sup>6,21,25</sup>. This has been proven in our study, since the number of episodes showed a greater explanatory power with respect to ACG categories than the total costs. Furthermore, data refining may lessen the weight of random factors in predicting expenditure, although it is known that no system of classification of patients into RUB explains all the variation in the use of resources<sup>6-7,10,26</sup>.

In general, the Grouper requires a limited number of variables for each patient: age, sex and diagnosis (not necessarily correlated in time). This simplicity of use is compatible with the needs of PHC, which must work with large daily volumes of information, limited time for each patient, professional cooperation (doctors, nurses, social workers, etc.) and repeated visits from the same patient. However, a greater degree of computerization of PHC and the establishment of mechanisms for consensus between health professionals would be required to increase data quality and the consistency of records, especially in the identification of diagnoses<sup>11,23</sup>.

The general results of the study (demographic variables [age and sex], case mix [morbidity] and resource use levels [RUB]), fall within the parameters expected in PHC in Spain. Furthermore, the distribution of patients within ACG categories is similar to the results obtained in other studies (60% of patients are grouped in 10 ACG categories), and stable over time<sup>4,6,8-9,12,18-23,25-28</sup>.

This may be because the grouping works by binary combinations of ADG, regardless of the number of recurrences and the type of disorder<sup>4,5</sup>. For example, a patient with one or more episodes of upper

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3 respiratory tract infection over time, with or without concomitant pharyngitis, may remain grouped in  
4 the same ACG category, resulting in widely-differing use of resources and degree of variation in  
5 costs. This point has been suggested by some authors as a limitation of the ACG system, although  
6 recent years have seen an expansion of categories from 51 to 103 to avoid such problems<sup>23</sup>.  
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11 Poor performance or adaptive capacity was observed in 10 ACG categories (N = 110,917, 48.8% of  
12 patients). The two categories with the highest CV were: Preventive/Administrative and Psychosocial,  
13 w/o Psychosocial Unstable. These results are difficult to compare for several reasons: a) These  
14 categories include many different circumstances and conditions (administrative processes, preventive  
15 actions and health promotion, unstable conditions with an unpredictable risk of recurrence, etc.), b)  
16 These conditions tend to be associated with poor-quality medical records (prescriptions not linked to  
17 a diagnosis, etc.), and c) The presence of different organizational models between centers (patient  
18 circuits, etc.) as a result of health policies, causing a high degree of variability that affects the use of  
19 resources and their costs.  
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27 We found that five categories accounted for 71% of poor performance. In general, acute disease  
28 (0300-Acute Minor, Age 6 +, 0400-Acute Major and 1800-Acute Minor/Acute Major), representing a  
29 large number of pediatric patients, had a poor adaptive capacity. The ACG classification in Catalonia  
30 might be improved by expanding some of these categories according to age groups and, especially,  
31 by quantifying the number of episodes occurring during the study period. However, in the categories  
32 4100-2-3 Other ADG Combinations, Age 35 + and 3900-2-3 Other ADG Combinations, Males Age 18  
33 to 34, the performance with respect to classification into RUB could be improved by separating  
34 different ranges of episodes or ADG.  
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42 Therefore, a possible scenario for the debate on the funding model for PHC teams could be  
43 developed using a combination of factors: a) the weighting of structural costs related to accessibility,  
44 b) the variable costs according to the case-mix (ACG) and patient complexity, adapting the  
45 classification to the country, and c) quality targets derived from the policy sought by the purchaser  
46 and expected by the customer. In this aspect, the adaptive capacity of the ACG system to the Catalan  
47 setting could be bettered by improving the definition of some categories. This would facilitate policy  
48 making using benchmarking with respect to the complexity (case mix) and efficiency of PHC centers  
49 with the population served, enabling capitation payments (risk adjustment)<sup>4,26</sup>.  
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56 The greatest limitations of the study are related to the quality of the records and information systems.  
57 Without standardization of methodologies in terms of patient characteristics and the number and  
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2 measurement of variables, the results and their generalizability should be interpreted with caution<sup>24</sup>.  
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4 In addition, possible differences between health professionals in the selection of diagnoses may  
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6 contaminate the comparison of costs between groups. However, strength of the study is that the large  
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8 sample size could minimize these drawbacks. The ACG system was designed to measure the health  
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10 status and medical resources consumed in a set of patients and, therefore, population-based studies  
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12 of risk-adjusted capitation payments and the clinical management of PHC centers may be of  
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14 considerable interest in Catalonia<sup>23, 29</sup>.

## 15 16 17 **CONCLUSIONS**

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19 The ACG system is an appropriate manner of classifying patients in routine clinical practice in PHC  
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21 centers in Catalonia, although improvements to the adaptive capacity through disaggregation of some  
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23 categories according to age groups and, especially, the number of acute episodes in pediatric  
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25 patients, would be necessary to reduce intra-group variation.

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32  
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35  
36 **Ethics approval:** The study project was approved by the Ethics and Clinical Research Committee of the Jordi  
37  
38 Gol Clinical Research Institute (IDIAP Jordi Gol).

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41 **Contributors:** AS, SV, RN, CV, AP and MV planned the study. AS, RN and SV supervised the campaign  
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43 registration, data entry and follow-up. AS was responsible for the statistical analysis with help from SV. AS  
44  
45 wrote the first draft of the paper and has the primary responsibility for the final content. All authors contributed to  
46  
47 and approved the final manuscript. AS is the head of the Catalan study.

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Table 1: Mean unit costs in 2008

Health resources	Unit cost (€)
Health visit	23.62
Laboratory tests	22.70
Conventional radiology	18.84
Diagnostic tests/therapy	37.85
Referral to reference specialist	106.29
Drug prescriptions	RRPvat

Source: analytical accounting conducted for this study, RRPvat: recommended retail price including Value Added Tax.

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Table 2: General characteristics of study: co-morbidity and cost model

Characteristics	Total	
Patients	N = 227,235	
<i>General</i>		
Number of physicians	224	
Number of episodes	1,020,606	
Number of visits	1,834,326	
Mean age, years	44.1 (23.7)	
- 25 Percentile	27.0	
- 50 Percentile	43.0	
- 75 Percentile	67.0	
Sex (female)	55.6%	
<i>General co-morbidity</i>		
Mean ADG	3.7 (2.2)	
- 25 Percentile	2.0	
- 50 Percentile	3.0	
- 75 Percentile	5.0	
Mean episodes	4.5 (3.2)	
Mean Charlson index	0.2 (0.6)	
RUB	2.4 (0.8)	
1	16.9%	
2	31.0%	
3	47.9%	
4	3.8	
5	0.5	
Outliers (N = 14,066)	6.2%	
<i>Cost model (in euros) per year</i>		
	Mean/unit	%
- Fixed costs	190.7 (193.3)	29.1%
- Laboratory	51.9 (73.8)	7.9%
- Conventional radiology	21.4 (34.1)	3.3
- Complementary tests	6.2 (19.6)	1.0%
- Referrals to specialists	73.1 (117.3)	11.2%
- Drug prescriptions	310.8 (681.2)	47.5%
Total cost of PHC	654.2 (851.7)	100.0%
- Cost of family medicine	92.9%	
- Cost of pediatric medicine(0-14years)	7.1.	

Values expressed as mean (SD: standard deviation) or percentage; RUB: resource utilization bands, ADG: Ambulatory Diagnostic Groups, PHC: Primary Health Care.

Table 3: Distribution of ACG categories with the most patients: variability of categories

ACG	ACG Description	N	%	Cost <sup>(1)</sup>	CV	Outliers <sup>(2)</sup>
4100	2-3 Other ADG Combinations, Age 35+	28864	12.7%	776.3	107%	6.5%
0300	Acute Minor, Age 6+	26909	11.8%	169.6	139%	6.6%
4910	6-9 Other ADG Combinations, Age 35+, 0-1 Major ADGs	14876	6.5%	1,624.4	67%	4.5%
2100	Acute Minor/Likely to Recur, Age 6+, w/o Allergy	11867	5.2%	304.7	91%	5.3%
4410	4-5 Other ADG Combinations, Age 45+, no Major ADGs	10551	4.6%	1,025.4	74%	5.3%
4420	4-5 Other ADG Combinations, Age 45+, 1 Major ADGs	10137	4.5%	1,336.2	79%	4.6%
0500	Likely to Recur, w/o Allergies	9872	4.3%	187.2	140%	6.6%
1800	Acute Minor/Acute Major	9077	4.0%	353.2	104%	5.9%
1600	Preventive/Administrative	8527	3.8%	229.5	215%	12.5%
0400	Acute Major	8160	3.6%	237.3	160%	8.1%
0900	Chronic Medical: Stable	6319	2.8%	506.7	114%	6.2%
3900	2-3 Other ADG Combinations, Males Age 18 to 34	5877	2.6%	341.7	117%	6.0%
3200	Acute Minor/Acute Major/Likely to Recur, Age 12+, w/o Allergy	5785	2.5%	525.0	89%	6.3%
2300	Acute Minor/Chronic Medical: Stable	5756	2.5%	612.6	95%	6.3%
3600	Acute Minor/Acute Major/Likely to Recur/Chronic Medical: Stable	5575	2.5%	1,022.1	72%	5.0%
4310	4-5 Other ADG Combinations, Age 18 to 44, no Major ADGs	4168	1.8%	554.8	86%	6.4%
4920	6-9 Other ADG Combinations, Age 35+, 2 Major ADGs	4089	1.8%	2,102.5	67%	3.5%
2800	Acute Major/Likely to Recur	3659	1.6%	351.0	102%	6.9%
1300	Psychosocial, w/o Psychosocial Unstable	3653	1.6%	340.4	175%	10.7%

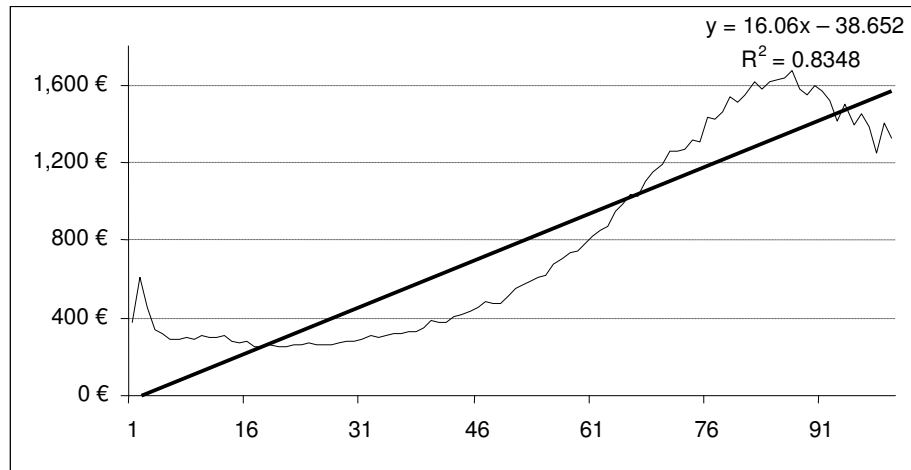
Nineteen ACG categories contain 80.9% of patients (N = 183,721). No patient was grouped in 37 ACG categories; ACG, Adjusted Clinical Groups (Code)<sup>(1)</sup>: Gross cost (mean/unit in euros), CV: Pearson's Coefficient of Variation,<sup>(2)</sup>:outliers: percentage of patients, cut-off:  $T = Q_3 + 1.5(Q_3 - Q_1)$  where  $Q_3$  and  $Q_1$  are the third and first quartiles of the distribution, respectively. Total sample: N = 227235, CV = 130.0%, outliers: 6.2%.

Table 4: Distribution of five poorly-performing ACG categories according to age, episodes and cost

ACG categories (coding and description)	Total	No outliers	Outliers			
Variables	N	Mean	N	Mean	N	Mean
<i>4100: 2-3 Other ADG Combinations, Age 35+</i>	28864		26992		1872	
Age		60.5 (14.8)		59.7 (14.6)		70.9 (12.8)
Episodes		3.9 (1.3)		3.9 (1.2)		4.5 (1.5)
Total cost		776.3 (828.2)		620.3 (448.7)		3026.1 (1504.4)
<i>0300: Acute Minor, Age 6+</i>	26909		25142		1767	
Age		33.1 (16.5)		31.9 (15.4)		50.5 (22.1)
Episodes		1.7 (1.1)		1.7 (0.9)		2.5 (1.4)
Total cost		169.5 (236.5)		125.2 (91.7)		800.0 (554.3)
<i>1800: Acute Minor/Acute Major</i>	9077		8538		539	
Age		32.1 (19.8)		30.8 (18.5)		51.6 (27.1)
Episodes		3.6 (1.5)		3.6 (1.4)		4.8 (2.3)
Total cost		353.2 (366.2)		288.7 (166.5)		1374.2 (843.8)
<i>0400: Acute Major</i>	8160		7503		657	
Age		38.5 (18.2)		36.6 (16.7)		59.9 (20.6)
Episodes		1.6 (0.8)		1.5 (0.7)		2.1 (1.1)
Total cost		237.3 (379.5)		158.3 (108.7)		1139.1 (877.8)
<i>3900: 2-3 Other ADG Combinations, Males Age 18 to 34</i>	5877		5523		354	
Age		28.1 (4.5)		28.0 (4.5)		28.7 (4.2)
Episodes		3.3 (1.0)		3.3 (1.1)		3.8 (1.2)
Total cost		341.6 (399.1)		273.7 (154.1)		1401.2 (1040.1)

Contrast statistic: Chi<sup>2</sup> test or Mann-Whitney Wilcoxon test; p<0.001 in all cases, ADG: Ambulatory Diagnostic Groups; coefficient of determination (R<sup>2</sup>): intra-group/total variability (ANOVA).

Figure 1: Correlation of the cost of care according to age.

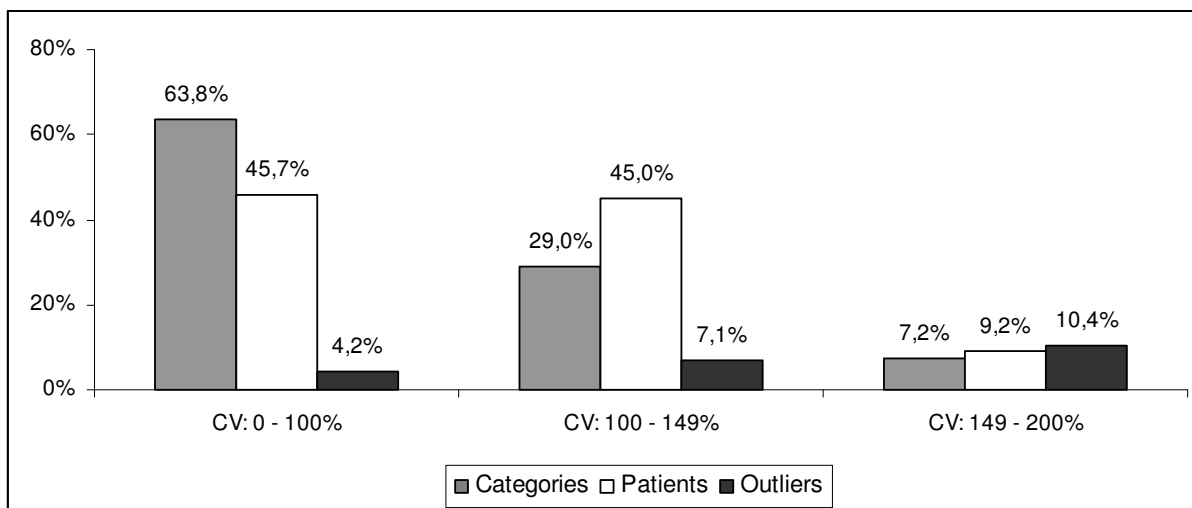


R<sup>2</sup>: Coefficient of determination

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Figure 2: Percentage distribution of coefficients of variation according to the number of categories, patients and outliers



CV: Pearson's coefficient of variation; contrast statistic:  $\chi^2$ ,  $p < 0.001$  for all categories.

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